′Abd al-Raḥmān al-Ṣūfī and His Book of the Fixed Stars: A Journey of Re-discovery

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Abstract

Al-Ṣūfī’s *Book of the Fixed Stars*, dating from around AD 964, is one of the most important medieval Arabic treatises on astronomy. This major work contains an extensive star catalog, which lists star co-ordinates and magnitude estimates, as well as detailed star charts. Other topics include descriptions of nebulae, colors of stars and Arabic folk astronomy. Al-Ṣūfī’s book was based on Ptolemy's classical work called the *Almagest* which was written around A.D. 137. Al-Ṣūfī updated Ptolemy's stellar longitudes from A.D. 137 to 964 by adding 12 degrees and 42 minutes on Ptolemy’s longitude values to allow for precession. However, it is surprising that at present no English translation of al-Ṣūfī’s treatise exists. Therefore this is a Doctorate thesis which includes for the first time a complete English translation of the main parts of al-Ṣūfī's work as well as a detailed study of this important book.

The main topics which have been discussed in this study include a brief biography on al-Ṣūfī, the extant manuscripts of al-Ṣūfī’s treatise, the structure of the book and star catalogue, and the star maps and charts. One of al-Ṣūfī's innovations in charting the stars was the production of dual illustrations for each of Ptolemy’s constellations. One illustration was as portrayed on a celestial globe. The other illustration was as viewed directly in the night sky. Al-Ṣūfī’s contribution to astronomy was not only limited to writing this book but he was also instrumental in developing the science of astronomy for a very long time. He also contributed to the building of an important observatory in the city of Shiraz as well as constructing many astronomical instruments such as astrolabes and celestial globes. His influence reverberated throughout history reaching as far as the end of the 19th century. This study also includes a major finding which is al-Ṣūfī’s magnitude unique 3-step intermediate magnitude system. Al-Ṣūfī identified more than one hundred new stars which he mentioned in his commentaries on the constellation but they were not included in the tables nor were they mentioned in the *Almagest* or any other ancient star catalogs.

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1. INTRODUCTION

> "A really correct and reliable edition, with reproductions of the drawings in the original shape, using some of the oldest extant manuscripts remains a desideratum," (Kunitzsch, 1989).

This was what Professor Paul Kunitzsch wrote when he was describing one of the most important books in the history of Arabic and Islamic astronomy. This book was called *Ṣuwar al-Kawākib al-Thamāniyah wa-al-Ārba'een*, later known by its short name *The Book of the Fixed Stars*. It was written in Arabic by the famous Persian author and astronomer ′Abd al-Raḥmān al-Ṣūfī around A.D. 964.

Ever since I read this comment by Professor Kunitzsch I wondered what prompted one of the foremost experts in the history of Arabic astronomy to write such a comment about a book, which had always been the one main reference in the history of Arabic observational astronomy? It is the one book that is almost always mentioned by anyone who wants to describe the level of development of Arabic astronomy in the Middle Ages (Evans, 1998). This impelled me to look for copies of this book and to search for any references, which mentioned either the book or the author. However, to my surprise, from the literature review that I made I found little detailed published information on this subject. I found out that until now al-Ṣūfī's work has not been translated into English, and has not even been commented on in recent times. The last translation of this significant work was done in French by Hans Karl Frederik Schjellerup back in A.D. 1874 (Schjellerup, 1874). However, Latin, Persian and Spanish translations are known to exist (Kunitzsch, 1989). Most of the scholarly works I found which mentioned this book have had something to do with the comparison of al-Ṣūfī's star coordinates with those provided by Ptolemy in his famous work *Almagest* (Knobel and Peters, 1915) or with other similar star catalogs (Fujiwara; Yamaoka; and Miyoshi, 2004). I have not seen many references which describe al-Ṣūfī's work for its own merits except as a general reference to the importance of his star catalog from a historical perspective (Hoskin, 1997) or the influence of his charts on Western or European astronomy (Harley; Woodward; and Lewis, 1987). The other main references I found on al-Ṣūfī described the nebulae which he wrote about in his book (Abinda, 1999).

Therefore I took upon myself to write a thesis on al-Ṣūfī's work *Ṣuwar al-Kawākib al-Thamāniyah wa-al-Ārba'een.* My main objective for this thesis was first directed at translating the main sections of this book. The other objective was to try and point out the importance of this author and this book in the history of astronomy. I found that al-Ṣūfī's work also includes other topics, such as stellar magnitude values, Arabic folk astronomy and so on, which should be highlighted for their own. My justification in writing this thesis is that very few people have access to al-Ṣūfī's work and many researchers believe that an English translation and a study of such works by Arab astronomers are very important at this time. This turned out to be a journey of re-discovery of a man who helped influence the science of astronomy and courageously tried to correct our views of the celestial sphere.

Before I embarked on this endeavor I needed to set up a method or framework by which I would go about conducting this research. Such a study requires the expertise of astronomy, history of science, Arabic and Islamic history as well as linguistics. However I do not claim to be an expert in all these fields and I was always grateful to receive constructive comments and corrections on the various topics, which are relevant to this study. Therefore to conduct this study I first had to understand the history of ancient classical astronomy and the main events that shaped the development of Arabic and Islamic astronomy throughout history. I also had to be aware of the old Arabic astronomical tradition and why it was important to many Arab and Islamic astronomers, including al-Ṣūfī. And in order to understand al-Ṣūfī's work I had to fully understand the general characteristics of Arabic and Islamic astronomy. I also needed to study Ptolemy's star catalog, which is to be found in the *Almagest.* I had to study its history, from Ptolemy's time until it passed down to al-Ṣūfī, and finally down to the present day. Therefore, in the second part of this study I tried to summarize the above-mentioned topics in order to give a better understanding of the history of Arabic astronomy before I could start to understand and analyze al-Ṣūfī's work.

ʹAbd al-Raḥmān, Abū al-Ḥusaīn, Ibn ʹUmar, Ibn Muḥammad, al-Rāzī, al-Ṣūfī, the author of this most important book in the history of medieval astronomy, was born in A.D. 903 in Rayy, south east of what is now called Tehran (Iran), and he died in A.D. 986. In the third part of this effort to re-discover this author I tried to construct a short biography on this 10th century astronomer. This included the background on al-Ṣūfī's time period as well as all those people, heads of states and scholars who influenced our author or have been influenced by him. I also tried to summarize the other works which were ascribed to our author, and discussed their importance in the history of Arabic astronomy. It is well known that al-Ṣūfī built an observatory in Shiraz (Sayili, 1960). Therefore, it was also important to describe the significance of this observatory, its location, the astronomers who worked in it, and the contributions they made to the progress of astronomy. The importance of al-Ṣūfī in the history of astronomy is a known fact; however it was good to see how al-Ṣūfī's work influenced the development of astronomy in the Islamic world as well as in the Western world later on. Al-Ṣūfī has been mentioned by many astronomers but his name has often been miss-spelled and miss-written. He has been referred to by various names such as: Abolfazen, Ebenasophy and Azophi (Kunitzsch, 1989). It had been a fascinating exercise to search for these names which were given to al-Ṣūfī in history and the reason they were transformed in this way. Finally, to commemorate the name of this important astronomer, it should be noted that in 1935 the International Astronomical Union named a crater on the Moon by the name of Azophi. It was interesting at that point in this study, to identify this crater, and include a picture of it in the final effort to construct this biography.

Al-Ṣūfī's star catalog was based on Ptolemy's star catalogue in the *Almagest* with the addition of 12 degrees 42 minutes to allow for precession. However, al-Ṣūfī also commented in detail on every constellation before every section of those star charts. Al-Ṣūfī also used ecliptical coordinates, as did Ptolemy before him. Al-Ṣūfī's original Arabic text contained 55 astronomical tables as well as duel charts to 48 constellations, one as seen in the heavens and another as depicted on a celestial globe. These tables and charts were divided into three main sections. The first contained 21 northern constellations which are: Ursa Minor, Ursa Major, Draco, Cepheus, Bootes, Corona Borealis, Hercules, Lyra, Cygnus, Cassiopeia, Perseus, Auriga, Ophiuchus, Serpens, Sagitta, Aquila, Delphinus, Equuleus, Pegasus, Andromeda and Triangulum. The second section contained the 12 constellation of the zodiac: Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpios, Sagittarius, Capricorns, Aquarius and Pisces. And finally, the third section contained the following 15 southern constellations: Cetus, Orion, Eridanus, Lepus, Canis Major, Canis Minor, Argo Navis, Hydra, Crater, Corvus, Centaurus, Lupus, Ara, Corona Australis and Piscis Austrinus.

The main objective of this thesis and my attempt to revive the treasures hidden in al-Ṣūfī's book was in translating this major work. Therefore, in the fourth section of this thesis I tried to translate the main introductory chapter as well as six complete chapters of al-Ṣūfī's work. This is because the text is immense and its full translation would not be within the scope of this thesis. I have included some explanations and commentaries in the discussions section of this study to help understand some of the concepts and ideas which were found in those chapters. The first part in the translation effort was to translate the introductory chapter where al-Ṣūfī explains the reasons why he wrote *The Book of the Fixed Stars*. He mentioned that his book was dedicated to the Buwayhid ruler, 'Aḍud al-Dawla, who was a great patron of astronomy and himself an accomplished scholars and astronomer. Al-Ṣūfī also described the methods he used in constructing his catalogue, especially in calculating precession. In his introductory chapter al-Ṣūfī also commented upon several other works, such as al-Battānī's star catalog, al-Daīnawari's book on old Arabic astronomical tradition and Ptolemy's *Almagest*. The second part in the translation effort was to translate the entire star catalogue which was found at the end of each constellation chapter. For all these translations I have used the oldest extant copy of al-Ṣūfī's book, as well as the copy written by the famous Muslim astronomer Ulugh Bēg in the 15th century, which is a well-written manuscript.

Al-Ṣūfī's work was written in old Arabic style with no comas or stops, therefore it was sometimes a little difficult to understand the meaning of every thought. As I described earlier, it was necessary at first to study the old Arabic astronomical traditions and the idea of the star mansions, as well as Ptolemy's account in the *Almagest*, in order to fully understand the translation of al-Ṣūfī's book. Therefore, in the translation efforts I tried to follow the ideas and sentence structure of al-Ṣūfī exactly as he wrote them, and at the same time attempt to make them comprehensible given our present style of writing and sentence structure, so I had to translate exactly as al-Ṣūfī wrote, and leave the analysis, comparison and error measurement for the next section of this study.

It was a normal rainy day when I walked into the British Library in London. I was looking for a copy of al-Ṣūfī work *The Book of the Fixed Stars*. After the tedious bureaucratic effort to register my request and obtain a visitor's library card, I was ushered into the main floor where the Arabic manuscripts were usually kept. I was well prepared: I had all the relevant information about the author and the book, as well as the manuscript number. "It is strange. We seem to have it but I could not find the manuscript number. We need several days to locate this book. Do you want me to hold it for you? You should come back in a few days if you want." This was the reply I got from the librarian at that time. I wondered then why an important book such as this one was not easy to locate. Was it buried under loads of other books? When was the last time anyone had requested it? Anyway, this was almost the same reply I got in many other libraries which were known to have copies of this manuscript. It proved to be a tedious effort to locate all the main sources and available copies or manuscripts of this book. I had to travel to Paris, London, Oxford and many other libraries worldwide in order to collect some of the major copies which I used in this study. It was only once all these extant manuscript were located that I began my translation and investigation of al-Ṣūfī's work.

The study and analysis of this book begins with a description of the structure and layout. What are the main ideas that are presented in the book? How was it written? And what are the main factors that distinguished this book from other similar works that predated it? I have tried to answer all these research questions and many more, in this attempt to study and analyze the most important work of observational astronomy to come out of the Middle Ages.

Another aspect of the study was the maps, which are considered a unique feature of this work. Al-Ṣūfī drew two distinct sets of maps of the constellations. One set depicted the constellation as seen in the sky, and the other as seen on a celestial globe. Such a concept was considered a 'first' in observational astronomy, in an effort to identify every constellation in the sky, determine it size and locate all of the major stars in each constellation.

The next step of the analysis was to compare al-Ṣūfī's stellar data with those found in the *Almagest*. This analysis eventually led to the examination of the accuracy of al-Ṣūfī's values compared to today's figures. In this study I tried to identify all those stars which show a difference in magnitude so I could analyze the reasons for these discrepancies and the level of accuracy of al-Ṣūfī's data. I also found that al-Ṣūfī identified many other stars which had not been mentioned by Ptolemy or any other astronomer before him. Al-Ṣūfī also mentioned the colors of some stars as well as stars which were normally used on the astrolabes. He also mentioned the location of some stars which he considered to be double stars. As mentioned earlier, many references are found in history of astronomy books to those few nebulae which al-Ṣūfī identified. Therefore, in this part of the study I tried to locate all the above mentioned stars as well as these nebulous objects and summarize what al-Ṣūfī wrote about them. I am hoping that all this information might hopefully be used in future studies and research of applied astronomical research. The final part of this re-discovery effort was to examine the old Arabic astronomical traditions mentioned in al-Ṣūfī's work. How significant were they? and why did he include them in his work?

As we will see, al-Ṣūfī and *The Book of the Fixed Stars* have a very important place in Arabic and Islamic astronomy. Al-Ṣūfī managed to combine the old Arabic *Anwā'* tradition with the ancient classical Greek astronomy to join two separate astronomies into one (Brown, 2009). Professor Kunitzsch wrote that a more detailed study of this subject is required; therefore I hope that I have managed to satisfy some of these endeavors. Finally, to recap what Schjellerup wrote in his introduction: "al-Ṣūfī's ... work deserves the highest confidence as in its perfection it surpasses Ptolemy's tables which had remained without a rival for the previous nine centuries."

2 KEY ELEMENTS OF ARABIC AND ISLAMIC ASTRONOMY

2.1 A Short History of Arabic and Islamic Astronomy

The study of astronomy and the degree which it has reached in our time, is a result of the huge efforts of ancient astronomers, philosophers and thinkers of the past. Astronomy, like any other science, is like a tree with it roots in the ground and its branches growing and flourishing. No branch could have evolved without these roots. Therefore, it is always essential to study and understand these roots before we attempt to proceed with our own study of our author ʹAbd al-Raḥmān al-Ṣūfī and his *Book of the Fixed Stars*.

Before we start our brief study on the history of Arabic and Islamic astronomy we have to set our terminologies straight. The terms Arabic and Islamic astronomy are sometimes confusing. Sometimes the term 'Arabic' is used and sometimes it is 'Islamic'. So what is the difference between the two and why do we have two different classifications for what seems to be one topic? Islamic science and astronomy usually refers to the work of those scientists and astronomers who lived in the Islamic empires in the Middle Ages. As a result Islam had an influence on them- even though some of them were not Muslims in their beliefs. These scholars mainly wrote their work in the Arabic language, which was the official language of the Islamic states. Therefore, the terms Arabic and Islamic are sometimes used interchangeably and sometimes as distinctive terms that describe these scholars. However, I believe that the best way to describe these scientists is by combining the terms: Arabic and Islamic scientists and Astronomers. If we only use the term Arabic then we will exclude many distinguished non-Arabs (Persians, Turks, Indians….) who contributed greatly to the history of Arabic and Islamic science. And vice versa: if we only use the term Islamic then we will also be excluding many non-Muslims (Christians, Jewish, Sabian…) who also made immense contributions to the advancement of Arabic and Islamic science and astronomy. This reasoning applies to our author ʹAbd al-Raḥmān al-Ṣūfī. He was a Muslim and a Persian astronomer who wrote all his works in Arabic.

Prior to beginning this study we also have to understand the historical background and the astronomical knowledge that was present in the geographical area where this astronomy evolved. Therefore, in the next part of this study I will attempt to give a brief picture of the historical development and significance of ancient astronomy leading to the study of the history of Arabic and Islamic astronomy.

2.1.1 Background on the History of Ancient Astronomy

Astronomy grew out of problems originating with the first civilizations, that is, the need to establish with precision the proper times for planting and harvesting crops and for religious celebrations and to find bearings and latitudes on long trading journeys or voyages. The curiosity of ancient people concerning day and night, the Sun, the Moon, and the stars eventually led to the observation that the heavenly bodies appear to move in a regular manner that is useful in defining time and direction on Earth. To ancient people the sky exhibited many regularities of behavior. The bright Sun, which divided day from night, rose every morning from one direction, from the east, moved steadily across the sky during the day, and set in a nearly opposite direction, in the west. At night more than 2000 visible stars followed a similar course, appearing to rotate in permanent groupings, around a fixed point in the sky. In the North Temperate Zone, people noticed that days and nights were unequal in length. On long days the Sun rose north of east and climbed high in the sky at noon; on days with long nights the Sun rose south of east and did not climb so high at noon. Observation of the stars showed that the relative position of the Sun among the stars changed gradually. Further study showed that the sky also holds the Moon and five bright planets. These bodies, together with the Sun, move around the star sphere within a narrow belt called the ecliptic. The Moon traverses the ecliptic quickly, overtaking the Sun about once every 29.5 days. This period is now known as the synodic month. Star watchers in ancient times attempted to arrange the days, the months and the years into a consistent time system, or calendar. The Sun and Moon always traverse the ecliptic from west to east. However, some of these planets -Mars, Jupiter and Saturn- also have a generally eastward motion against the background of the stars, move westward, or retrograde, for varying durations during each synodic period. Thus, the planets appear to pursue an eastward course erratically, with periodic loops in their paths. In ancient times, people also imagined that celestial events, especially the planetary motions, were connected with their own fortunes. This belief, called astrology, encouraged the development of mathematical schemes for predicting the planetary motions and thus furthered the progress of astronomy during ancient times.

Several ancient people, notably the Egyptians, the Mayans, and the Chinese, developed interesting constellation maps and useful calendars (Walker, 1996). Among those ancient cultures were the Babylonians who accomplished even greater achievements (Hunger et al., 1999). The Babylonians distinguished stars according to groups or constellations and introduced the sexagesimal system of calculation. To perfect their calendar, they studied the motions of the Sun and Moon. It was their custom to designate the first day of the month when the lunar crescent first appears after sunset. Originally this day was determined by observations, but later the Babylonians wanted to calculate it in advance. They also realized that the apparent motions of the Sun and Moon from west to east around the ecliptic do not have a constant speed. These bodies appear to move with increasing speed for half of each revolution to a definite maximum and then to decrease in speed to the former minimum. The Babylonians attempted to represent this cycle arithmetically by giving the Moon, for example, a fixed speed for its motion during half its cycle and a different fixed speed for the other half. Later they refined the mathematical method by representing the speed of the Moon as a factor that increases linearly from the minimum to maximum during half of its revolution and then decreases to the minimum at the end of the cycle. With these calculations of the lunar and solar motions, Babylonian stargazers could predict the time of the new Moon and the day on which the new month would begin. As a by-product, they knew the daily positions of the Moon and Sun for every day during the month. In a similar manner the planetary positions were calculated, with both their eastward and retrograde motions represented. Archaeologists have unearthed hundreds of cuneiform tablets that show these calculations. A few of these tablets, which originated in the cities of Babylon and Uruk, on the Euphrates River, bear the name of Naburiannu, who flourished about B.C. 491, and Kidinnu, who flourished about B.C. 379 (Neugebauer, 1969: 137).

However the Greeks were later to make one of the most important theoretical contributions to the science of astronomy. It all started with the *Odyssey* of Homer who referred to such constellations as the Great Bear, Orion, and the Pleiades and described how the stars may serve as a guide in navigation. Other poems informed the farmer which constellations rose before dawn at different seasons of the year to indicate the proper times for plowing, sowing, and harvesting (Evans, 1998: 3). In about 370 B.C. the astronomer Eudoxus of Cnidus explained that a huge sphere bearing the stars on its inner surface moved around the Earth in a daily rotation. In addition, to account for solar, lunar, and planetary motions, he assumed that inside the star sphere there existed other interconnected transparent spheres that revolved in various ways (Heath, 1932: 65). This cosmological system of nested celestial spheres was depicted by Peter Apian in his Cosmographicus in A.D. 1524 as shown in Figure 1 below.

Figure 1 The Universe According to the Greeks with Nested Celestial Spheres was Depicted by Peter Apian in his Cosmographicus in A.D. 1524

Probably the most original ancient Greek observer of the heavens was Aristarchus of Samos. He believed that the motions of the sky could be explained by the hypothesis that the Earth turns around on its axis once every 24 hours. He also explained that the Earth along with the other planets revolve around the Sun; however most Greek philosophers rejected this explanation. The theory of the Earth-centered Universe, known as the geocentric system, remained virtually unaccepted for about 2000 years. From the 2^{nd} century B.C. until the 2^{nd} century A.D. Greek astronomers combined their celestial theories with carefully planned observations. The astronomers Hipparchus and later on Ptolemy determined the positions of about 1000 bright stars and used this star chart as a background for measuring the planetary motions (Grasshoff, 1990). Abandoning the spheres of Eudoxus for a more flexible system of circles, they postulated a series of eccentric circles with the Earth near a common center to represent the general eastward motions at varying speeds of the Sun, Moon, and planets around the ecliptic. To explain the periodic variations in the speed of the Sun and Moon and the retrogressions of the planets, they postulated that each of these bodies revolved uniformly around a second circle, called an epicycle, the center of which was situated on the first as shown in Figure 2. By proper choice of the diameters and speeds for the two circular motions ascribed to each body, its observed motion usually could be mathematically represented. In some cases a third circle was required. Ptolemy described this technique in his great work the *Almagest*.

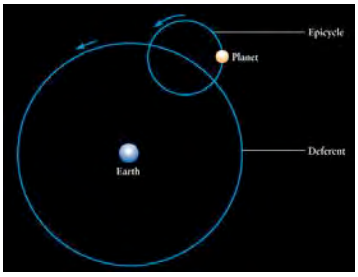


Figure 2 The Ptolemaic System with Deferents and Epicycles

With the conquests of Alexander the Great in the Mediterranean region around B.C. 330, Greek civilization dominated the area for centuries. As a result of this cultural interaction, Greek astronomy was exchanged between the Syrians, the Hindus, and the Arabs (Sarton, 1959). Arab and Islamic astronomers compiled star catalogs in the 9th and 10th centuries and subsequently developed tables of planetary motion, which were mainly based on Greek astronomy. Many scholars of history believe that although the Arabs were good observers, however they made very few useful contributions to astronomical theories (Lindberg, 1992: 175). However this shallow reasoning has long been revamped as a result of continuous discoveries and research on the history of Arab and Islamic astronomy (Saliba, 1994). In the 13th century, Arabic translations of Ptolemy's *Almagest* filtered into Western Europe. It is this act which has re-stimulated the interest in astronomy leading to the Copernicus and the Newtonian revolutions.

2.1.2 A Brief History of the Arab and Islamic Empire

At the beginning of the seventh century A.D. the Arabian Peninsula was rocked with the birth of a new religion: Īslām. This religion first engulfed the Arab world and changed the whole social and political structure of the area. It also transformed the whole perceptions and interest of the Arabs who populated this region. On the 29th of September in A.D. 571 the Prophet Muḥammad was born. In A.D. 611 he received the first revelation from God and in A.D. 622 he migrated to Madīnah which marks the start, of the known Islamic *Hijrī* calendar and the birth of the first Islamic state under the leadership of the Prophet himself, then later by his successors or Caliphs. This early era of Islamic history is marked by the struggle to spread the message of faith and to strengthen the newly-born state. Therefore as a result of this, war was inevitable in order to spread and fulfill the message and defend the gains that were achieved.

Upon the death of the Prophet Muḥammad in A.D. 632, Abū-Bakr, the friend of the Prophet and the first adult male to embrace Islam, became caliph. Abū-Bakr ruled for two years to be succeeded by ′Umar who was the caliph for a decade. During ′Umar’s rule Islam spread extensively east and west conquering the Persian Empire, Syria and Egypt. ‘Umar also established the first public treasury and a sophisticated financial administration. He established many of the basic practices of Islamic government. ′Umar was succeeded by ‘Uthmān who ruled for some twelve years during which time the Islamic expansion continued. He is also known as the caliph who had the definitive text of the Qur’an copied and sent to the four corners of the Islamic world. He was in turn succeeded by ‘Alī, the Prophet’s cousin and son-in-law who is known to this day for his eloquent sermons and also for his bravery. With his death the rule of the ‘rightly-guided’ caliphs, who hold a special place of respect in the hearts of Muslims, came to an end.

The Islamic community had expanded rapidly after the Prophet's death, and within a few decades the territory under Islamic rule extended onto three continents: Asia, Africa and Europe. Over the next few centuries this Empire continued to expand and Islam gradually became the chosen faith for the majority of its inhabitants. As Islamic civilization developed, it absorbed the heritage of ancient civilizations like Egypt, Persia and Greece, whose learning was preserved in the libraries and with the scholars of its cities. Some Arab and Islamic scholars turned their attention to these centers of learning and sought to acquaint themselves with the knowledge taught and cultivated in them. They, therefore, set about with a concerted effort to translate the philosophical and scientific works available to them, not only from the Greek and Syriac languages (the languages of eastern Christian scholars), but also from the scholarly language of pre-Islamic Persia, and even from Sanskrit, an ancient Indian language.

In A.D. 661 the rule of the Umayyad dynasty began which was to last for about a century. During this time Damascus became the capital of an Islamic world, which stretched from the western borders of China to southern France. Not only did the Islamic conquests continue during this period through North Africa to Spain and France in the West and to Central Asia and India in the East, but the basic social and legal institutions of the newly-founded Islamic world were established. All this started with the first Umayyad Caliph Mu’aweyah Ibn Abū Sufyān whose rule lasted until A.D. 680. Mu’aweyah’s conflict with ‘Alī the last of the rightly-guided caliphs and his sons brought about the first internal power struggle of the Islamic world. Those who supported ‘Alī and his son’s right to succession were to be called Shiite (Shī’ah) Muslims. Those who supported Mu’aweyah and the idea of majority rule were to be called Sunnī Muslims. Therefore the Umayyad rule from the beginning was characterized by continuous struggle to expand while keeping this Dynasty alive.

The Abbasids (al-‘Abbāsīyeen), who succeeded the Umayyad in A.D. 750, shifted the capital to Baghdād, which soon developed into an incomparable center of learning and culture as well as the administrative and political heart of a vast world. They ruled for over 500 years but gradually their power waned and they remained only symbolic rulers bestowing legitimacy upon various sultans and princes such as the Buwayhid and the Seljūks who wielded actual military power. The Map below in Figure 3 shows the extent of Abbasids Islamic Empire during the 9th century.

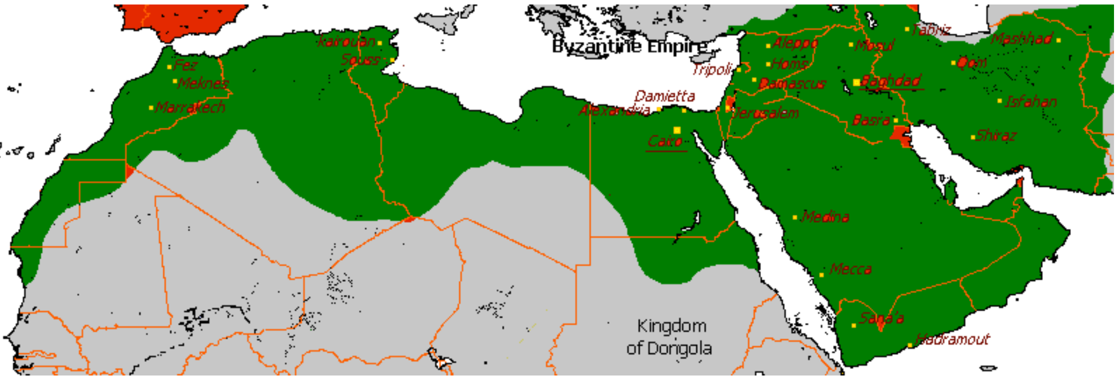


Figure 3 Map of the Islamic Empire in the 9th century.

The Abbasid caliphate was finally abolished when Hulagu, the Mongol ruler, captured Baghdād in A.D. 1258, destroying much of the city including its incomparable libraries. While the Abbasids ruled in Baghdād, a number of powerful dynasties such as the Fatimids (al-Fāṭimīyeen), Ayyubids (al-Aybūyīeen) and Mamluks (al-Mamālīk) held power in Egypt, Syria and Palestine. The most important event in this area as far as the relation between Islam and the Western world was concerned was the series of Crusades declared by the Pope and supported by various European kings. The purpose, although political, was outwardly to recapture the Holy Land and especially Jerusalem for Christianity. At the beginning there was some success and local European rule was set up in parts of Syria and Palestine. Muslims eventually prevailed and in A.D. 1187 Ṣalāh al-Dīn, recaptured Jerusalem and defeated the Crusaders.

2.1.3 Astronomy During the Early Days of Islam

During the early period of Islam, the Muslims were preoccupied with the struggle and the affairs of state. They were not able to pursue any significant scientific endeavors. Most scholars concerned themselves with theology and other religious studies that accompanied the establishment and transmission of this faith. Astronomy, which is a part of the scientific corps, suffered as a result of this neglect. Unfortunately before Islam, astronomy was associated with the practice of divination and also with the worship of idols, stars and planets (Shami, 1994). Therefore many early Muslims disassociated themselves from the study of astronomy fearing they would be tainted by having any connection with previous unholy practices. This does not mean that Islam prohibited the study of this science; however, this unease with astronomy at the beginning laid the road for Muslims to draw the distinction between astronomy and astrology. Islam was very clear in prohibiting divination and any other astrological practices but at the same time encouraging the science of astronomy for the benefit of mankind. However, this did not completely stop the practice of astrology by some Arab and Islamic scientists and rulers in Islamic societies (Sherem, 2003: 114).

2.1.4 Astronomy During the Umayyad Period

From the start of their rule the Umayyad experienced many internal uprising against their state. Most of the Umayyad Caliphs were mainly occupied with putting down these uprisings as well as trying to expand the borders of their empire eastward and westward. Therefore most of the rulers and caliphs in the Umayyad period were more preoccupied with politics then with aspects of social and cultural interests.

However there were some exceptions to this norm. We know from several historical references that one of Mu'aweyah's grandsons whose name was Khāled Ibn Yazīd Ibn Mu'aweyah had some interest in science (Shami, 1997: 97). It is said that he was one of the first to order scientific books to be translated for him from Greek. Unfortunately this early translation activity was restricted to a personal level and did not have any wide impact elsewhere. Therefore, the first century of Islamic rule was not very productive from an astronomical point of view.

2.1.5 Astronomy During the Abbasid Period

The Abbasid dynasty took over control of the Islamic empire from the Umayyad dynasty in A.D. 750 before which most of the expansions of the state had taken place. This Empire started to enjoy a relative period of stability as the authority of the Islamic empire was reaffirmed. Another important aspect of the Abbasid Empire was that it contained one of the most diverse cultures and ethnic groups that have ever been assembled in one state. It included the Arabs in Arabia, the Persians in Iran, The Turks in central Asia, the Berber in North Africa, the Indians on the Indian subcontinent, and the Chinese in Asia. This Empire also included many religions and sects under one roof such as Muslims, Christians, Jews, Sabians, Hindus, Buddhists and many more.

The Golden period of the Abbasid rule extends from the start of the rule of the first Caliph Abī al-'Abbās until the end of the rule of the Caliph al-Mutawakel in A.D. 861. During this period the Arabic language became the official language of the Empire. Arabic was the language of the Quran and it was used by almost all scholars and scientist as well as in the daily lives of many citizens in this vast Empire. The adoption and use of the Arabic language, not to mention the wide conversion to Islam, also helped in uniting the many cultural groups in the largest Empire that has ever existed in the history of mankind. For example, al-Ṣūfī wrote all his works in Arabic even though he was of Persian descent.

The scientific and astronomical interests of the Abbasid Dynasty started in the reign of the second Caliph, Abu J'afar al-Mansūr. This caliph was known for his love of science especially that which involved the stars and the study of the heavens. He was known to have surrounded himself with scientists, astronomers as well as astrologers whom he consulted in many of his affairs. Some of those scholars were: Nubūkhet and his son Sahl, Ibrahīm al-Fazārī, 'Ali al-Isterlābī and 'Umar Ibn al-Farkhan al-Ṭabarī. It is also well known that the caliph built the city of Baghdad and it is said that he consulted with one of his astrologers Nubūkhet regarding the location and time of building this city (Shami, 1994). However, Al-Mansur's legacy is that he was the first to order the translation of books on astronomy not to mention astrology from Greek and Indian to Arabic. This heralded the start of the translation movement that would later have a profound impact on the science of astronomy of that period.

By the time Hārūn al-Rashīd came to be the new Caliph in Baghdad in A.D. 786, scientists and scholars had become very common around the households and courts of the Caliph. Al-Rashīd followed in his family's footsteps and continued to encourage and provide for those scientists with generous funds and offers. Al-Rashīd did not stop there. He also established Dar al-Ḥikmah or 'House of Wisdom' which was a monumental step in building what was to become the first-known 'Research Institute' similar to the specialized research institutes of today (Abinda, 1999:185). Many important scholars worked at the Dar al-Ḥikmah, which also contained many books and scientific instruments from all scientific fields of study. It included also a specialized department for translation of all kinds of books from Greek, Indian, and Persian into Arabic. One of the most important books that was translated from Greek at the time of al-Rashīd was the *Almagest* of Ptolemy. This was considered by the Arabs to be one of the best books to have ever been written on astronomy and the main reference source for all their work on this subject (al-Bīrūnī, 1030. *al-Qānūn al-Mas'ūdī*).

From an astronomical point of view, this golden period in the reign of the Abbasid Dynasty produced many scientists and astronomers who made huge contributions to this science. These scientists produced new mathematical as well as astronomical theories. They also developed and constructed new astronomical instruments and observatories. They also wrote and corrected the works of the ancient Greek and Indian astronomers and produce new astronomical handbooks and tables by adopting new techniques in spherical trigonometric sciences, which they developed specially for this purpose. It is no secret that they inherited of the legacy of the Greek astronomical science but they also developed the science of astronomy to a new level that surpassed all those who came before them (Lyons, 2009).

The next Caliph who was also a great supporter of science was al-Ma'mūn, the son of al-Rashīd. He started his rule in A.D. 812. He also surrounded himself with many men of science and knowledge, especially in the sciences of astronomy. It is also known that he himself was a great enthusiast for this science and an amateur astronomer who was directly involved in many of the astronomical observations and discussions in this field. However al-Ma'mūn's rule was also considered a troubled time in regards to theological and philosophical struggle, which took place between the various Islamic religious schools of belief. Even though al-Ma'mūn was a patron of science, literature, theology and philosophy he was also known for his strict Islamic theological and philosophical ideas. He belonged to a school of thought called *al-Mu'tazilah*, which adhered to scientific logic and rationalism above everything. However some of the *al-Mu'tazilah's* beliefs were in opposition to the principles upheld by many Muslim Sunni theologians (Nagel, 1999: 118). He was also a supporter of the Shiite sects, even though the Abbasid and the majority of their subjects were predominantly of Sunni beliefs.

The second part of the Abbasid period started when the Caliph al-Mutawakel came to power in A.D. 847. This was the start of an age of decline for this Empire which lasted for up to four more centuries. During this period the Abbasid caliphs were under the control of the Turks then after that under the influence of the Buwayhid rulers, then later they fell to the Seljuk dominance in the region. Most of the caliphs were puppets in the hands of some ruler or sultan in some part of the Abbasid Empire. At this time another threat started to emerge in the east. The Mongol armies under the leadership of Jangis-Khan started to move westwards. The Mongol victories and occupation were usually accompanied by great massacres and atrocities. The armies of the Mongols destroyed many cities, such as Samarkand and Bukhara and killed thousands of people on their way towards the capital Baghdad. After Jangis-Khan died Hulaku took over power and continued with the same savage approach. In A.D. 1256 Hulaku surrounded Baghdad and burned the city killing most of its inhabitants in one of the biggest massacres in history. With the destruction of Baghdad all the libraries, places of education and learning, along with the greatest collection of books and works of science and literature, were destroyed. By destroying this city and killing the last Abbasid caliph al-Musta'sem the Abbasid Dynasty was finally at an end. As a result of the massacres by the Mongols, chaos and famine followed which temporary halted the progress of science in the region. However a man by the name of Naṣīr al-Dīn al-Ṭūsī was able to revive the science of astronomy. He was a fierce opponent to the Abbasid rule and a close friend of the Mongol ruler Hulaku. Al-Ṭūsī managed to save some books and works of science from the ruins of the destroyed city of Baghdad and he later convinced Hulaku who was addicted to astrology to build an observatory in Maragha, which was to become the center of astronomical research in the 13th century (Hoskin, 1997: 58).

By the end of the 14th century another wave of Mongol and Tatar occupation swept the area. This time it was under the leadership of Timor-Lank who took the city of Samarkand as his capital. Timor's armies also committed their own massacres while occupying the mid-eastern regions. They destroyed several cities and killed its people. Therefore no major scientists or astronomers emerged during this period with the exception of Ulugh Bēg who was one of the descendants of Timor-Lank in Samarkand (Abinda, 1999: 232).

2.1.6 Astronomy in Andalusia.

In A.D. 711 the Arabs invaded Andalusia (the Iberian Peninsula: Spain and Portugal) and created one of the strongest Empires Europe had known since the destruction of Rome by the Barbarian hordes. Spain prospered under the rule of the Umayyad, who established a Dynasty there after they had lost the caliphate in the east to the Abbasids. Islamic culture in Spain began to flourish in earnest during the reign of 'Abd al-Raḥmān the second of Cordoba. 'Abd al-Raḥmān actively recruited scholars by offering handsome inducements to live in what many from the lands in the East considered the 'provinces'. As a result, many scholars, poets, philosophers, historians and musicians migrated to Andalusia and established the basis of the intellectual tradition and educational system which made Spain so outstanding for the next 400 years (Hitti, 1949: 639). The court of Cordoba, like that of Baghdad, was open to Muslims, Jews and Christians alike. One prominent Bishop complained that young Christian men were devoting themselves to the study of Arabic, rather than to Latin (Hunke, 1964: 529). This is a reflection of the fact that Arabic was the international language of science in that era, just as English is today. Another result was that an infrastructure of libraries, mosques, hospitals and research institutions rapidly grew up and famous scholars in the East, hearing of these amenities, flocked to the West. They in turn attracted students of their own. One of the first mathematicians and astronomers of Andalusia was the 10th century scientist Maslamah al-Majrīṭī. He wrote a number of works on mathematics and astronomy, studied and elaborated the Arabic translation of Ptolemy's *Almagest* and enlarged and corrected the astronomical tables of al-Khawarizmī (Abinda, 1999: 238). Another leading mathematician and astronomer who flourished in Cordoba in the 11th century was al-Zarqālī, known in the Latin West as Arzachel. He combined theoretical knowledge with technical skill, and excelled at the construction of precision instruments for astronomical use. Al-Zarqālī contributed to the assembling of the famous Toledan Tables, which were a highly-accurate compilation of astronomical data at that time (Evans, 1998, 279). Many of his works were translated into both Spanish and Latin. Still another scientist was al-Bitrujī who was called Alpetragius by Latin scholars of the Middle Ages. He tried to develop a new theory of planetary movement while attempting to modify Ptolemy's model. Unfortunately al-Bitrujī's attempts were not very successful, however his works were studied by western philosophers and translated into Latin in the 13th century (Hoskin, 1991: 60). The influence of these scholars and their astronomical works was immense. Today many stars still bear the names given to them by these Arabic and Islamic astronomers, and many Arabic words- such as zenith, nadir and azimuth- are all still in use in our scientific vocabulary today.

2.2 Characteristics of Arabic and Islamic Astronomy

Ever since astronomy emerged in the Arabic and Islamic world it was divided into several fields. The first was Arabic folk astronomy which was related to the mansions of the Moon and the first appearance of each mansion and each lunar month. This science which was called *‘Ilm al-Anwā’* was popular among many Arab and Islamic scholars, especially the *Fuqaha’* or the Islamic jurists and theologians. This Arabic folk astronomy will be discussed in more detail in the next section of this study. The second field of astronomy was the application of astronomy to aspects of religious practice as Islamic religious rituals brought into focus the importance of astronomy for Muslim communities. The third field of astronomy was mathematical astronomy which related to observation of the fixed stars and planets, mathematical calculations of planetary motions and use and construction of astronomical instruments. In his ‘Introduction’ in *The Book of the Fixed Stars* al-Ṣūfī divides astronomers into two types. The first “… took the road of the astronomers (*al-Munajjimīn*) utilizing picturesque celestial globes constructed by those who did not observe the stars with their own eyes. However they adopted the latitudes and longitudes which they found in books. They drew them on the globe without knowing which was false and which was true…the other party took the Arab method of the science of *al-Anwā’* and the Lunar mansions relying on what they found in books in this field. We have found in the science of *al-Anwā’* many books, the best and most complete in this art is the book by Abu Ḣanifa al-Dainaouri.”

The word *‘Ilm al-Nujūm* (science of the stars) was used by many Muslim scholars in the early Middle Ages to include both the science of astronomy and astrology. Astrology was referred to as *‘Ilm Aḥkām al-Nujūm* (science of the decree of the stars) and also as *‘Ilm al-Tanjīm* (science of divining by the stars). Astronomy was referred to as *‘Ilm al-Falak* (science of the spheres) but more commonly as *‘Ilm al-Hay’a* (science of the heavenly configurations). In the early classifications of the type of sciences the two disciplines were considered as branches of the same science (Shami, 1997: 45). It is only at a later date that astronomy became fully distinct from astrology. Astronomy was thereafter considered a mathematical science and astrology was shifted to the applied physical science (Saliba, 1994: 66). In the next few pages I will try to briefly examine the characteristics of these scientific fields in the development of Arabic and Islamic astronomy in the medieval era.

2.2.1 Religious Tradition in Arabic and Islamic Astronomy

The influence and contribution of Islam as a religion in the development of science in general and astronomy in particular has been a subject of fierce debate both by Muslim and non-Muslim writers alike. Some writers are of the opinion that religion put the brakes on the development of science (Huff, 1993: 235), whereas some believe that had it not been for religion, astronomy would not have progressed to what it is today (Chapman, 2002). However, there is no doubt that one of the reasons for the development of Arabic and Islamic science and astronomy is God’s commandment to explore the laws of nature. The idea was to admire all creations for their complexity and to cherish the Creator for his ingenuity. Holding to these beliefs, Islamic contributions to science have covered many roots of thought, including mathematics, astronomy, medicine and philosophy (Iqbal, 2002).

> Read! In the name of your Lord who created. Created the human from something which clings. Read! And your Lord is Most Bountiful. He who taught (the use of) the Pen, Taught the human that which he knew not. (Qur’an:chapter 96,verse1-5)

> Verily (Behold) in the creation of the heavens and the earth, and the alternation of night and day - there are indeed signs for men of understanding; Men who remember Allah, standing, sitting, and lying down on their sides, and contemplate the creation of the heavens and the Earth (with the thought) "Our Lord! Not for nothing have You created (all) this. Glory to You! Give us salvation from the suffering of the Fire." (Qur’an: chapter 3, verse 190-191)

The above two verses are from the Qur’an, the Holy Book of Islam. The first verse is the first revelation which was given to the Prophet Muḥammad in the Qur’an. The first command in this verse is “Read”. It is a command to read, write and learn all kinds of science and knowledge. The command in the next verse is to contemplate in the Heavens and the Earth. Of all the references in the Qur’an to scientific matters, the most numerous are to astronomy and cosmology, more specifically the creation and structure of the Universe, the Earth, the Sun and the Moon. A very interesting book was written on this subject by M. Bucaille (1987) titled *The Bible, The Qur'an, And Science* in which this area is described in detail. Bucaille identified more than forty verses in the Qur’an which provide information on astronomy and the concept of creation of the universe.

I do not intend here to present a theological study on Islamic religion for I can in no way give a detailed survey about such a complex structure and system of beliefs. However, in order to comprehend the importance of astronomical studies in the lives of Muslim scholars such as al-Ṣūfī we need a little background on Islamic theology. We have to understand the significance of the beliefs and rituals of this religion in order to understand the characteristics of Arabic and Islamic astronomy and the importance of astronomy to the Arabs and the Muslims. In no other religion has science especially the science of astronomy been a focal point of religious beliefs and practices. This is immediately reflected in almost all of the works of Arab and Islamic writers whereby they first dedicate their efforts to God and His Prophet at the beginning of their books. al-Ṣūfī also starts his book in this manner by saying the usual phrase of praise to God: "Thank *Allah* (God) the only one, the just. May the blessing and peace of *Allah* be on Muḥammad and his family."

The above verse and commands from the Qur'an cannot be ignored in the Islamic belief framework. Stemming from the first clause of the above system is the belief in the one God (Allah), and adherence to all God's wishes and commands. The first act of faith in Islam is the recognition, acceptance and observance of the obligatory religious rituals, which have been ordained by God. These are called the 'five pillars of Islam'. The first is *Islam*: It is the declaration of submission to the will of the creator and the recognition of the obligations towards Him. The second is *Ṣalāh*: These are the five obligatory daily prayer rituals. The third is *Ṣīam*: It is the fasting in the month of Ramadān. The fourth is *Zakāh*: It is an obligatory donation to the poor. And finally, the last is the *Haj:* which is the obligatory pilgrimage to the city of Makkah.

The five Islamic prayer times *Ṣalāh* are based on the astronomical position of the Sun in the sky. They were originally calculated (as was mentioned by the teachings of the Prophet Muḥammad) on the basis of the length of the shadow and the start and the end of the twilight during the day. Therefore the times of these prayers are not the same from one place to another, instead depending on the observer's latitude and longitude. The Muslims originally acquired the techniques to perform the mathematical calculations of finding the prayer times from the ancient Indian sciences. One of these early prayer timetables was written by al-Khawarizmī in Baghdad in the 9th century. In the 13th century the development of prayer timetables was institutionalized into an official organization called *al-Mūwaqqit* (Saliba, 1994: 79). These offices used to be part of the local mosques or religious schools and professional astronomers performed the observations and calculations of these prayer schedules using exact mathematical methods and instruments such as sundials, quadrants and astrolabes. From then on, Muslims excelled in the development of these astronomical timetables, especially in the major Islamic centers such as Baghdad, Damascus, Tunis, Cairo and later Istanbul. Very highly sophisticated tables were written based on special trigonometric functions that were developed specifically to solve the problems of spherical astronomy for any latitude (Kennedy, 1983).

In 638 A.D the second Caliph, ′Umar, first introduced the Islamic Calendar, which was purely based on lunar cycles. Omar consulted with his advisors on the starting date of the new Muslim chronology. It was finally agreed that the most appropriate reference point for the Islamic calendar was the *Hijrah*, which chronicles the migration of the Prophet Muḥammad from the city of Makkah to Madīnah in September A.D. 622. The Islamic calendar is purely a lunar calendar since intercalation was forbidden in the Qur’an; therefore the Muslim *Hijrī* year is shorter than the Gregorian year by about 11 days. The Islamic *Hijrī* calendar is usually abbreviated to A.H. (Anno Hegirae). The original Arabic names of the months in the Islamic (*Hijrī*) year were related to the seasons, however, by adopting a lunar calendar in which the months shift every year, important Muslim festivals, which always fall in the same *Hijrī* month, may occur in different seasons. For example, the *Haj* which is the yearly pilgrimage to the city of Makkah and *Ṣīam* or fasting in the month of Ramadān can take place in the summer as well as in the winter.

For religious reasons, the beginning of a *Hijrī* month is marked not by the start of a new Moon, but by the physical (i.e., an actual human) sighting of the crescent Moon at a given location. For example, the beginning of fasting in Ramadān is based on the local sighting of the new Moon. From an astronomical point of view, the calculation of the birth of the new Moon can be measured exactly. However, determining the visibility of the crescent is not as conclusive. Efforts to obtain an astronomical criterion for predicting the time of first lunar visibility go back to the Babylonian era, with significant improvements and work done later by Muslim and other scientists (King, 1993). These efforts have resulted in the development of a number of criteria for predicting first possible sighting of a lunar crescent. Early Muslim astronomers first implemented the visibility conditions, which they found in the ancient Indian astronomical sciences. They adopted the 48 minutes (12 equatorial degrees) condition of the setting time between the Sun and the Moon. If the difference in setting time was more than 48 minutes then the Moon could be visible. al-Khawarizmī used this method to compile astronomical tables. Later Muslim astronomers derived more complicated criteria for the crescent visibility (King, 2004).

The *Ka’bah* in the city of Makkah (in the country of Saudi Arabia today) is the most sacred sanctuary in Islam. Muslims are required to stand facing towards the *Ka’bah* during their *Ṣalāh* or prayer rituals five times a day. The *Ka'bah* in Islamic theology is considered the first shrine built for the worship of the one God, therefore it is considered a very holy place and the center of the world. This is evidenced in many works by Islamic geographers where they place the *Ka'bah* at the center of the inhabitable world (Nasr, 1976:37). Makkah is also the city where every Muslim is obliged to make pilgrimage at least once during their lifetime. The *Ka'bah*, also known by its other name the *Qiblah,* is a rectangular one-room building with the sides that are 22m (major axis) by 18 m (minor axis) in length. Its main axis is about 30 degrees counter-clockwise from the meridian. It is also believed that the walls of the *Ka'bah* are astronomically aligned with the major axis pointing towards the rising point of Canopus and the minor axis towards the summer sunrise and winter sunset (King, 1993). The direction of prayer for all Muslims, wherever they may be, has to be oriented towards the *Ka'bah*. Therefore mosques all over the world had to be built with their prayer walls facing the direction of the *Ka'bah*. Other important rituals in Islamic theology also involve the direction towards the sacred House. Therefore, finding the direction of the *Qiblah* is very important in performing many of the obligatory rituals ordained by Islam. Muslim geographers and astronomers starting from the 8th century took it upon themselves to find the best methods of *Qiblah* direction using the measurements of geographical coordinates and the mathematical science of geometry and trigonometry that they had inherited from the Greeks. In the ninth century many observations were conducted to find the coordinates of Makkah and Baghdad in order to find the most accurate *Qiblah* direction. Most of the famous astronomers and geographers at one time or another worked on and wrote treaties about this problem. One of these astronomers was the famous Muslim scientist al-Bīrūnī in the eleventh century and another was al-Khalīlī in the fourteenth century. al-Khalīlī wrote very accurate treatises giving *Qiblah* directions for each degree of latitude from 10 to 56 degrees and longitude from 1 to 60 degrees based upon exact formulae (Hoskin, 1997: 55).

2.2.2 Scientific Tradition in Arabic and Islamic Astronomy

When the Arabs came into contact with Greek science and philosophy there emerged a new breed of scholars in the Arab world called the *Falasifah* (Huff, 1993). The aim of these *Falasifah* (philosophers) was to live rationally in accordance with the laws that governed the Universe. Since they believed the God of the Greek philosophers to be identical with Allah, they studied the works of Greek philosophers such as Aristotle, Pythagoras and Plato. This Greek philosophy was referred to as the 'foreign sciences'. Arab and Islamic scientist became attracted to these foreign sciences as early as the 9th century. During the Abbasid rule an explosion of interest in the 'foreign science' had taken place as a result of the unprecedented translation movement. This phenomenon produced a large number of translations, especially of Greek scientific sources, which were mainly neglected in the Greek and Latin world (Iqbal, 2002). The translation of the *Almagest* and other works by Greek scientists laid the foundations of the scientific tradition of Arabic and Islamic astronomy. We should note here that the Greek scientific tradition considered philosophy to be an integral part of science. For example, to be a good astronomer you had to be a good philosopher (Saliba, 1994: 53). This concept was also reflected in the Arabic and Islamic scientific tradition.

The superiority of Aristotelian philosophy and the Ptolemaic system of astronomy were generally accepted by many Arabic and Islamic astronomers (Musa, 2001: 48). The geocentric model, whereby the Earth is a sphere which lies at the center of a spherical heaven which rotates about an axis that passes through the center of the Earth, was accepted as correct for over a thousand years by almost all Arabic and Islamic astronomers. The geometrical structure with the system of eight spheres was also regarded as representing the physical reality of the Universe. The culmination of Arabic and Islamic astronomy was in the development of the astronomical tradition of treatises called *Zīj* which were based on trigonometric and mathematical techniques. The term *Zīj* is probably originally Persian meaning a thread or cord (Kennedy, 1956:123), however it is commonly used to describe astronomical tables and handbooks. The earliest examples of these *Zīj (*Arabic plural is: *Azyāj)* were based on Persian and later on Indian sources. However, by the ninth and tenth centuries the *Zīj* followed the tradition of the *Almagest* and the Handy Tables of Ptolemy. Many aspects of mathematical astronomy as well as astrology were included in the texts and tables of these *Zījes*. A typical *Zīj* usually included:

-Information on chronology, including methods of converting dates from one calendar to another.

-Trigonometric functions, most commonly the sine function which replaced the Ptolemaic chord function.

-Information on spherical astronomy, which included solutions to problems of spherical astronomy such as transformation coordinates and time measurements.

-The equation of time, i.e. the difference between mean and apparent solar time.

-Planetary theory, which includes mean motion, planetary equations, latitudes, stations and retrograde motion.

-Parallax tables for determination the apparent position of the Moon.

-Tables of solar and lunar eclipse calculations.

-Lunar and planetary visibility, for predicting the date of first visibility of the lunar crescent and apparitions and disappearances of planets and stars.

-Mathematical geography, including lists of latitudes and longitudes of different known cities around the world.

-Tables of the fixed stars, including coordinates and magnitude estimates.

-Mathematical astrological tables.

Almost all astronomers produced a *Zīj* of some kind. The earliest of such treatises was *al- Zīj al-Mumtaḥen* which was produced in Baghdad under the patronage of al-Ma'mūn (Musa, 2001). Other important *Zījes* are *al-Zīj al-Sabi'* of al-Battānī, *al-Zīj al-Ḥakimī* of Ibn-Yunus, *al-Zīj al-Mas'ūdī* of al-Bīrūnī, *al-Zīj al-Ilkhanī* of al-Ṭūsī and *al-Zīj al-Ṣultanī* of Ulugh Bēg. In 1956 Kennedy published a list of 125 Arabic *Zījes;* however we now know of more than 200 *Zījes*, most of which are unfortunately not extant today.

Most of the entries in the astronomical tables or *Zījes* were expressed in standard medieval Arabic alphanumerical notation (Table 1). This continued to be the standard format for most astronomical tables, which were to be written for many centuries to follow. The table below shows these letters and their corresponding numeric values.

Table 1: Arabic Alphanumerical Notation and their Corresponding Numeric Values.

1 ا	10 ي	100 ق
2 ب	20 ك	200 ر
3 ج	30 ل	300 ش
4 د	40 م	400 ت
5 ه	50 ن	500 ث
6 و	60 س	600 خ
7 ز	70 ع	700 ذ
8 ح	80 ف	800 ض
9 ط	90 ص	900 ظ
		1000 غ

Arabic and Islamic astronomers referred to all the celestial bodies they saw in the sky by the term *Kawākib*. This term in our modern technical vocabulary is translated as 'Planets'. However Arabic and Islamic astronomers referred to the planets as *al-Kawākib al-Sayārah* i.e. wandering stars and to the stars as *al-Kawākib al-Thābitah* or the fixed stars. Both the term *Nujūm* (stars) and *Kawākib* were used to designate stars. al-Ṣūfī also uses the term *Kawākib* for constellations and he even named the 48 star constellations *as al-Kawākib al-Thamāniyah wa-al-Ārba'een.* As for the number of these fixed stars, Arab and Islamic astronomers identified about 1025 different stars. However, in this regards al-Ṣūfī says:

"Many people believe that all the stars in the sky which are called fixed amount to 1025 stars. But this is an obvious mistake for those earlier scientist have observed this number of stars and they divided them into 6 divisions of brightness, and they made the brightest as the first magnitude and the one less as the second magnitude then the one below that as the third magnitude until they reached the sixth magnitude. They found the number of stars below the 6th magnitude to be more than they could count so they left them. This fact can be confirmed when we look at any of the constellations and its well-known stars; we find around those stars many stars which are not counted as part of the constellation".

Therefore Arabic and Islamic astronomers were obviously well aware of the vast numbers of stars in the heavens but they kept cataloging only those stars as per the tradition of the *Almagest*. They also kept using the 6-magnitude system which was developed by Hipparchus. In his catalogue al-Ṣūfī lists 1025 stars which can be see by naked eye; 360 of these are in northern constellations, 346 are in the zodiac constellations, 316 are in the southern constellations and 3 additional stars of the Arabic asterism *al-Thafīra*. As for al-Bīrūnī, he lists 1029 stars which were between the 1st and the 6th magnitudes (Bīrūnī, 1030).

Arabic and Islamic astronomers built many astronomical observatories and constructed many astronomical instruments, such as sundials, astrolabes, quadrants, celestial globes and armillary spheres, which were used to conduct important observations at that time. One of the first observatories was al-Shamāsīyah Observatory which was built around A.D. 829 by the Caliph al-Ma'mūn east of Baghdad. It was attended by many astronomers including the sons of Mūsā Ibn Shākir, Sanad Ibn 'Alī, al-'Abbas al-Jawharī, Yehyā Ibn Abū Manṣūr as well as the famous astronomer al-Faragānī (Musa, 2001: 236). Al-Ma'mūn also built another observatory overlooking the city of Damascus whose main purpose was to observe the Sun and the Moon (Sayili, 1960). Al-Battānī was one of the greatest observational astronomers in the early period of Arabic and Islamic astronomical history. His observational program lasted for more than 30 years in the city of Raqqa in the north of Syria. It is believed that he spent his own money building and using instruments in his private observatory (Sayili, 1960: 98). Al-Ṣūfī also built his own observatory in the city of Shiraz. The details of al-Ṣūfī's observatory and observation program will be discussed in another section of this study. Jabal al-Muqattam observatory was another important observatory built on a small mountain east of the city of Cairo. The astronomer 'Alī Ibn Yunus supervised the construction and made his own observations at this observatory (Sayili, 1960). However the most important of the Arab and Islamic observatories was no doubt the observatory of Maragha. It was built during the rule of Hulagu in the period A.D. 1259-1266. Maragha Observatory was built on a large hill on the outskirts of the city of Maragha in the Iranian province of Azerbaijan. The observatory was officially funded by the state. Therefore it continued to function for a relatively long time after the death of its official backer Hulaku. This was the first example of such an act, where state backing continued even after the death of the prince or ruler. Naṣīr al-Dīn al-Ṭūsī supervised the construction of the observatory and was the first curator and astronomer at this observatory. Many other important astronomers also worked at this observatory, including Mu'ayyad al-Dīn al-'Urḍī and al-Fakher al-Maraghī. Al-Ṭūsī also added a library which contained thousands of books and references mainly on astronomy and other related sciences (Sayili, 1960: 194). Another important observatory was built by the prince-astronomer Ulugh Bēg in the city of Samarkand in A.D. 1420. It was considered the most famous of the observatories in the Islamic period after Maragha Observatory. This observatory was also known to have had very large and accurate astronomical instruments which Ulugh Bēg used to make very accurate observations of the positions of the stars (Knobel et al., 1917).

There are no references to organized or dedicated observatories in Morocco or in Andalusia like those in the East. However we know of several private efforts and observation programs that were performed in these areas. It is well known that starting from the 10th century the astronomer al-Majrīṭī was conducting his own astronomical observations (Shami, 1997: 198). al-Zarqālī was another of those astronomers; in the 11th century he published his famous *Ṭulaiṭula Zīj* which was translated into the Toledan tables and was widely used in the Latin west in the Middle Ages (Chabas et al., 2003). There is also a dubious reference to the fact that the Minarets of the Mosques of Seville and Cordova were used as observation decks; but history scholars are still debating the truth of the source of this reference (Evans, 1998).

2.2.4 Astrology in Arabic and Islamic Astronomy

Astrology as defined by the ninth century astrologer; Abū Ma'shar "…is the knowledge of the effect of the powers of the stars at a given time as well as the future time." Abū Ma'shar was supposed to have studied astrology until he became an atheist (Saliba, 1994: 68). The early history of astrology in Islam was closely connected with divination and there is no denying that some Arabs had much interest in astrology before and after the time of the prophet Muḥammad (Shami, 1994). The prophet said: "…whoever studies anything of the stars (*nujūm*) would have studied magic…", and he also said: "…that whoever consults an astrologer or seer asking to know the future then he is fighting God." The position of Islam is very clear in this regard but this did not deter some Muslim scientists and even rulers from practicing astrology in all the periods of Islamic rule. However, tension developed between

Islam as a religion and the foreign sciences, in as much as those sciences had any bearing on religious metaphysical questions. The most obvious grounds for conflicts between religion and these foreign sciences were in the field of astrology, for astrology as a discipline violates directly religious dogma in many matters such as the eternity of the world, the problem of free will and predestination (Nagel, 1999).

The negative Muslim attitude toward astrology took on a new form in the ninth century, by which time the translations of books were almost completed. Astrology was now seen as part of the a coherent but foreign body of Greek philosophy, primarily that part which dealt with the problems as the eternity of the world and free will. Early Islamic philosophers and scientists were strong supporters of this Greek tradition; for example al-Kindī was both a philosopher and an astrologer and was considered the spokesman for the foreign sciences (Saliba, 1994: 55). However, by the tenth and eleventh centuries the majority of philosophers and theologians had taken a clear negative stand against astrology. Several treatises by al-Farābī, Ibn Sīnā, al-Ghazālī, Ibn Rushd and many others were written which clearly rejected astrology (Shami, 1997: 305).

During the ninth and tenth centuries the religious attacks on astrology began to endanger the astronomers, whose profession had previously been conceived to be the same as that of the astrologer. For the sake of survival the astronomers of the eleventh and twelfth centuries began a process of redefinition of their field that entailed a rejection of the astrologer's craft and a greater emphasis on religious matters. Therefore the theologian's main argument centers on the idea that because of this confrontation, scientist and astronomers have been forced to become increasingly critical of foreign philosophical and astrological claims. As a result the office of the *Mūwaqqit* (timekeeper) was introduced into the bureaucracy of the mosque, the main center of the Islamic community, during the thirteenth century (Hoskin, 1997: 55). Most of the astronomical texts thereafter were written by such *Mūwaqqits*.

In this new environment Islamic astronomy was finally freed from political patronage, the *Mūwaqqits* could then in principle direct their attention to any astronomical problem and they no longer had to produce astrological texts and were able to be more responsive to the religious need of society. The astronomers, freed from the earlier respect for Greek science, with their discipline now accepted by society under the rubric of *Mīqāt*, found that they were able to formulate their astronomy on new philosophical principles. In that, they were probably under the influence of the Islamic philosophical tradition in which truth was supposed to be within a system that is consistent, harmonious and well articulated, with religion having an essential position in that system. The old Greek dictum of ‘saving the phenomena’ was not considered to be sufficient, for at times the phenomena were saved at too high a cost by contradicting the physical world and its mathematical representation. A few problems were identified in the major texts of Greek astronomy, such as the *Almagest* mainly the problem of the equant, which can make sense only as a mathematical point and not as a physical one. Therefore several Muslim astronomers tried to construct new planetary models. One of the earliest criticisms of the Ptolemaic system came from Ibn al-Haytham in the eleventh century and culminated in the work of Ibn al-Shātir who worked as a *Mūwaqqit* at the Umayyad mosque in Damascus and whose work showed many points of similarity between that of Copernicus who lived 150 years later (Kennedy et al., 1976).

2.2.3 The Decline of Arabic and Islamic Astronomy.

The decline of Muslim scientific and astronomical activity after a brilliant and successful start has attracted the attention of a number of Muslim writers and historians since the 17th century. One of the most preferred explanations for the decline was political causes such as the Crusades in the twelve-century and the destruction of libraries and men of knowledge by the Mogul invasion in the thirteen-century. Another explanation attributes the decline to economic factors such as the decline of the importance of the Silk Road, and the accompanying shift of economic power away from Islamic countries towards Europe as a result of the geographic discoveries that took place in the 15th and 16th centuries.

Huff (1993), a leading figure in the field of comparative historical study of science, states that Muslims had made a brilliant start in the Middle Ages, and quickly gained and established a clear superiority over China, India and Europe in almost all fields of science, but that their activity started to decline after the 12th century. He includes al-Kindī, al-Farābī, al-Rāzī (Alrazes), Ibn Sīnā (Avicenna), al-Bīrūnī, and Ibn Rushd among the Muslim philosophers who contributed to the development of early modern science. He states that the philosophers could not maintain influence in their societies after some of their ideas became the targets of the theologians’ attacks, causing the former to lose the general support of the Muslim population. In this period, the theologians used the opinions of al-Ghazālī and Ibn Taymīya to attack philosophers. According to Huff, the Muslim philosophers did not have clearly defined and valid social roles in society. Those who studied philosophy and science mostly had additional duties to perform. For example, Ibn-Rushd was also a jurist, and Ibn al-Shātir was a *Mūwaqqit* preparing prayer timetables for the daily prayers of Muslims. Huff also notes the negative role of the doctrines developed by the theologians, which rendered systematic studies of nature a meaningless activity. Lastly, he states that in the Medieval

Muslim world, the legal and social institutions were not developed to support the activities of Muslim scientists.

Some of the general reasoning in the above studies of Huff might be justified. In his studies the main blame was directed towards the theologians-philosophers debate- mainly the attack of al-Ghazālī on the philosophers in the 12^{th} century. However, other recent studies conducted by Kennedy (1976) and Saliba (1994) regarding the problem of the decline of Islamic science – including Islamic astronomy – do not attribute the decline to the attacks of the theologians on the philosophers. Although these attacks incontestably took place, the decline could not be blamed on those theologians such as al-Ash'arī and al-Ghazālī. These recent studies in Islamic theoretical astronomy have shown that the most original astronomical works began to emerge almost a full century after the death of al-Ghazālī and culminated in the fourteenth century in the works of the Damascene *Mūwaqqit*, Ibn al-Shātir. The religious leaders' attacks were mainly leveled at the astrologers and not at the astronomers, and especially those astronomers who wanted to be astrologers, the implication being that atheism was a natural end of such studies. Their rejection centered on the astrologer's main claim, namely the ability to foretell the future in a world predetermined by the stars.

Therefore the decline of Islamic astronomical science could not be attributed to the theologians' attacks on the astronomers and philosophers because astronomical research continued to flourish long after the majority of these attacks were made. It is also arguable that were it not for those attacks, Islamic scientists would not have been freed from the confines of Greek philosophy. And by taking this argument further one must wonder how much the European scientific revival owes its origin to this theologian-philosopher debate in as much as it opened up new horizons and avenues for exploration. Some historians have claimed that scientific thought in Europe only developed from the ancient Greeks, in an attempt to blur the effects of Islam on the Renaissance, the Reformation and the subsequent scientific endeavor. This opinion has long lost its historical credibility, but there are still some who would like to defend it. A simple question should be sufficient to bring this claim into perspective: Why had the Europeans been unable to start the Renaissance and develop their scientific thinking much earlier, as they had access to the works of the ancient Greek philosophers and scientist in their hands for over a thousand years? Why did Europe wait another 1200 years for the Muslim development of scientific thought and philosophy? Ancient Greek thought by itself does not provide the concepts and motivation to initiate such a scientific enterprise. A much stronger motivational effort was required to start this endeavor. This was the motivation of belief initiated by Islam and the Qur’an in the minds of Arabs, Muslims and non-Muslims in the Middle Ages.

2.3 Old Arabic Astronomical Traditions

Before Islam the Arabs in the Northern Arabian Peninsula were generally nomadic people who wondered in the desert mostly during the night escaping from the high temperature. They had very few urban settlements because of the environmental challenges which were forced on them. These Arabs had a very basic knowledge of astronomy. They recognized and named some of the constellations or asterisms in the sky. This knowledge was believed by most scholars to be essential in helping them find their way in the desert. They also recognized the movements of the Sun, the Moon and the planets and they used them to develop their calendar which was a simple system based on a 12-month lunar visibility. They did not have any organized studies of the movement of the planets and position of the stars, and they did not use any astronomical instruments or mathematical tools. However, surprisingly early on they managed to recognize the difference between the length of the solar and lunar year and they developed a simple intercalation method whereby every couple of years they would readjust their calendar to compensate for this difference. Intercalation usually depended on the whims of the prevailing political ruler or social condition at the time. However, the Arabs who populated the southern peninsula (Yemen today) were relatively civilized compared to there northern cousins. These southern Arabs were well known for building important cities, castles and water dams (e.g. *Mā'reb* dam which collapsed around B.C. 120). They were also known for their craftsmanship, art and science. These people had a well-established social and political system that was well developed in the region. However, the bulk of the astronomical and astrological knowledge that we have comes from the northern Arabs who have been described as '*Arab al-Jāhilīyah'*, meaning the misguided and/or illiterate Arabs. This terminology was first used in the Qur'an and by the Prophet Muḥammad to describe the misguided ways of those people. This was the overall picture described by almost all historians when they came to depict the astronomical knowledge of the Arabs in the fourth century before Islam (Musa, 2001).

This is an oversimplification of the Arabic astronomical knowledge base especially when it comes to the Moon. Lunar astronomical science was an important tool used by the ancient Arabs just as it was used by many other ancient civilizations in the Middle East region (Boukahi, 2007). This astronomical information was merged with a form of astrological-meteorological experience that came to be known as the *Anwā'*. The *Anwā'* was used as a meteorological system for predicting the weather and identifying the beginning of the seasons in order to specify the dates of festivals, holidays, pilgrimage and the best times for traveling and commerce. With the coming of Islam the study of the lunar cycle became important, with references in the Qur'an such as: "He it is who made the Sun a source of light and the Moon shedding luster, and ordained for it stages (*Manāzil*), that you might learn the method of calculating the years and determining time.” (Qur’an: chapter 10, verse 6). Another verse describes the Moon and the mansions by saying: “We have appointed stages (*Manāzil*) for the Moon, till it wanes into the shape of an old dry branch of a palm tree.” (Qur’an: chapter 36, verse 39). Arabic and Islamic scholars took these references as meaning the lunar stations, and the *Anwā’* was expanded further within the ancient Arabic astronomical tradition.

The bulk of the astronomical and astrological knowledge about the lunar mansions and the *Anwā’* comes from the poetic and literary corpus that is found in Arabic literary and historical references. An example is provided by one of the old poets who said: “When the full Moon occults the Pleiades - the cold arrives at the beginning of winter”. Another example is: “When the full Moon occults the Pleiades the Sun is in Scorpio”. This astronomical phenomenon can only happen in November, when the winter cold begins (al-Bīrūnī). Another literary form was called the *Saja‘*. These were sayings or proverbs- some of which were in the *Anwā’* astronomical tradition. For example one old Arabic *Saja‘* says: “When *al-Buṭain* rises, debts are paid, finery appears, and the perfumer and the smith are pursued”. This saying describes the rising of the lunar mansion *al-Buṭain* in the month of May. This is when pasture dries up and the Arabs group together in encampments. Families and friends meet together again, they dress up, put on perfume and they fulfill old obligations (Ibn Qutayba).

2.3.1 Lunar Mansions and *Anwā’* in Arabic Astronomical Tradition

Many ancient civilizations, including the Indians, the Chinese and the Mayans, were well aware of the motion of the Moon in the heavens. Nearly every ancient culture worshiped the Moon at one time. Even today people still celebrate the Moon by holding feasts, dances, and rituals during some specific lunar phases (Verdet, 1987:67). Similarly, for the Arabs the Moon was one of the early clocks, and also one of several natural cues used by them to predict events such as winter, seasonal rains and the harvest (Varisco, 1997:24). They even worshiped the Moon as well as other astronomical bodies such as the Sun, Venus, Sirius, Saturn and Jupiter at one time (Nami, 1986:133). They also constructed idols that they worshiped in the name of these astronomical bodies such as: *Wad*, *al-Iat* and *al-‘Izzah*. It was said that the God idol *Hubal*, which was the main idol worshiped prior to the emergence of Islam, was a Moon God (Abinda, 1999:146).

The Moon is the Earth’s nearest neighbor in space. It completes one orbit against the stars (the sidereal month) every 27days, 7hours, 43 minutes. The Moon’s orbit does not coincide exactly with the apparent orbit of the Sun in the sky. They are tilted at an angle of approximately 5 degrees to one another. The Moon shifts position from one star to the next towards the east every night until it catches up to the first star from the east after approximately 28 days (Lunar month). Therefore when we divide the circular orbit, which is 360 degrees by 28 days, we find that the Moon shifts position towards the east by approximately 13 degrees every night. In order to systemize this lunar motion, the Arabs divided the apparent path of the Moon in the sky into 28 divisions. These 28 divisions are called '*Manāzil al-Qamar'* (Lunar Mansions). Another name for these lunar stations was '*Nujūm al-Ākhed'* which is translated as 'the stars that take', i.e. the Moon takes these positions every 24 hours. The Arabs developed this special lunar zodiac and divided the motion of the Moon during the lunar month into the 28 lunar stations that lay at an equidistance position so that on average the Moon spends one night in every position. They chose 28 asterisms (star groupings) for these positions not far from the ecliptic to be the landmarks for the location of the Moon in any day of the lunar month. Some of these stations do not exactly lie on the ecliptic because the orbit of the Moon does not correspond exactly to the path of the ecliptic. These mansions or stations are not all equal in size because the Arabs chose the most prominent stars or asterisms that can be clearly identified by the naked eye. In any one night we can see only 14 lunar stations out of the total 28 and the other 14 can not be seen. Therefore, every time one station disappears in the west another appears in the east. This newly-appearing station was called '*al-Raqīb'* translated to 'waiting'. Therefore, this *Raqīb* station can be considered as the 15th lunar stations in the station's order. This is similar to the 12 solar zodiac signs that we know today. Every time one signs disappears in the west another appears in the east. Therefore every one of these constellations would equal two and a third lunar stations. While the Moon shifts from one lunar station to another in one night the Sun on the other hand takes 13 days to move from one station to another. Therefore the Sun spends 13 days in any one station (or fairly close to it). The Sun completes its apparent motion moving between these 28 stations in one year. After one year the Sun returns back to the same position that it started from. Therefore these lunar mansions were also used as a solar calendar for all the seasons. This calendar system was used to predict the weather, fix the dates of important social and religious events and it gradually developed to become an integral part in the lives of the Arabs throughout the year.

The term *Anwā'* (singular *Naw'*, verb *Nā'*) according to most Arabic and Islamic scholars is the term used to describe the twenty-eight astronomical lunar mansions or stations. According to the definition of Dr Varisco (1997) "…the *Anwā'* were described as asterisms or star groupings along the Zodiacal belt, the annual risings and settings of which were used to mark times for rain, wind, heat and cold. Some Arabs went so far as to attribute these *Anwā'* with the power over rain." The exact meaning of the word *Anwā'* is still debated by linguistics. Some considered that the verb *Nā'* means to rise up with difficulty, implying that the star rises up in the morning with difficulty where it can barely be seen near the eastern horizon. The ancient Arabs believed that this term means to go down or to sway down and that it should only refer to the setting of a star and not to its rising. Therefore the verb *Nā'* is considered a homonym (Varisco, 1997). However, most Arab astrologers attributed the *Naw'*, to the rising mansion because they believed that the power or force of the mansion was when it was still young and rising while the setting mansion was a week mansion with no power (Abinda, 1999). This confusion or difference in explanation of rising and setting has been found in the classical poems and verses of the Arabs. However there was a clear consensus by most Arabic and Islamic scholars later in the 9th and 10th centuries, that *Nā'* referred to both the celestial setting of a star (or asterism) on the western horizon and at the same time the rising of the corresponding *Raqīb* star in the east (al-Bīrūnī). Al-Ṣūfī also confirms this meaning that *al-Anwā'* or *Naw'* "…is when a star sets in the west at dawn and when it's *Raqīb* (corresponding star) rises in the east from under the light (of the Sun)." Therefore, the *Naw'* is the first time of the year when a particular station rises from the east in the morning and when the Sun is to be found in that station and blocks it in the morning. At this same time another station sets in the western horizon. Therefore the *Naw'* is the term used to describe a specific time of year that corresponds to the first rising or setting of a particular station only once a year. For example the lunar mansion of *al-Thurayyā* (the Pleiades) rises in the east in the morning of 13 May and sets in the evening in the eastern horizon on 13 November (Abinda, 1999). The other known confusion in the *Anwā'* system was the duration of the rising or setting of the lunar mansions. Some made it to be 13 days which is the time of rising or setting of one star mansion to next while others only attributed it to the start of the first rising of the mansions. Others assigned different durations for every mansion (al-Thaqefī). When this period is over this mansion ceases to affect the weather. Therefore the duration or the power of the mansion sometimes differs from 13 days to a few days or sometimes only one day.

2.3.2 The Lunar Mansions in Arabic Tradition

The table 2 below summarizes the lunar mansions according to Arabic tradition. The names of the lunar mansions are based on al-Ṣūfī's description in his book. I have included the corresponding modern assigned names, HR number, the time of rising and setting, the weather condition and duration that were attributed for these mansions according to the *Anwā'* tradition.

Table 2: Summary of the Lunar Mansions According to Arabic Tradition.

Number	Name of	Present day	Rising	Setting	Assigned	Weather

	Lunar Mansion	designation (HR number)	date	date	Duration	condition
1	*al-Sharaṭān*	β γ Aries 553, 546	16 April	19 Oct	3	Spring equinox
2	*al-Buṭain*	ε δ π Aries 887, 951, 836	29 April	31 Oct	3	Little rain
3	*al-Thurayyā*	Pleiades 1145,1156,1178,1188, 1149,1165,1142	13 May	11 Nov	5-7	Rain
4	*al-dabarān*	α Taurus 1457	26 May	24 Nov	1-3	Heat, wind
5	*al-Haq'a*	λ φ1 φ2 Orion 1879, 1876, 1907	9 Jun	7 Dec	6	Heat, no rain
6	*al-Han'a*	γ ξ Gemini 2421, 2484	22 Jun	20 Dec	3	Heat
7	*al-dhirā'*	α β Geminorum 2891, 2990	4 Jul	2 Jan	3-5	Rain expectation
8	*al-Nathra*	ε γ δ Cancer 3429, 3449, 3461	17 Jul	15 Jan	7	Rain
9	*al-Ṭarf*	χ Cancer λ Leo 3262, 3773	1 Aug	28 Jan	6	Rain
10	*al-Jabha*	ζ γ η α Leo 4031, 4057, 3975, 3982	14 Aug	10 Feb	3	Rain
11	*al-Zubra*	δ θ Leo 4357, 4359	28 Aug	23 Feb	4	Rain
12	*al-Ṣarfa*	β Leo 4534	9 Sep	7 Mar	3	Temperate
13	*al-'Awwā'*	β η γ δ ε Virgo 4540, 4689, 4825, 4910, 4932	22 Sep	20 Mar	3	Good weather
14	*al-Simāk*	α Virgo 5056	5 Oct	3 Apr	4	Water gets cold
15	*al-Ghafr*	ι χ λ Virgo 5338, 5315, 5359	18 Oct	17 Apr	1-3	Cold, dry
16	*al-Zubānā*	α β Libra 5531, 5685	31 Oct	30 Apr	3	Rain
17	*al-Iklīl*	β δ π Scorpio 5984, 5953, 5944	13 Nov	13 May	4	Heavy rain
18	*al-Qalb*	α Scorpio 6134	30 Nov	26 May	3	Winter, cold
19	*al-Shawla*	λ ν Scorpio 6527, 6027	9 Dec	9 Jun	1-3	Winter, cold
20	*al-Na'āim*	σ φ τ ζ γ δ ε η Sagittarius 7121, 7039, 7234, 7194, 6746, 6859, 6879, 6832	22 Dec	23 Jun	6	Water freezes
21	*al-Balda*	Relatively empty star field surrounded by 6 stars in Sagittarius in the shape of a small	4 Jan	6 Jul	1-3	Water freezes

		arc 7341, 7304, 7264, 7217, 7150, 7145				
22	*Sa'd al-dhābiḥ*	α β Capricorn 7754, 7776	17 Jan	19 Jul	1	End of winter
23	*Sa'd al-Bula'*	μ ε Aquarius 7990, 7950	30 Jan	1 Aug	1	Temperate
24	*Sa'd al-Su'ūd*	46 Capricorn β ξ Aquarius 8311, 8232, 8264	12 Feb	14 Aug	3	Grain comes out
25	*Sa'd al-Akhbiya*	γ π ζ η Aquarius 8518, 8539, 8559, 8597	25 Feb	27 Aug	3	Good weather
26	*al-Fargh al-Muqaddam (al-Fargh al-Awwal)*	α β Pegasus 8781, 8775	9 Mar	10 Sep	3	Spring
27	*al-Fargh al-Mu'akhkhar (al-Fargh al-Thānī)*	ε φ Pegasus 8308, 9036	22 Mar	23 Sep	4	Spring
28	*Baṭn al-Ḥūt*	β Andromeda 337	4 Apr	6 Oct	3	Spring

2.3.3 The Literary Sources on Old Arabic Tradition

Arab and Islamic scholars wrote many books on the subject of the *Anwā'* and the lunar mansions. They collected most of the old sayings and poems which allude to this Arabic tradition and the knowledge of the stars and the *Anwā'*. Unfortunately many of these books have been lost, and few of the remaining extant works have been published. The rest are kept in libraries all over the world. However, the names and authors of many of these books have been mentioned in bibliographical and historical references such as the *al-Fahras* by al-Nadīm, *al-Āthār al-Bāqiyah* by al-Bīrūnī and *Wafīyāt al-A'yān* by Ibn Khalkān not to mention by our author al-Ṣūfī himself. The most important authors and their books on the *Anwā'* tradition were:

-Abū Yehyā Ibn Kunāsa (died A.D. 823). His book on *Anwā'* was mentioned by al-Ṣūfī as well as by al-Bīrūnī.

-Ibn al-Ā'rābī (died A.D. 845). His book on *Anwā'* was mentioned by al-Ṣūfī as well as by Ibn Khalkān.

-Ibn Qutayba al-Daīnawari (died A.D. 890). His book on *Anwā'* was mentioned by al-Nadīm as well as by Ibn-Khalkān. This is one of the most important books on this subject and which is still extant today.

-Abū Ḥanīfa al-Daīnawari (died A.D. 895). His book on *Anwā'* was mentioned by al-Ṣūfī, al-Nadīm as well as by al-Bīrūnī. This is another of the important books on the *Anwā'* as mentioned by al-Ṣūfī and it is also extant today.

-al-Zajjāj (died A.D. 928). His book on *Anwā'* was mentioned by al-Nadīm as well as by Ibn-Khalkān.

-Ibn Durāyd (died A.D. 933). His book on *Anwā'* was mentioned by al-Nadīm as well as by Ibn-Khalkān.

2.3.4 The Origin of the Arabic Lunar Mansion System

The origin of the Arabic lunar mansions system is still a debatable topic among scholars of ancient astronomy. Similar 28 lunar stations have been found in Indian, Chinese and other historical records since 3000 B.C. These lunar mansions have not been found as part of Babylonian or other Middle Eastern astronomy up to now, but this does not mean that such a system was not at one time a part of these astronomical sciences. The Babylonians might have used a similar lunar zodiac system which we still have not been able to locate up to now in our excavations of Babylonian archeological artifacts. Many historians believe that we still do not know very much about the origins of the ancient sciences in the Middle Eastern civilizations. Another questionable presumption is that the origin of the Arabic lunar mansions lies in the Indian zodiacal system (eg. See Varisco, 1997:7). However this view is not accepted by many contemporary astronomical historians, nor by some medieval Arab scholars such as al-Bīrūnī. A simple question which comes to mind is how the Arabs adopted such a zodiacal system from the Indians when they could have adopted the Babylonian or the Assyrians numerical and calendar systems which were much more accessible to them.

Another very common misconception in history is that many historians believe that the term 'Arabs' is used to describe the Arabian tribes who populated the Arabian Peninsula in the 7th century (Hitti, 1943:10). This over-simplification of the origins of the Arabs and the Arabic language echoes many deeply-rooted convictions in ancient historical studies. Historians and scholars of ancient civilizations have divided the people who have lived in the area into several ancient civilizations, mainly the Sumerians, Acadians, Babylonians, Assyrians, Hebrews, Caledonians, Canaanites, Egyptians and finally the Arabs. Many of these scholars wrongly believed that these civilizations should be considered separate cultures, because they have separate languages and are dissimilar in their social, cultural and religious beliefs (Hitti, 1949:36). Other historians go as far as to state that the inhabitants north of the Arabian Peninsula became Arabs following the Islamic conquests (Qubaisi, 1999:90) The main reason for this misconception is that some historians wrongly consider that the origin of the Arabic language goes back to the 'Adnannite' *('Andān*) and 'Qahtannite' (*Qahṭān*) tribes who spoke the Arabic language according to the dialect of the tribe of '*Quraīsh'*. This Arabic dialect was the one used in the Qur'an which was revealed to the prophet Muḥammad in A.D. 610, who himself was a member of the Quraīsh tribe. This classical Arabic dialect is now commonly referred to as *al-'Arabīya al-Fuṣḥá*. The Adnannite tribes were settlers in the northern areas of the Arabian Peninsula while the Qahtannite were in the southern parts (Yemen today). However, it is a known fact that other important Arabic tribes before the spread of Islam were also found in other areas such as '*al-Manāthira'* in Iraq and '*al-Ghassāsina'* in Syria. Therefore the origin of the Arabic tribes cannot be confined only to these tribes because the locality of the ancient Arabic language extended to a far greater geographical area in the Middle East and as far as Northern Africa. The dominance of the Arabic language in the *al-'Arabīya al-Fuṣḥá* dialect was no doubt due to the importance of the Qur'an, the spread of Islam and the dominance of the Arabian tribes who ruled the Islamic Empire after the death of the prophet Muḥammad.

Contemporary studies in Arabic linguistic and lexicographical analysis have shown that the similarities between the classical Arabic dialect of *al-'Arabīya al-Fuṣḥá* and the northern dialects of the ancient culture such as the Assyrians and the Babylonians (67% similar) far exceed the similarities between the classical and the ancient southern Arabic dialects of the Yemen region (only 49% similar) (Qubaisi, 1999:92). This implies that the cultural interaction between the Adnannite tribes and the northern ancient civilizations was more common then it was between the Adnannite and the southern Arabic tribes of the Arabian Peninsula. These studies reveal that the difference between these civilizations is mainly in the different dialects which they spoke, while the origin of all these languages is an old form of ancient 'Semitic' or 'Arabic' dialect, which is unknown today. These studies also show that the difference in the dialects between these civilizations and the variations in the method of writing does not mean that their origin is dissimilar. For example we know that Arabic was written by different methods such as Cuneiform and Indian letters even though the basic language was the same. This proposal goes against the convictions of historians of ancient civilizations like Leo Oppenheim (1964) who wrote: "…one should mention in this enumeration of Semites in Mesopotamia that contact with the Arabs of the desert, prior to their irruption into Mesopotamia and the adjacent regions in the seventh century A.D. was in the main, only slightly and incidental. "

Such studies based on Arabic linguistics have a profound impact on the study of the history of astronomy of ancient civilizations leading up to the beginning of early Arabic and Islamic astronomy. The cultural interaction between the ancient civilizations does not stop with the passage of time although it might have experienced some highs and lows depending on the economical, social and cultural circumstance of the era. Therefore, when we know that these ancient civilizations are but a continuity of one original root we can understand the significance of the interactions, the relationships and the way of life of the numerous civilizations of this region. When we consider the geographical distribution of the Arabic language and the Middle Eastern ancient civilizations that populated this region then we can piece together some of the evidence of the cultural exchange between these civilizations and the origin of the ancient Arabic system of lunar mansions and the *Anwāʼ* tradition. This topic is still being debated between historians of ancient civilizations and hopefully there will be new studies to answers such questions in the future.

2.4 The *Almagest* from Ptolemy to al-Ṣūfī

> "...the *al-Magestī* is considered the foundation of this science and its author is the main authority among its people. It is called in Greek 'The Syntaxis' meaning 'Compilation'…" (al-Bīrūnī, 1030; al-Qānūn al-Mas'ūdī)

At the beginning of his major astronomical treatise, al-Bīrūnī, who is considered one of the most important Arab scientists of the medieval era, attributed the roots of all the science of astronomy to this one book called the *Almagest*. In his brief comment al-Bīrūnī also commended the author of this book as being the chief among his peers. So what is the *Almagest* and who was the author of this most important book in the history of astronomy?

2.4.1 Ptolemy and the *Almagest*

"The *Almagest* is a complete exposition of mathematical astronomy as the Greeks understood the term…" as Toomer (1998: 1) very briefly explains in his English translation of the *Almagest*. It is a mathematical as well as an astronomical treatise, detailing the motions of the Stars, the Sun, the Moon and the five known planets at that time. It is the most important sources of information on ancient Greek astronomy. It also provides information on many Greek mathematicians and astronomers. It summarized in one book all the ideas of ancient Greek scholars, such as Aristotle, Pythagoras, Apollonius and Hipparchus. The *Almagest* also included a catalog of stars which might have been originally compiled by Hipparchus in 130 B.C. However, since Hipparchus' books are no longer extant, astronomers use the *Almagest* as the source for information on Hipparchus' works.

The *Almagest* was originally named '*μαθηματική σύνταξις*' i.e. '*Syntaxis Mathematica*' or '*The Mathematical Compilation*'. It might have also have been named by its long title as: *The 13 books of Mathematical Compilation of Claudius Ptolemy*. However it was also titled '*Hè Megalè Syntaxis*' or the '*The Great Compilation*'. The title of this book was translated by the Arabs to '*al-Kitāb al-Magestī* ' i.e. '*The Great Book*'. The Arabs added the Arabic article '*al*' to the word '*Magestī*' which was later corrupted by Medieval Latin writers to simply read the '*Almagest*' (Evans, 1998: 23).

Very little is known about the life of Ptolemy. However we know that his full name was 'Claudius Ptolemaeus'. He lived and worked all his life in Greco-Roman Egypt from A.D. 83 until his death in approximately A.D. 168. He was either of Greek origin or a Hellenized Roman-Egyptian working in the library of Alexandria which was the largest and most important center of learning at that time. Some medieval writers wrongly wrote that Ptolemy was related to the Greek Ptolemaic kings of Egypt and thus some painters drew Ptolemy with a crown on his head (Hoskin, 1997: 42). Al-Nadīm listed many treatises which were written by Ptolemy on a variety of subjects. However, three major works stand out which are as important to the study of the history of science as the *Almagest*. These major works are: the *Geography*, which is a thorough discussion on the geographic knowledge of the ancient world, with coordinates of the major places in terms of latitude and longitude; the *Tetrabiblos* (meaning the Four Books) which is an astrological treatise consisting of Four Books on astrology; and a major treatise on Optics (Berggren et al., 2000: 21). He also wrote many other treatises on astronomy which are still extant today to some degree such as: *The Handy Tables*, *The Planetary Hypotheses*, *The Analemma*, and *The Planisphaerium* (Evans, 1998).

All the observations which were quoted in the *Almagest* cover a period from A.D. 127 to A.D. 141. However the *Almagest* was written by Ptolemy before the *Geography*, the *Tetrabiblos*, *The handy tables* or *The Planetary Hypotheses* because it was quoted in these works. The *Almagest* was also dated to the reign of the Roman Emperor Antoninus (A.D. 138-161). Ptolemy adopted the beginning of the reign of Antoninus as the epoch of his star catalogue. The date of the *Almagest* has recently been more precisely established by N. T. Hamilton. Ptolemy set up a public inscription at Canopus which was a port town in Egypt in A.D. 147/148 as a dedication in the tenth year of Emperor Antoninus. Hamilton found that the version of Ptolemy's models set out in the Canopic inscription was earlier than the version in the *Almagest*. Therefore with all the above evidence the *Almagest* could not have been written before approximately 150 A.D. (Toomer, 1998: 1).

During the ninth century, when the Arabic translation movement began, the *Almagest* was one of the first books to be translated from Greek into Syriac and into Arabic. The Arabs called it the *Almagest* because they were so impressed with its content and its comprehensive information on the subject of astronomy. It was first translated at the time of the Abbasid Caliph, al-Rashīd. The first person to recognize the importance of this book was the first Vizier of al-Rashīd who was called Yehyā Ibn Barmak. He ordered several translators to translate it in to Arabic but their first attempt was not very successful. It was not to the liking of the Vizier. He then gave it to the two main caretakers of *Dar al-Ḥikmah* by the name of Sālem and Abū Hassan who had more knowledge of astronomy and they made a better job the next time round as al-Nadīm wrote in his *al-Fahras*. Under the patronage of another Abbasid Caliph, al-Ma’mūn, the son of al-Rashīd, another translation was made by al-Ḥajjāj in A.D. 827. Then in A.D. 880 Isḥaq Ibn Ḥunāyn also made another effort to translate the

Almagest which was later revised by Thābit Ibn Qurra in A.D. 901. Only the last two Arabic translations are still extant today. At present there are 14 manuscripts containing the Arabic translation of the *Almagest* which can be found in various libraries (Kunitzsch, 2004). Several decades later Gerard of Cremona probably used copies of the two Arabic versions when he made in Toledo in A.D. 1175 his translation of the *Almagest* into Latin (Kunitzsch, 1986). This Latin translation became a unique book, which influenced the study of astronomy in Europe until the 15th and 16th centuries, even after the original Greek copy of the *Almagest* was first printed in Venice in 1515 and later in Basel in 1538 (Knobel et al., 1915). In the last century the *Almagest* was again translated into French by Halma in 1813 and into German by Karl Manitius in 1912 which was later revised by O. Neugebauer in 1963. In the last few decades the *Almagest* has been re-studied by Kunitzsch in his 1974 German edition, *Der Almagest*. However, the most up to date English translation was done by Toomer in 1984 based on the Greek text established by Heiberg in 1898. This important translation by Toomer has been re-printed several times since then.

2.4.2 The History of the Star Catalogue

The world's first star catalogues were compiled by the Chinese in the 4th century B.C. (Kanas, 2007:18). However in the Western world the first stellar observations were made by Timocharis in the 3rd century B.C. Then Hipparchus compiled his own star catalogue more than a century later relying on Timocharis' data and on Babylonian observations (Evans, 1998). Hipparchus had discovered that the longitude of the stars had changed over time since Timocharis' observations. This led him to determine the first value of the precession of the equinoxes. In A.D. 150 Ptolemy published his star catalogue and he fixed the precession rate at 1 degree in 100 years which was later modified by Arab astronomers at the time of al-Ma'mūn to 1 degree in 66 years. Ptolemy's star catalogue is to be found in books VII and VIII of his *Almagest*. It contains a catalogue of 1022 stars which included the stars' descriptions, positions and magnitudes grouped into 48 constellations for the epoch of A.D. 137. This catalogue became the standard star catalogue used in the Western, Arab and Islamic worlds for over a thousand years.

In the 9th century al-Battānī compiled his star catalogue for the epoch A.D. 880. However his catalogue only contained 533 stars. He applied the most up to date precession rate at that time of 1 degree in 66 years thereby adding 11 degrees 10 min on Ptolemy's longitude values (Nallino, 1899). Several years later al-Ṣūfī compiled his famous '*Book of the Fixed Stars*'. It was a complete star catalogue based on Ptolemy's results in the *Almagest*. He also applied the precession rate of 1 degree in 66 years and he added 12 degree 42 min to

Ptolemy’s longitude values. Decades later in A.D. 1030, al-Bīrūnī included a star catalogue in his famous book *al-Qānūn al-Mas’ūdī.* He again applied the same precession rate as al-Ṣūfī and added 13 degrees for his catalogue. However, in A.D. 1274 Naṣīr al-Dīn al-Ṭūsī modified the precession rate to 1 degree in 70 years. This more accurate constant was used in the last of the great Islamic compilations which was done by Ulugh Bēg. This star catalogue was based on Ptolemy’s as well as on al-Ṣūfī’s works.

Ever since the Arabs started to study and comprehend the *Almagest* they started to draw attention to some of the imperfections and irregularities in Ptolemaic astronomy. By the ninth century many Arabic texts started to emerge under the titles of ‘*Shukūk’* or ‘doubts’ concerning Ptolemy’s system of deferents and epicycles. Among such early authors who draw attention to such inconsistencies was Thābit Ibn Qurra. Other such texts were compiled by Ibn al-Hytham in the Eastern Islamic states (Hoskin, 1999: 61). One of Thābit Ibn Qurra’s main claims to fame was in raising the question of the variation of precession and by developing the theory of trepidation to solve this problem. The theory of trepidation was not adopted by eastern Arabic and Islamic astronomers like al-Battānī and al-Ṣūfī. However it was welcomed by many Arabic and Islamic astronomers in Andalusia where by it was incorporated into the influential Toledan Tables and included in Peter Apian *Cosmography* as late as A.D. 1524. Figure 1 shows Peter Apianus’ Universe with the nested celestial spheres including the mechanisms of trepidation and precession.

2.4.3 Accusation Against Ptolemy Star Catalogue

Even though Ptolemy mentioned in the *Almagest* that he compiled his star catalogue based on his own observations, many scholars believed that his catalogue was mostly based on Hipparchus’ catalogue made 266 years earlier. One of the first astronomers to point this out was al-Ṣūfī. However, he mentions that Ptolemy relied on Menelaus’ observations 41 years before the epoch of the *Almagest* and Ptolemy simply added 25 minutes to Menelaus’ longitudes. On average the star longitudes in Ptolemy’s catalogue all have a systematic error of approximately one degree. This is mainly due to the fact that the Ptolemy’s measurement of precession was low: 1 degree in 100 years instead of the modern value of 1 degree in 72 years. This error can be explained if Ptolemy used the coordinates of Hipparchus and added 2 degrees 40 minutes to account for precession from Hipparchus’ date to Ptolemy’s.

In A.D. 1598 Tycho Brahe commented that the star catalogue in the *Almagest* had been compiled through the conversion of Hipparchan stellar coordinates. Tycho calculated the accurate value of precession without the use of the stellar coordinates of the *Almagest* which could not have been made earlier by Arab astronomers. The Arabic and Islamic astronomers based their calculations on the *Almagest* and thus could not discover the systematic error in Ptolemy's longitude, even though they recognized earlier on that Ptolemy's value of precession was incorrect. However, some Arab and Islamic astronomers -among them al-Ṣūfī- held the view that Ptolemy's catalogue was merely a continuation of an earlier one. This argument was re-affirmed further by Halley in 1718, Lalande in 1757 and Laplace in 1797. In the 19th century this dispute intensified even further with J.B Delambre's investigation of the history of the *Almagest*. Delambre wrote that: "…one could explain everything in a less favorable, but all the simpler manner, by denying Ptolemy the observation of the stars and equinoxes, and by claiming that he assimilated everything from Hipparchus, using the minimal value of the latter for the precession motion." (Grasshoff, 1990: 29). In 1915 Knobel and Peters (1915) who made an important study on Ptolemy's catalogue finally concluded that Ptolemy only added 2 degrees 40 minutes to Hipparchus longitudes.

However not all scholars in this field held the above opinion. In 1901 Franz Boll established from newly-discovered manuscripts that Hipparchus' catalog only contained 850 stars. Then in 1917 Dreyer argued that the major source of error in Ptolemy's catalog was the defect in his solar theory. The final step in Ptolemy's rehabilitation was made by Heinrich Vogt in 1925. Vogt showed clearly in his important paper that by considering Hipparchus' Commentary on Aratus and Eudoxus and making the reasonable assumption that the data given there agreed with Hipparchus' star catalogue, then Ptolemy's star catalogue cannot have been produced from the positions of the stars as given by Hipparchus, except for a small number of stars where Ptolemy does appear to have taken the data from Hipparchus. After this paper the arguments started to shift in favor of Ptolemy and that the star catalog was actually compiled by him as he said in the *Almagest*.

Unfortunately this was not always to be the case. The strongest accusations of forgery made against Ptolemy came from R.R. Newton in his book '*The Crime of Claudius Ptolemy*' published 1977. Newton wrote that every observation claimed by Ptolemy in the *Almagest* was fabricated and he strongly accused Ptolemy of committing a scientific crime: "…a crime committed by a scientist against fellow scientists and scholars, a betrayal of the ethics and integrity of his profession that has forever deprived mankind of fundamental information about an important area of astronomy and history. Instead of abandoning the theories, he deliberately fabricated observations from the theories so that he could claim that the observations prove the validity of his theories."

Regardless of the evidence produced by Tyco Brahe, Delambre, Vogt, Neugebauer, Pedersen, Newton and many others it is certain that a substantial proportion of Ptolemy’s star catalogue was grounded in Hipparchus’ observations whose data were also taken from the Babylonians. Ptolemy’s intention was to develop a comprehensive theory of celestial phenomena. He had no access to the methods of data evaluation which modern astronomers now have. Ptolemy was forced to choose the most reliable measurements from the available data he had access to. As a final comment, and in Ptolemy’s defense, I would like to quote the Epigram which was written by Ptolemy himself in the *Almagest*: “I know that I am mortal and a creature of a day, but when I search out the massed wheeling circles of the stars, my feet no longer touch the Earth, but side by side with Zeus himself, I take my fill of ambrosia, the food of the Gods.”

3 Al-ṢŪFĪ'S BIOGRAPHY

3.1 A Short Biography

Al-Ṣūfī and his '*Book of the Fixed Stars*' have a very important place in the history of Arabic observational astronomy. Surprisingly we know very little about al-Ṣūfī's life and career. However from Hājī Khalīfa's (A.D. 1601-1658) book *Kashef al-Thonūn wa Asamī al-Kutub wa al-Funūn* we know that al-Ṣūfī's full name was: 'Abd al-Raḥmān, Abū al-Ḥusaīn, Ibn ′Umar, Ibn Muḥammad, Ibn Sahl al-Rāzī known as Abū al-Ḥusaīn al-Ṣūfī.

Hājī Khalīfa also wrote that al-Ṣūfī was the '*Munajjem'* of Baghdad who served Aḍud al-Dawla and died in A.H. 374. In Arabic the word *Munajjem* both means an 'astrologer' or an 'astronomer'. However I prefer to use here the word 'astronomer' even though al-Ṣūfī was also an astrologer in his capacity as astronomer/astrologer royal to the Buwayhid *Amīr* (Prince) Aḍud al-Dawla as we will later see. Hājī Khalīfa also mentioned the city of Baghdad; however there is no other record that states that al-Ṣūfī was ever in Baghdad even though Baghdad was the political capital as well as the cultural center of that period.

The earliest biographical reference to al-Ṣūfī is found in *al-Fahras* (al-Nadīm, A.H. 377/A.D. 988). This is one of the most important historical and biographical books in Arabic history, which was written one year after al-Ṣūfī's death. In this book al-Nadīm wrote that al-Ṣūfī was "…one of the most important astronomers who served Aḍud al-Dawla." However there is no mention of al-Ṣūfī's birth or death or any other information. In another historical record, which is the famous chronology of Ibn al-Āthīr (A.H. 630) we find one sentence which mentions al-Ṣūfī: "…in this year (A.H. 376) Abū al-Ḥusaīn, ′Abd al-Raḥmān, Ibn ′Umar, al-Ṣūfī the astronomer to Aḍud al-Dawla died. His birth was in Rayy in the year A.H. 291." A few years later in another biographical book, which is *Akhbār al-'Ulamā' Bi Akhbār al-Ḥukamā'* by al-Qifṭī (A.H. 646/A.D. 1248) we find the most detailed record on al-Ṣūfī. In his book al-Qifṭī wrote:

> " 'Abd al-Raḥmān, Ibn 'Umar, Ibn Muḥammad, Ibn Sahl, al-Ṣūfī, Abū al-Ḥusaīn al-Rāzī, is the honored, the perfect, the most intelligent and the friend of the King Aḍud al-Dawla Fanakhasrū Shāhenshāh Ibn Būwayh. He is the author of the most honored books in the science of astronomy. He was originally from Nisā and is of a Persian descent. He was born in Rayy. When Aḍud al-Dawla was referring to knowledge and teachers he used to say: "…my teacher in al-Zīj is the honored Ibn al-A'lām and my teacher in the

fixed Stars, their location and movements is al-Ṣūfī". Among his works are: *Kitāb al-Kawākib al-Thābitah Muṣawaran, Kitāb al-Urjūza fi al-Kawākib al-Thābitah Muṣawaran and Kitāb al-Tathkira wa Maṭareh al-Shu'a'*. Hilāl Ibn al-Muḥsin said in his book: "in the year A.H. 376 in the 13th of Muḥarram on Tuesday Abū al-Ḥusaīn, Abd al-Raḥmān, Ibn 'Umar al-Ṣūfī the astronomer to Aḍud al-Dawla died. He was born in Rayy in the night of Saturday the 14th of Muḥarram in the year A.H. 291."

From the above record we can deduce several facts about al-Ṣūfī's life. The title '*al-Rāzī*" means that he is from the town of Rayy. The city of Rayy was a major city in northern Iran, estimated to be more than five thousand years old. However, the city gradually lost its importance after the Mongol invasion. It is south east of what is now called Tehran the capital of modern day Iran and it is now a suburb of this city. Rayy was home to many important individuals and scholars in the Arabic and Islamic Empires. Many of those had the title of *al-Rāzī*. One example of such a scholar was the famous medical doctor 'Rhazes'. Al-Ṣūfī's family was originally from Nisā or the city of Nisabour in western Khurasan Province in modern-day Iran. Al-Ṣūfī was also a Persian not an Arab even though he wrote all his works in Arabic, which was the preferred language of most scholars and writers at that time. According to al-Qifṭī al-Ṣūfī was born on Saturday the 14th of Muḥarram in the year A.H. 291. This date corresponds to a Tuesday on the 6th of December in the year A.D. 903. He died on the Tuesday the 13th of Muḥarram in the year A.H. 376 which corresponds to Tuesday the 25th of May A.D. 986. The location of his death is not known, but most probably it was Shiraz. He lived to be 83, which is a fairly good old age for his time. From the introductory chapter of this work we know that he spent most of his life between the provinces of Rayy and Fars and in the cities of Rayy, Isfahan and Shiraz in Iran. In his work al-Ṣūfī wrote that he made his observations from Shiraz where he also must have constructed his observatory. He also wrote that he visited Daīnawar, which was the home of the famous scholar and astronomer Abū Ḥanīfa al-Daīnawari. He also visited Isfahan to research a celestial globe constructed by another important astronomer of that period.

Figure 4 is a depiction of an astronomer using a Triquetrum or a parallectic ruler. This figure was mistakenly identified as al-Ṣūfī (Figure 4) however this drawing was taken from an image (Figure 5) of a manuscript found in Istanbul University. It was a depiction of astronomers working at the Istanbul Observatory, which was constructed by Taqī al-Dīn in A.D. 1575. There are no portraits of al-Ṣūfī. This is not a surprise because we seldom find any portraits of people during that time. This is because it is not allowed to draw a portrait of a person in Islamic religion.

Figure 4: A Depiction of an Astronomer Using a Triquetrum or a Parallectic Ruler.

Figure 5: Image found in a Manuscript in the Istanbul University.

Al-Ṣūfī lived and died during the period and rule of the Buwayhid (*Būwayh* or Buyid) dynasty during the 10th century. Al-Ṣūfī clearly mentioned that his book was dedicated to the Buwayhid ruler, Aḍud al-Dawla.

Figure 6: Map of the Buwayhid Emirates during the 10th century.

The Buwayhids Dynasty also known as Buyids was a Persian Shī'ah Dynasty that originated in Dylaman. The Dailam or Daylam or Deylamite were an Iranian people from northern Iran, from al-Borz Mountains and along the shore of the Caspian Sea. The Buwayhids founded a confederation that controlled most of modern-day Iran and Iraq in the 10th and 11th centuries. The three founders of the Buwayhids confederation were 'Ali Ibn Būwayh and his two younger brothers, Ḥasan and Aḥmad. They were originally soldiers in the service of the Samanids and Ziyarids. Over the next nine years the three brothers gained control of the main provinces of Iran and Iraq. The Buwayhids revived symbols and practices of Persia's Sassanid Dynasty. For example, 'Aḍud al-Dawla used the ancient Sassanid title *Shāhenshāh* which means (king of kings). The main Buwayhids *Amīrs* who ruled the area during the life of al-Ṣūfī were:

1- Būwayh Ibn Fanakhasrū
He was the father of 'Alī, Ḥasan and Aḥmad**.**

2- 'Imād al-Dawla (died in A.D. 949) ('Alī Ibn Būwayh)
He was the founder of the Buwayhid dynasty
He was ruler of Fars (capital Shiraz) from A.D. 934-949.

3- Rukn al-Dawla (died in A.D. 976) (Ḥasan Ibn Būwayh)

He was the first Buwayhid ruler of northern and central Iran.

4- Mu'iz al-Dawla (A.D. 945-967) (Aḥmad Ibn Būwayh)

He was the first of the Buwayhid rules of Iraq (Baghdad).

5- 'Iz al-Dawla (A.D. 967-978) (Bākhtyār Ibn Aḥmad)

He was the Buwayhid ruler of Iraq after his father Mu'iz al-Dawla

6- 'Aḍud al-Dawla (A.D. 936-983) (Fanakhasrū Ibn Ḥasan)

He was the ruler of the Buwayhid Dynasty in Fars/Iran as well as in Iraq.

7- Sharaf al-Dawla (A.D. 960-989) (Shirdīl Abū al-Fawāris Ibn Fanakhasrū)

He was ruler of Fars and Kerman (A.D. 983-989), as well as Iraq (A.D. 987-989).

He was the eldest son of 'Aḍud al-Dawla .

8- Ṣamṣām al-Dawla (A.D. 963-998) (Marzubān Ibn Fanakhasrū)

He was the Buwayhid ruler of Iraq (A.D. 983-987), as well as Fars and Kerman (A.D. 989-998). He was the second son of 'Aḍud al-Dawla.

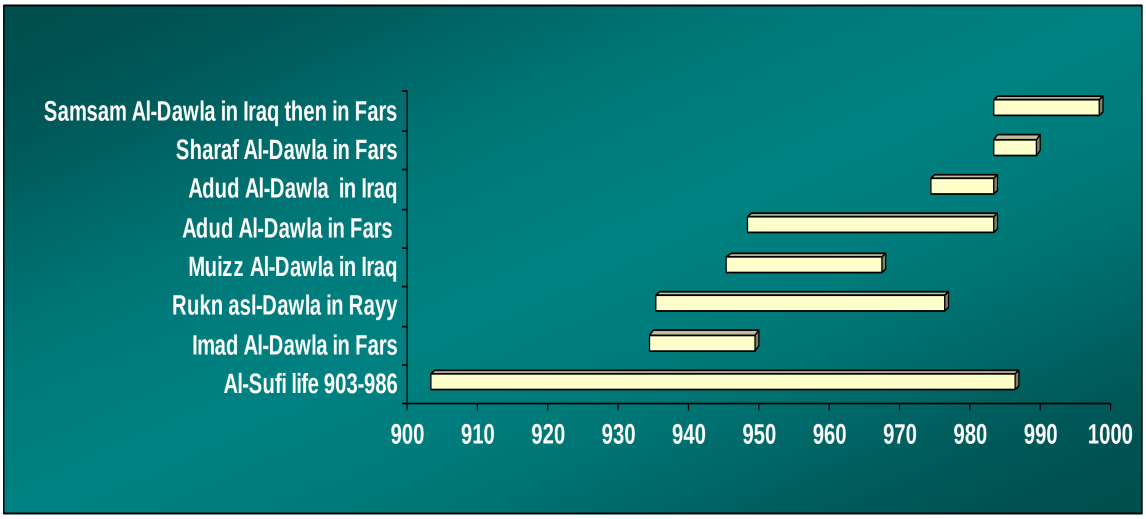


Figure 7: Time Line of al-Ṣūfī's Life and the Buwayhid Rulers.

From the time line of al-Ṣūfī's life and the relevant Buwayhid rulers in figure 7 we see that al-Ṣūfī lived throughout most of the rule of these major Buwayhid rulers. However, the most significant scientific contributions of al-Ṣūfī were made during the reign of 'Aḍud al-Dawla. The *Book of the Fixed Stars* was written in A.D. 964 and dedicated to ‘Aḍud al-Dawla who was the ruler of Fars during that time in the city of Shiraz. However al-Ṣūfī also dedicated other books to other members of the Buwayhid Dynasty.

Like most Daylamites at the time, the Buwayhids were originally Zāydi or ‘Fiver Shī’ah (one of the branches of the Shī’ah sect). After taking power in Iran and Iraq, they began to lean closer to the ‘Twelver Shī’ah sect, due to political considerations. ‘Aḍud al-Dawla, as other Buwayhids rulers before him, rarely attempted to enforce a particular religious view upon his subjects, who were predominantly Sunnī. This might have been reflected on al-Ṣūfī who was most probably a Sunnī Muslim. This can be deducted from al-Ṣūfī’s name itself. We know that his father’s name is ‘Umar. This definitely signifies that he must have been originally a Sunnī Muslim rather than a Shī’ah because Shī’ahs were in conflict with the third Caliph ‘Umar; therefore the name ‘Umar was seldom used by the Shī’ah.

The name al-Ṣūfī is a very important indicator of the personal status of al-Ṣūfī during this period. Generally the ‘al-Ṣūfī’ title signifies that a person who holds this title is part of an Islamic religious ‘*Ṣūfī*’ order or maybe he is a descendent of a family which was part of a ‘*Ṣūfī*’ order. The *Ṣūfī* movement is an Islamic philosophical and religious discipline whose objectives are the reparation of the heart and dedicating oneself entirely to worshiping God through self-denial and living with minimal material comforts. This movement has spanned several continents and cultures throughout the Islamic world. Its origin at the beginning was Arabic. However it quickly spread to Persian, Turkish and other cultures in the Islamic empire. Sufism was divided into many Sunnī as well as Shī’ah orders who trace their origins either to ‘Alī or the other original three Caliphs after the prophet Muḥammad. The word *Ṣūfī* either refers to the simple cloaks which were made of ‘*Ṣouf*’ or ‘Wool’ which these early Muslim ascetics wore, or possibly to the word ‘*Ṣafa’* which means ‘purity’ of the heart. During the 10th century some of the *Ṣūfī* orders evolved to include some Neo-Platonic philosophical ideas together with Gnosis beliefs. This movement also incorporated *Ṣūfī* beliefs with the sciences of alchemy, numerology and astrology (Aassi, 1994). Two of the most important *Ṣūfī* leaders of this movement were Thū al-Nūn al-Masrī (died A.D. 859) and Jáber Ibn Ḥayyān (died A.D. 815). Jáber Ibn Ḥayyān, who was later called ‘Geber’ in the west, was also given the title of ‘al-Ṣūfī’. Since al-Ṣūfī was given this religious honorary title then we assume that he must have been influenced by such *Ṣūfī* movements and by some of the leaders of these orders in his area. The most probable person might have been Yūsuf Ibn al- Ḥusaīn al-Rāzī (died A.D. 916) who was a student of Thū al-Nūn al-Masrī. Yūsuf Ibn al-Ḥusaīn al-Rāzī resided in Rayy which was the birthplace of al-Ṣūfī and where we assume al-

Ṣūfī spent the early part of his life. Mansūr al-Ḥallāj was another important Persian *Ṣūfī* poet who lived during the early years of al-Ṣūfī's life. He was executed in A.D. 922 in Baghdad for heresy by the Abbasid Caliph al-Muqtadir for his disputed self-proclaimed divinity after a lengthy investigation and trial.

3.2 Al-Ṣūfī's Contemporaries and other More Ancient Individuals

In his book al-Ṣūfī mentioned several important individuals and scholars. He also mentioned some of their works which he commented upon and sometimes criticized. The main person whom al-Ṣūfī mentions was Ptolemy. Al-Ṣūfī refers to Ptolemy by name 119 times in his '*Book of the stars*'. I have already written about Ptolemy in an earlier section of this study. The other Greek astronomers which were mentioned in al-Ṣūfī's book were Timocharis and Menelaus. I have also mentioned these two astronomers in the same section on Ptolemy. Al-Ṣūfī also mentioned some other important individuals in his book and these were:

3.2.1 'Aḍud al-Dawla:

'Aḍud al-Dawla was the son of Rukn al-Dawla. His first name was Fanakhasrū Ibn Ḥasan. He was given the title of 'Aḍud al-Dawla by the Abbasid caliph in A.D. 948. He was made *Amīr* of the Provence of Fars after the death of his childless uncle 'Imād al-Dawla. In A.D. 974 'Aḍud al-Dawla was sent by his father to Iraq to crush a rebellion by his cousin 'Iz al-Dawla. After defeating his cousin's forces, he claimed the Emīrate of Iraq for himself, thus angering his father for some time until the relationship eventually went back to normal. After his father's death he became the senior *Amīr* of the Buwayhids, controlling Fars, Iraq and most of the other provinces in Iran. 'Aḍud al-Dawla was credited with sponsoring and patronizing many scientific projects during his time. He ordered an observatory to be built in Isfahan under the guidance of al-Ṣūfī. 'Aḍud al-Dawla considered al-Ṣūfī to be his teacher in the position of the fixed stars, their location and movements as he said. 'Aḍud al-Dawla was a great patron of astronomy and himself an accomplished scholar and astronomer. In his book al-Ṣūfī clearly mentions that '*The Book of the Fixed Stars*' was dedicated to 'Aḍud al-Dawla. He also founded the *Bimāristān-i Aḍudi* (hospital) in Rayy, which is where the great medical doctor al-Rāzī (Rhazes) worked. 'Aḍud al-Dawla died in A.D. 983 and is buried in the city of Najaf in Iraq. He is widely regarded as the greatest ruler of the Buwayhid dynasty.

3.2.2 Al-Battānī

Al-Battānī, known in the West as al-Bategnius, was a famous astronomer and mathematician. He has been recognized as the greatest astronomer of his time and one of the greatest of the Middle Ages. His full name was Abū 'Abdullah Muḥammad Ibn Jāber Ibn Sinān al- Battānī. He was born in A.D. 858 near the city of Battān in the state of Harrān in present day Syria and died in A.D. 929 in the city of Samarra in Iraq. He was originally of the *Sabi'* sect but he converted to Islam in his life time. His father was the famous scientist Jāber Ibn Sinān. Al-Battānī wrote many books on astronomy and trigonometry. His most famous book was an astronomical treatise with tables, which was translated into Latin in the twelfth century and is known by the title '*De Scienta Stellarum - De Numeris Stellarum et motibus.*' His treatise on astronomy was extremely influential in Europe until the Renaissance and was translated into several languages. Al-Ṣūfī mentioned al-Battānī many times in the introductory chapter to his book. However, al-Ṣūfī also condemned al-Battānī as an observer by stating that his catalog was but a copy of Ptolemy's *Almagest* with the correction for precession.

3.2.3 Abū Ḥanīfa al-Daīnawari

Abū Ḥanīfa al-Daīnawari was a famous Persian scholar from the city of Daīnawar which is a city between Hamadan and Kermanshah in present day Iran. His full name was Abū Ḥanīfa Aḥmad Ibn Dāwoud al-Daīnawari. He was born in A.D. 828 and died in A.D. 896 at Daīnawar. He wrote many treatises on many subjects such as astronomy, agriculture, botany, geography and history. His most renowned contribution is his Book of Plants (*Kitāb al-Nabāt*) for which he is considered to be the founder of Arabic botany. His work on Arabic Astronomical Tradition, the Book on al-Anwā' (*Kitab al-Anwā'*) is also a very well known work which al-Ṣūfī considered to be the best-written book on this subject which shows that he was as well versed as others in the history of Arabic tradition, Arabic poetry and prose. However al-Ṣūfī criticized al-Daīnawari for his mediocre knowledge of the stars and their movements. He also mentioned that al-Daīnawari did not actually observe the stars but he only confirmed what was written on this subject before him. Al-Ṣūfī reached this conclusion after he read al-Daīnawari's book even though he visited the home of al-Daīnawari himself and saw where he used to make his observations.

3.2.4 Ibn al-A'arabī

Ibn al-Ā'rabī was a famous Arab linguistic and scholar. His full name was Abū 'Abdullah Muḥammad Ibn Ziyād al-Ā'rabī al-Kūfī. He was born in A.H. 150/A.D. 767 and died in A.H. 231/A.D. 845 in the city of Sāmurra' at an old age of eighty-one according to al-Nadīm. Al-Nadīm also wrote in his book that al-Ā'rabī lectures were usually attended by more than one hundred people and he used to give his talks without a book in his hands. This is an indication of the extent of his knowledge in his field of Arabic linguistics and that he also knew a lot about Arabic Poetry. Al-Ā'rabī has also written a book on al-Anwā'. Al-Ṣūfī mentioned that al- Daīnawari quoted many things from al-Ā'rabī in his own book on al-Anwā'. However al-Ṣūfī also criticized both al-Daīnawari and al-Ā'rabī for their lack of knowledge in this field.

3.2.5 Ibn Rawāha

According to al-Ṣūfī Ibn Rawāha was a known astronomer from the city of Isfahan. al-Ṣūfī describes his first encounter with Ibn Rawāha in the year A.H. 337/A.D. 948 when he was in Isfahan with his teacher Abū al-Faḍel. Al-Ṣūfī mentioned that he saw Ibn Rawāha using an astrolabe which was in his possession. However al-Ṣūfī criticized Ibn Rawāha because he did not know the difference between the various stars on the astrolabe. Twelve years later in the year A.H. 349/ A.D. 960. Al-Ṣūfī again met Ibn Rawāha, this time in the presence of ‘Aḍud al-Dawla, and he again criticized him for the his lack of knowledge of the stars in the sky. This last encounter encouraged al-Ṣūfī to start writing his ‘*Book of the Fixed Stars*’, which was to be finished 4 years later in A.D. 964. Ibn Rawāha was not mentioned in any of the main biographical references but only by al-Ṣūfī in the introductory chapter to his book.

3.2.6 Ibn Kunāsa

Ibn Kunāsa was another famous scholar in the field of Arabic astronomical tradition. His full name was Abū Muḥammad ‘Abdullah Ibn Yehyā, and he was known by the name of ‘Ibn Kunāsa’. According to al-Nadīm, Ibn Kunāsa was born on A.H. 123/A.D. 740 and died in A.H. 207/A.D. 822 in the city of Kūfa. He was originally from the city of Kūfa but he lived and studied in Baghdad. Al-Nadīm wrote that Ibn Kunāsa was also a writer and a poet who wrote a book on *al-Anwā’* and *Kitāb Ma’ni al-She’er* (The Meaning of Poetry) and another book on the Qur’an and poetry, among many others. However al-Ṣūfī also criticized Ibn Kunāsa along with al-Ā’rabī for writing about the stars which indicated their lack of knowledge in this area. Al-Ṣūfī also mentioned that al-Daīnawari referred to wrong information from the book of Ibn Kunāsa regarding the path of the Moon and the degree the Moon travels from the ecliptic.

3.2.7 Abū al-Faḍel Muḥammad Ibn al-Ḥusaīn

In the history of Arabic astronomy there were two important individuals who went by the name of Abū al-Faḍel Muḥammad Ibn al-Ḥusaīn. Both of these lived in the same region during the period of al-Ṣūfī. The first was Abū al-Faḍel Muḥammad Ibn al-Ḥusaīn Ibn Ḥamīd known by the name of Ibn al-Ādamī. According to Ibn al-Qifṭī he (Ibn al-Ādamī) died in A.H. 308/A.D. 920; however, there is no other historical reference which mentioned when he was born or where he died. Ibn al-Qifṭī also wrote: “He (Ibn al-Ādamī) was an important scholar and a well known researcher in the field of astronomy. He started to compose his large Zīj; however, he died before he finished it. It was completed by his student al-Qāsem Ibn Muḥammad Ibn Hāshem al-Madāinī, known as al-‘Alawī, and he called it: *Nuthum Kitāb* *al-‘Ukad.* This book was a complete reference, which contained the basic science of astronomy and the calculation of the movement of the stars according to the (Indian) concept of the Sind-Hind. This book also contained new ideas on the orbits of the stars (theory of trepidation), which no one else mentioned before him. Before this book was written the idea regarding this moment of the stars was not understood until this book was written which explained this strange movements”. The other reference identifies Abū al-Faḍel Muḥammad Ibn al-Ḥusaīn Ibn al-‘Amīd (A.D. 930-970) (Kunitzsch, 1970). Ibn al-‘Amīd was the vizier of Rukn al-Dawla in Rayy and later he served his son ‘Aḍud al-Dawla in Iraq. He is also known for his interest in astronomy and according to al-Bīrūnī (*al-Qānūn al-Mas’ūdī* and *Taḥdīd al-Āmākin*) he patronized the building of an observatory in Rayy in A.D. 950. However it is not clear whether he also contributed to the actual astronomical observations at this observatory or not. Al-Ṣūfī mentioned Abū al-Faḍel twice in his introductory chapter. He referred to him as *al-Raees* or the ‘chief’ as well as the most honored *Ūstāz* or master or teacher. Al-Ṣūfī first mentioned that he visited the city of Daīnawar with his teacher Abu al-Faḍel in the year A.H. 335/ A.D. 946. Then, two years later, in the year A.H. 337/A.D. 948 he visited Esfahan with his teacher again. Either the extract from Ibn al-Qifṭī was wrong since al-Ṣūfī mentioned that he was with Abū al-Faḍel in the years A.H. 335 and A.H. 337 or Abū al-Faḍel is Muḥammad Ibn al-Ḥusaīn Ibn al-‘Amīd as Kunitzsch mentioned (Kunitzsch, 1970).

3.2.8 ‘Alī Ibn ‘Isā al-Harrānī

There is no mention in any of the historical books or any of the Arabic biographical references about ‘Alī Ibn ‘Isā al-Harrānī except the extract from al-Ṣūfī’s book. Al-Ṣūfī considers al-Harrānī on the same level as al-Battānī and the composers of *Zīj al-Mumtaḥen*. However al-Harrānī did not escape also from al-Ṣūfī’s criticism. Al-Ṣūfī mentioned that he saw a large celestial sphere that was constructed by al-Harrānī who must have been an important astronomer or an instrument maker. However al-Ṣūfī identified several mistakes on this sphere: the positions or names of some of the important stars had been wrongly drawn.

3.2.9 Asḥab al-Mumtaḥen (the composers of *al-Mumtaḥen Zīj*)

The *Mumtaḥen Zīj* was one of the first astronomical works to be produced in the Abbasid period at the time of the Abbasid caliph al-Ma’mūn. It was composed by a group of astronomers under the leadership of the able astronomer Yehyā Ibn Abi Mansūr (Musa, Ali, 2001:295). They especially revised the *Almagest* precession rate from 1 degree in 100 years to 1 degree in 66 years.

3.2.10 Al-Hajjāj Ibn Yūsuf Ibn Maṭar

al-Hajjāj Ibn Yūsuf Ibn Maṭar was an Arab mathematician who was born in A.D. 786 and died in Baghdad in A.D. 833. He was the first to translate Euclid's Elements from Greek to Arabic. He also translated Ptolemy's *Almagest* at the time of the Abbasid Caliph al- Ma'mūn. The Arabic copy of al-Hajjāj's translation of the *Almagest* is still extant today. Al-Ṣūfī relied on this translation in his work according to his own admission in the introductory chapter of his book. However, he also mentions that the copy of al-Hajjāj's translation which he had, contained a mistake which was probably due to an error made by the copyist. The Bibliotheque Nationale de Tunisie contains a manuscript of al-Hajjāj's *Almagest* which was copied in A.H. 478 / A.D. 1085 from a copy of Abū al-Ḥusaīn al-Ṣūfī (Shaboh, 1989).

3.2.11 'Utāred Ibn Muḥammad

" 'Utāred Ibn Muḥammad al-Ḥāseb was a famous astronomer of his time…" is what was written about him by Ibn al-Qifṭī. Al-Nadīm also mentioned 'Utāred in his book. He wrote that Utāred was a mathematical astronomer and an honored scholar who wrote several books which are: *Kitāb al-Jafer al-Hindi, Kitāb al-'Amal Bi al-Īsterlāb, Kitāb al-'Amal Bi thāt al-Ḥalak, Kitāb Tarkīb al-Āflāk, Kitāb al-Marāyā al-Muḥarraka*. However, neither of the above biographers mentioned his birth or his death. Al-Ṣūfī criticised 'Utāred and al-Battānī for writing about the stars relying on the books they found without actually making any observations themselves.

3.2.12 Nabonassar (Nabūkhat Nassar)

Nabonassar was the ruler of Babylon in B.C. 747. He was an army commander who won control of Assyria and Babylon and ruled as a vassal king in the Assyria Empire until his death in B.C. 734. Ptolemy made a list of ancient kings called the 'Canon of Kings' which was used in chronological calculation to help date astronomical phenomena. Ptolemy made the start of his chronological calculation from the first year of the reign of Nabonassar which corresponds to 26 February B.C. 747 of the Julian calendar. This date was used by Ptolemy because it was the earliest date that an astronomical observation was available to him. These astronomical observations were to be found in a collection of clay tablets called the Babylonian Chronicles which record events beginning in the reign of Nabonassar. The dates in the Canon are considered by most historians to be fairly accurate from B.C. 747 onward.

3.2.13 Alexander the Great (Thū al-Qarnaīn)

Alexander the Great was the King of Macedonia in ancient Greece. He was born in Greece in B.C. 356 and died in Babylon, in present day Iraq, in B.C. 323. His successful military campaigns led to the conquest of most of the known world which were mainly in Asia Minor, Egypt, Arabia, the Middle East and reached as far as the India sub-continent. His conquests started the era of Greek cultural influence over those conquered lands especially in Egypt and the Middle East. He is identified in Arabic traditions as *Thū al-Qarnaīn* which means 'The Two-Horned One'. This is possibly because of a horn-headed figure that appeared on coins minted during his rule and the rule of his successors in ancient Middle East. The reference to *Thū al-Qarnaīn* also appears in the Qur'an which some believe refers to Alexander the Great. However, many Muslim scholars disagree that Alexander was *Thū al-Qarnaīn*. The reason for this is that *Thū al-Qarnaīn* is described in the Qur'an as a monotheist believer who worshipped Allah (the one and only God), whereas Alexander was a polytheist.

3.3 All of the Main Known Works by al-Ṣūfī

Al-Ṣūfī was basically renowned as an observational astronomer and an instrument maker rather than a theoretician or mathematical astronomer as ‘Aḍud al-Dawla mentioned. Al-Ṣūfī must have written many books or treatises on observation and astronomical instruments, however very few of his works have reached us. The ‘*Book of the Fixed Stars*’ was the main work which al-Ṣūfī was famous for as we can see in our present study. However we also know of two extant works on observational instruments. The first is a treatise on the astrolabe and the other is a work on the celestial globe. In his biographical book *Akhbār al-‘Ulamā’ Bi Akhbār al-Ḥukamā’* al-Qifṭī lists only three works by al-Ṣūfī. However, from other historical records we know that al-Ṣūfī also wrote a Zīj, which is an astronomical handbook. Unfortunately this no longer exists. Al-Ṣūfī was also the astrologer to the Buwayhid rulers; therefore he must have written several treatises on this subject, but we know very little about these. In his capacity as the astrologer royal to ‘Aḍud al-Dawla he cast the horoscope for this ruler. This horoscope is to be found in the book *Dustūr al-Munajjimīn* which is a collection of astrological treatises written in the 10th century (Kennedy and Destombes, 1966). ‘Aḍud al-Dawla, like many other rulers of that period was very much interested in astrology. An exert in al-Qifṭī’s book states that ‘Aḍud al-Dawla frequently visited Abū al-Faḍel Ja’far the son of the caliph al-Muktafī who was an astrologer, in order to get astrological predictions. I have listed below all the main works by al-Ṣūfī along with a brief description on each:

a) *Kitāb al-Kawākib al-Thābitah*

This is the *Book of the Fixed Stars* with pictures of the constellations. This was the main work which al-Ṣūfī was famous for and which is the topic of our present study. This work was mentioned in many Arabic historical and biographical references such as al-Qifṭī, al-Nadīm and Hājī Khalīfa.

b) *Kitāb al-Urjūza fi al-Kawākib al-Thābitah Muṣawaran*

This is a poem on the fixed stars. It is called ‘*al-Urjūza by Ibn al-Ṣūfī*’ which means ‘*The Poem by Ibn al-Ṣūfī*’. It is composed of 495 verses which are divided into 48 stanzas, one for each constellation. Every stanza describes the constellation in a simple and easy to understand language. The style is not exactly a literally poetic style therefore it is called “Urjūza’ which means ‘Prose’ rather then a poem. The writer was trying to compose an easy to memorize poem and not a scientific piece of work; therefore it does not include much detailed scientific information on many of the constellations. Al-Qifṭī attributed this poem to al-Ṣūfī however this poem was written by the son of al-Ṣūfī and not by al-Ṣūfī himself. The first 6 verses from this poem clearly identify the person who wrote this poem and to whom it was attributed. The second verse explains that this poem was written by Abū ‘Alī the son of Abū al-Ḥusaīn al-Ṣūfī. The fourth verse states that this poem was dedicated to Shāhenshāh Abū al-Ma‘ali Fakher al-Din, who was the second son of Rukn al-Dawla. Fakher al-Dawla took power in Rayy in A.D. 976 after his father’s death. He took the title of *Shāhenshāh* in A.D. 984 until his death in A.D. 997; therefore this poem must have been composed some time between A.D. 984 and A.D. 997 and most probably after al-Ṣūfī’s death in A.D. 986. However, another reference in the Encyclopedia Iranica (Kunitzsch, 1970) identifies Shāhenshāh Abū al-Ma‘ali Fakher Din Allah as the Artuqid ruler in A.D. 1143; thus Kunitzsch rejects the claim that this poem was ever written during the time of al-Ṣūfī or by his son. A copy of this poem is to be found at the end of the below-mentioned manuscripts of al-Ṣūfī’s *Book of the Fixed Stars*. This is why there was sometimes a little confusion as to who wrote this poem. This also explains another confusion, which is the name of al-Ṣūfī because he was referred to as Ibn al-Ṣūfī in many historical reference works.

- Vatican Library, Manuscript: MS Rossi 1033, Copy dated A.H. 621/A.D. 1224
- Paris Bibliotheque Nationale, Manuscript: Arab 979, Copy date unknown
- Munich library , Manuscript: Arab 870, Copy date unknown

c) *Kitāb al-Tathkira wa Matāreh al-Shu’a’*

The title of this book as mentioned in the biographical work of al-Qifṭī, is ‘*The Book of Information and Projection of the Rays*’. Unfortunately it is no longer extant. It is not entirely clear whether is was one book with the above name or two different books ‘*Kitāb al-Tathkira*’ and ‘*Matāreh al-Shu’a*’ since it is no longer available. This book was on astrology which included mathematical tables and instructions using a specific method of calculating astrological charts. The concept of ‘projection of the rays’ is a little-understood astrological method which was also mentioned by many who wrote on astrology such as al-Khawarizmī, al-Ṣūfī and, later on, al-Bīrūnī (Kennedy, 1972). A reference to this concept with a table that was attributed to al-Ṣūfī is to be found in al-Bīrūnī’s book al-Qānūn al-Mas’ūdī (A.D. 1030).

d) *Kitāb al-Madkhal Fi ‘Ilm al-Āḥkām*

This book is entitled *Kitāb al-Madkhal Fi ‘Ilm al-Āḥkām* or ‘*Introductory Book to the Science of Astrology*’. This is one of the unpublished books of al-Ṣūfī that is listed by A. Sezgin (Geschichte des Arabischen Schrifttums GAS V, 1975).

e) *Fi Sharḥ al-‘Amal bi al-Kura*

This book is entitled: ‘*Fi Sharh al-‘Amal bi al-Kura*’ or ‘*On the Explanation of the Use of the Celestial Globe*’. There are only two extant manuscripts of this book-both in the Saray library in Istanbul. This work was dedicated to Ṣamṣām al-Dawla, therefore this book might have been written after Ṣamṣām al-Dawla assumed ruler-ship of Iraq province in A.D. 983, toward the end of al-Ṣūfī’s life. A critique on this book was published by Kennedy (1990) who summarized the various chapters.

f) *Kitāb al-‘Amal bi al-Isṭerlāb*

This book is entitled: ‘*Kitab al-‘Amal bi al-Isṭerlāb*’ or the ‘*Book on Using the Astrolabe*’. There are seven incomplete manuscripts of this book in libraries in Paris, Istanbul, Tehran and St Petersburg (previously Leningrad). This book was one of the most exhaustive books ever written on this subject in the Middle Ages. It contained 1760 mostly short chapters on almost all aspects of construction and use of this instrument. It was dedicated to Sharaf al-Dawla the son of ‘Aḍud al-Dawla at the time when Sharaf al-Dawla was still the *Amīr* of Kerman before the death of his father. A critique on this book was also published by Kennedy and Destombes (1966) who point to the influence of Indian astronomy on al-Ṣūfī’s work even though al-Ṣūfī is better known for his star catalog which was based on Ptolemy’s work. This shows that al-Ṣūfī was well informed on both Greek and Indian astronomy, not to mention his knowledge of Arabic tradition.

g) *Zīj al-Ṣūfī*

The Zīj of al-Ṣūfī was first mentioned by the important astronomer Ibn-Yūnus in Cairo-Egypt in A.D. 1000. Ibn-Yūnus makes a reference in his great book *al-Zīj al-Kabīr al-Hākimī* to the solar mean motion which he found in al-Ṣūfī’s Zīj (Kennedy, 1956). Another reference to the Zīj of al-Ṣūfī is also to be found in Abraham Ibn ‘Ezra’s book *Libre de Rationibus Tabularum*. Even though Ibn ‘Ezra must have had a copy of al-Ṣūfī’s Zīj and he mentions several parameters such as the motion of the Sun, the length of the lunar year and mean motion of Saturn, most of these were not exactly correct. For example Ibn ‘Ezra quotes a value of 92:39 deg for the ‘excess of revolution’ which al-Ṣūfī mentions as 93 deg in his treatise on the Astrolabe. Ibn ‘Ezra also mentioned that al-Ṣūfī used a constant of precession of 1 deg every 70 years which is obviously an incorrect statement since al-Ṣūfī used the value of 1 deg every 66 years (Samso, 1994). Therefore, from the above references we can assume that the Zīj of al-Ṣūfī was a well known astronomical treatise which was widely circulated during that period; however, it is no longer extant (Mercier, 1987).

3.4 Al-Ṣūfī's Observatory.

Arabic and Islamic astronomers were well known for their accurate observations of the sky. Their astronomical observations and results for the positions of the planets, Sun and Moon are proof of the accuracy of their results. Many observatories have been built throughout the Islamic world such as Qāsūon Observatory in Damascus, al-Shamāsīya Observatory in Baghdad and Ibn-Yūnus Observatory in Cairo. Many prominent scientist and astronomers such as al-Khawarizmī, al-Battānī, Ibn-Yūnus as well as al-Ṣūfī were appointed to observe the night sky, develop new research methods and construct new astronomical instruments. These observatories were influenced by early ancient observations and instruments constructed by the Greeks, Babylonians, Indians and the Persians. During the 10th century the main observatories, which were patronized by royal kings and princes, reached a new stage of development whereby they became specialized institutions dedicated to research in astronomy. However, these observatories were not administratively organized until the next century after the construction of al-Ṣūfī's observatory (Sayili, 1960).

Around the 10th century, al-Ṣūfī became by far one of the greatest of those observational astronomers who was lucky to have had the patronage of an important ruler of that period. His early observations were probably made in his home city of Rayy. It is also believed that he must have spent his own money on the construction of astronomical instruments as did many astronomers before him. Al-Bīrūnī writes in *al-Qānūn al-Mas'ūdī* (A.D. 1030) and in another treatise *Taḥdīd al-Āmākin* that Ibn al-'Amīd ordered the construction of a mural quadrant in the city of Rayy in A.D. 950. This instrument was used by Abū al-Faḍel al-Hirawī and Abū Ja'far al-Khāzin to measure the obliquity of the ecliptic. If Ibn al-'Amīd was the person to whom al-Ṣūfī refers as his teacher Abū al-Faḍel Muḥammad Ibn al-Ḥusaīn then he must have known about this instrument and was probably one of the important people who worked at this observatory in the city of Rayy. A mural quadrant is an angle-measuring device mounted on or built into a wall which was oriented on the meridian. A similar instrument was used by Tycho Brahe at his observatory in Uraniborg as pictured in the figure 8 below.

Figure 8 A Mural Quadrant Instrument Mounted or Built into a Wall

Al-Bīrūnī stated in his book *Taḥdīd al-Āmākin* that al-Ṣūfī built an observatory under the patronage of ʻAḍud al-Dawla in Shiraz where he must have made most of his observations. Al-Ṣūfī mentioned in his ʻ*Book of the Fixed Stars*' in the chapter on the constellation Taurus that the observations he made were from the third climatic zone. This most probably corresponds to the city of Shiraz (Latitude: 29:53. Longitude: 52:58). He also measured the obliquity of the ecliptic from the year A.D. 965 until A.D. 970 from the same city. The observations of al-Ṣūfī and measurements of the obliquity were also later favorably mentioned by Ibn-Yūnus. Al-Bīrūnī also said that al-Ṣūfī observed the vernal equinox and the autumnal equinox from the city of Shiraz. The instrument which was utilized for this observation was an equatorial ring, similar to the one in figure 9, with a diameter of about 250 cm, having a 5 min subdivision on its scale. This instrument was considerable in size and was thus called the ʻ*Aḍudī* Ring after the ruler ʻAḍud al-Dawla who must have also participated at this Observatory along with many important astronomers of that time such as al-Quhī, al-Sijzī, Ibn Yumn al-Yūnānī and Gulām Zuḥal. The ʻ*Aḍudī* Ring was also mentioned in al-Ṣūfī's book in the chapter of constellation Argo Navis, where it was used to determine the latitude of the city of Shiraz as 29 deg and 36 min. The ʻ*Aḍudī* Ring was also mentioned in other historical references such as the work of al-Nasawī and by the astronomer Ghīyāth al-Dīn al-Kashī (Sayili, 1960:105).

The Arabs and Muslims also developed and constructed many astronomical instruments which were used to conduct important observations during the Middle Ages. It is also a well-known fact that many different instruments were used in those observatories

(Sayili, 1960:307). Even though these instruments might have been old Babylonian, Indian or Greek inventions, the Arabic and Islamic astronomers developed the instruments taking them to new levels of sophistication as well as inventing new types of astronomical instruments. From the few available treaties written by al-Ṣūfī on the astrolabe and the celestial globe and from the available historical records, we know that al-Ṣūfī used several observational instruments such as a sundial, a quadrant, an astrolabe, a globe, a five-meter diameter equinoctial armillary sphere and different sized Rings.

Al-Qifṭī wrote that Ibn Sunbūdī, who was considered to be an able an astronomer and an instrument maker, saw at the Cairo library in A.D. 1043 a celestial globe made of silver which was constructed by al-Ṣūfī for ‘Aḍud al-Dawla. According to Ibn Sunbūdī the weight of this globe was three hundred *dirham* and it was purchased for three thousand *dīnār*. It must have been a considerable piece of work, but unfortunately it is no longer available today. Al-Qifṭī also states that this Ibn Sunbūdī also saw in Cairo another celestial globe made of copper by Ptolemy which had been in the possession of Prince Khāled Ibn Yazīd Ibn Mu’aweyah.

Figure 9 An equatorial ring

3.5 The Importance of al-Ṣūfī in the History of Astronomy

Al-Ṣūfī's work has been mentioned throughout history. Many of the most influential Arabic and Islamic scientists, scholars and astronomers have based their work and astronomical observations on al-Ṣūfī's work. Al-Ṣūfī was also mentioned by Western scholars as well as by modern astronomers. Throughout history al-Ṣūfī's name was sometimes miss-spelled or miss-written. He has been referred to by various names such as Esophi by Leo Africanus, and Azophi by the Spanish Jewish astronomer Ibn 'Ezra (Kunitzsch, 1986). He was again mentioned by the name Azophi by the 16th century European map makers Albrecht Durer and by Peter Apian (Kunitzsch, 1987). Even though al-Ṣūfī's name only appears once as Abolfazen in the Alfonsine Tables, he was many times referred to throughout the whole work as one of the 'learned men' (Samso, 1994). Al-Ṣūfī's influence on astronomy and stellar nomenclature can also be traced to other cultures as far as East Africa, the Comoros Islands and Madagascar (Brown, 2009).

I have tried to list below some of the important scholars and astronomers who have made use of al-Ṣūfī's work, starting from the 11th centaury after al-Ṣūfī's death and up to the beginning of the 20th century. I have included the contribution which al-Ṣūfī made to the work of these scientists. This list by no means cites all the references which include al-Ṣūfī's work but it covers a few important examples of the influence which al-Ṣūfī and his book has had in the history of astronomy over the past 10 centuries.

a) Al-Bīrūnī

Abū al-Raīḥān al-Bīrūnī was born in Khawarizm (now in present Uzbekistan) in A.D 973 and died in A.D. 1048 in Ghazna (now in present Afghanistan). He was an outstanding astronomer, mathematician, physicist, physician, geographer, geologist and historian. His great contributions in so many diverse fields earned him the title the 'Master' or 'Professor par excellence'. Some historians have called the period of his activity as the 'Age of al-Bīrūnī'. Al-Bīrūnī wrote many important books on astronomy and other related subjects some of which are:

- *Al-Āthār al-Bāqīya* is a treatise on timekeeping written in A.D. 1000. Al-Bīrūnī mentions al-Ṣūfī several times in this book in the last chapter on the lunar mansions. He remarks that the information he has on this subject was collected from several books such as the works of Ibn-Kunāsa, Al-Daīnawari and al-Ṣūfī. This book also includes a table of the Arabic lunar mansions with star magnitudes as mentioned by Abū al-Ḥusaīn al-Ṣūfī.

- *Al-Tafhīm Li Awa'el Sinā't al-Tanjīm* is a book that is an introduction and a summary on mathematics, astronomy and astrology written in A.D. 1029. While commenting on the Arabic name of the constellation Andromeda al-Bīrūnī makes a reference to the way al-Ṣūfī depicts this constellation.
- *Al-Qānūn al-Mas'ūdī Fi al-Haya' Wa al-Nujūm* was written in A.D. 1030. This book was dedicated to Sultan Masūd al-Ghaznawī. It discusses several theories on trigonometry, astronomy, solar and lunar and planetary motions, and also contains a collection of twenty-three observations of equinoxes. In this book we find many references to the observations made by al-Ṣūfī. Al-Bīrūnī also included a star catalog based on that produced by al-Ṣūfī. He even made a comparison of the star magnitudes between Ptolemy and al-Ṣūfī, however he also criticized al-Ṣūfī for not going further in correcting many of the mistakes which were found in the *Almagest*. The *al-Qānūn* of al-Bīrūnī also included astrological tables which were produced by al-Ṣūfī in his book *Matāreh al-Shu'a*'.
- *Taḥdīd al-Amākin* is a treatise on geography. In this book we also find references to the observation as well as the observatory of al-Ṣūfī and many other astronomers of that period.

b) Ibn-Yūnus

Ibn-Yūnus was an important mathematician and astronomer of the late 10th century. His name was Abū al-Ḥasan 'Alī Abū Sa'id 'Abd al-Raḥmān Ibn Aḥmad Ibn Yūnus al-Sadafī al-Masrī. He was born around A.D. 950 and died in A.D. 1009 in the city of Cairo. He worked as an astronomer for the Fatimid Dynasty for twenty-six years during the reign of the Caliph al-'Az*ī*z and then al-Ḥākim. Ibn-Yūnus dedicated his most famous astronomical work, *al-Zīj al-Kabīr al- Ḥākimī,* to the Fatimid caliph al-Ḥākim Bi *Ā*mr Allah. In this *Zīj* we find references to al-Ṣūfī's *Zīj* and praise for al-Ṣūfī's observations which Ibn-Yūnus must have used for his own calculations (Sayili, 1960).

c) Bahā' al-Dīn al-Karaqī

Al-Karaqī wrote his *Montaha al-Idrāk fi Taqāsīm al- Āflāk*. This book contains a catalog of eighty-one stars which were based on al-Ṣūfī's book. Al-Karaqī adjusted his data for precession for his epoch of 1 October A.D. 1112 by adding 2 deg 15 min to al-Ṣūfī's longitudes. A copy of this book is found at the library of Berlin (manuscript MS Ahlwardt 5669) (Kunitzsch, Encyclopedia Iranica).

d) Al-Ṭūsī

Al-Ṭūsī was another important Persian mathematician and astronomer of the 13th century. He was also known as a biologist, chemist, philosopher, physician, scientist and theologian. His full name was Muḥammad Ibn Muḥammad Ibn al-Ḫasan al-Ṭūsī better known as Naṣīr al-Dīn al-Ṭūsī. He was born in A.D. 1201 in the city of Ṭūs (Khorasan Province) and died in A.D. 1274 in Baghdad. He was at first a member of the Isma'ilī sect and later he switched to the Twelver Shī'ah sect. At the beginning of the Mongol invasion he joined the ranks of the Ismaili order but later he joined the forces of Hulagu-Khan after the Mongols occupied the Alamut castle which was an Isma'ilī stronghold. Al-Ṭūsī later befriended Hulagu-Khan and convinced him to construct an observatory to establish accurate astronomical tables for the purpose of astrological predictions. In A.D. 1259 al-Ṭūsī finished the construction of this most advanced observatory in the city of Maragha which was the capital of the Ilkhanate Empire during this period. Al-Ṭūsī produced his famous work *Zīj al-Ilkhānī* based on the observations made at this observatory. *Zīj al-Ilkhānī* contained the most accurate and extensive astronomical tables for the positions of the stars based on the catalog of al-Ṣūfī.

Figure 10 The Final Page of the Manuscript OR5323 Preserved at the British Library.

Al-Ṭūsī also made a Persian translation of al-Ṣūfī's book which was later used by Ulugh Bēg (Kunitzsch, 1986). The above figure 10 is the final page of the manuscript OR 5323 preserved at the British library in London and dating from the 14th century A.D. This manuscript has the seal of Hulagu which indicates that it was one of the manuscripts that was available in the library of this Mongol ruler and therefore must have been also available to al-Ṭūsī.

e) Ulugh Bēg

Ulugh Bēg was the Timurid ruler who lived in the capital city of Samarkand in the 15th century. His name was Mirza Muḥammad Taregh Ibn Shahrokh known under the title of Ulugh Bēg which means the ‘Great Ruler’. He was born in Sultaniyeh in Persia in A.D. 1393 and was killed by his son on A.D. 1449 and is buried in Samarkand. He was also famous as an astronomer and mathematician during that period. In A.D. 1428 he built an enormous observatory where he compiled, in A.D. 1437, the *Zīj al-Ṣultānī*. This Zīj contained a star catalog with 994 stars which was considered the best star catalog since the work of al-Ṣūfī. Ulugh Bēg mentioned that “…we have observed all the stars except 27 stars which were too far to the south to be visible at the latitude of Samarkand, and we have taken these 27 stars from the work of ‘Abd al-Raḥmān al-Ṣūfī.” (Knobel, 1917). In Knobel’s study of the magnitude of the stars in Ulugh Bēg’s catalog he concluded that Ulugh Bēg did not observe the magnitudes of any stars and those he gives were simply copied from the magnitudes in al-Ṣūfī’s Catalog. On the other hand, Kunitzsch mentions that Ulugh Bēg used al-Ṭūsī’s Persian translation to compile his catalog rather then al-Ṣūfī’s original Arabic text. However, another study of the magnitude system in old catalogs showed the independence of the catalogs of al-Ṣūfī and Ulugh Bēg. Even though Ulugh Bēg was influenced by al-Ṭūsī’s Persian translation as well as al-Ṣūfī original Arabic work, he did not entirely duplicate their catalogs (Fujiwara, 2004).

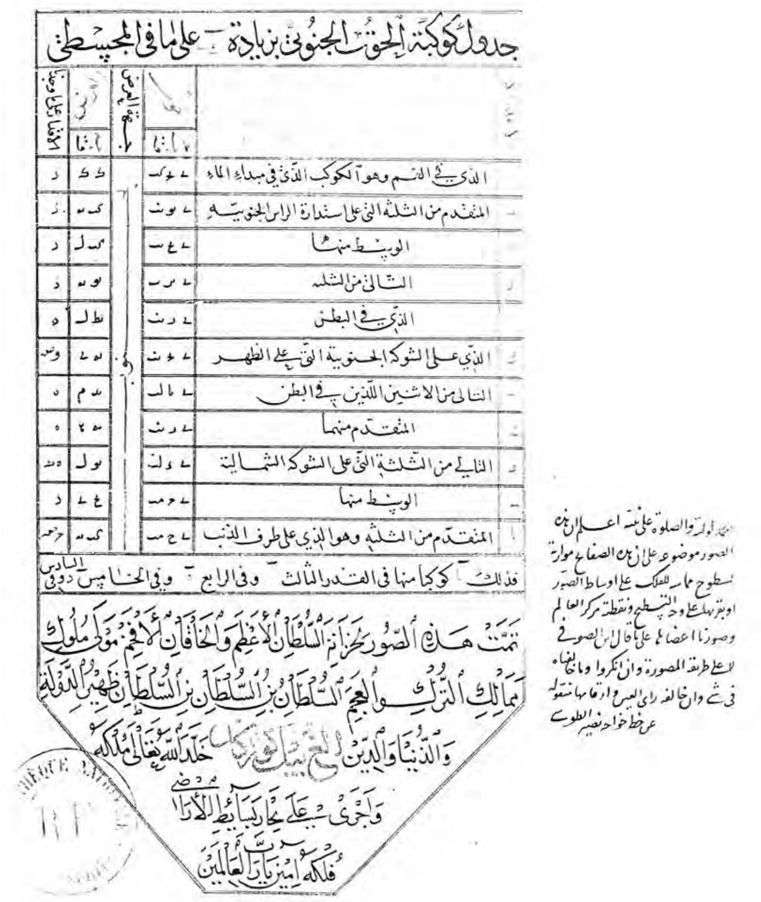


Figure 11 The Final Page of the Manuscript MS5036 Preserved in Paris.

The above Figure 11 is the final page of the manuscript MS5036 preserved in Paris. It is Ulugh Bēg's personal copy of al-Ṣūfī's *Book of the Fixed Stars*. The statement at the end of this manuscript relates that this copy was produced for the library of King Ulugh Bēg. The statement next to the table asserts that the pictures were drawn according to the instructions of Ibn al-Ṣūfī and the data were taken from the copy of Khawājā Naṣīr al-Dīn al-Ṭūsī. This is a very interesting manuscript in that it shows how information was transferred from al-Ṣūfī to al-Ṭūsī until it reached Ulugh Bēg. We also have here an early example of a mistake in that al-Ṣūfī is referred to by the name of 'Ibn al-Ṣūfī'.

f) Zakarīyā Ibn Muḥammad al-Qazwīnī

Al-Qazwīnī was a Persian physician, astronomer, geographer, judge and writer. He was born in the city of Qazwīnī in A.D. 1203 and died in A.D. 1283. His full name was Abū Yehyā Zakarīyā Ibn Muḥammad al-Qazwīnī. He wrote several books but the most famous was his Cosmography called '*Ajā'eb al-Makhlūqāt wa Ghrā'eb al-Mawjūdāt* (*Marvels of Creatures and Strange Things Existing*). This work was very popular and was frequently quoted throughout the Arab and Islamic world. It is preserved today in many copies in many libraries and it was also translated into Persian and Turkish. The descriptions of the forty-eight constellations in this book were taken directly from al-Ṣūfī's book however al-Qazwīnī does not mention al-Ṣūfī or the sources of his information. Another of al-Qazwīnī's work was his geographical dictionary called, *Athār al-Bilād wa-Akhbār al-'Ibād (Monument of Places and History of God's Slaves).*

g) The Authors of Alfonsine Treatises

The Alfonsine Treatises were a collection of about 30 treatises written in the city of Toledo in Spain by the order of the Castilian King Alfonso the 10th (Chabas et al., 2003). The most important of these treatises was the Alfonsine Tables which was a book or a *Zīj* on astronomy compiled mainly to correct anomalies in the previous Tables of Toledo written by Gerard of Cremona and based on the work of al-Zarqālī. Another of those treatises was a collection of books called '*the Four Books on the Eighth Sphere*' also called *Libros de las Estrellas Fixas (Books on the Fixed Stars)*. These works were not only a translation but rather a summary or a compilation in which al-Ṣūfī was the main source used (Samso, 1994). The first draft of these works were made in Toledo in A.D. 1256 by Yehudah Ibn-Mosheh and Guilleb Arremon Daspa but were later revised in A.D. 1276 again by Yehudah Ibn-Mosheh with the help of Joan de Mesina and Joan de Cremona. Most of the Alfonsine Treatises were originally written in Spanish but many were later translated into Latin. The Alfonsine Treatises were the most popular astronomical books in Europe until the late 16th century. According to Samso (1994) the '*Four Books on the Eighth Sphere*' might be considered one of the sources through which al-Ṣūfī's star catalog could have been introduced into Europe despite the fact that it was written in Spanish and not Latin. *ḥ*

h) Aḥmad Ibn Mājid

Aḥmad Ibn Mājid, known as the 'lion of the sea', was one of the most famous Arab seafarers of the Indian Ocean in the 15th century. He was born in Julfar near Rās al-Khaīmah in present day United Arab Emirates. He wrote more than 40 treatises on navigation in the Arab and Indian Ocean. Ibn Mājid was known to have guided Vasco da Gama from the coast of East Africa to Calicut in India in A.D. 1498. Ibn Mājid knew the work of al-Ṣūfī and quoted him in his book '*Kitāb al-fawā'ed Fi Osūl 'Ilm al-Bahr wa al-Qawā'd*' (Kunitzsch, Encyclopedia Iranica). The interaction and works of such Arab seafareres and traders helped to spread Arabic astronomy such as the astronomy of al-Ṣūfī through out the cultures surrounding the Indian Ocean.

i) Albrecht Durer

Albrecht Durer was a well-known German painter and printmaker. He was regarded as one of the greatest artists of the Renaissance in Northern Europe. He also produced theoretical treatises on geometry, mathematics, prospective and ideal proportions. He was also known for making the first printed star maps in Europe. Albrecht Durer was born in the city of Nuremberg on the 21st of May 1471 and died on the 6th April 1528.

The Figure 12 shows the northern star chart printed by Durer in Nuremberg, Germany in 1515. The chart consisted of a pair of woodcuts depicting the northern and southern sky with the constellation figures known to European astronomers at that period. All previous European and Arabic star charts were individually hand-drawn, and hence restricted to single copies. In the corners of the northern chart, Durer draws four figures. The first was Aratus Cilix' (Aratus of Cilicia). The second was 'Ptolemeus Aegyptus' (the Egyptian Ptolemy). The third was 'M. Mamlius Romanus' (the Roman Marcus Manilius). And finally on the bottom right of the chart we find 'Azophi Arabus' (the Arab al-Ṣūfī).

Figure 12 Northern Star Chart Printed by Durer in Nuremberg, Germany, in 1515

Figure 13 Apian’s Star Charts Drawn in the Form of an Eight-Sided Astrolabe

j) Peter Apian

Peter Apian was a German mathematician, astronomer and cartographer. He was born in Leisnig in Germany on the 16th of April 1495 and died in Ingolstadt on the 21st of April 1552. He wrote his *Cosmographicus liber* in 1524 and his *Astronomicum Caesareum* in 1540. These were important works on astronomy that were very popular until the 17th century. Apian also produced several works on mathematics and astronomy such as sine tables, and manuals on the use of instruments such as sundials, as well as measuring instruments used for calculating time and distance. He was also one of the first astronomers to discover that a comet's tail always points away from the Sun. The *Astronomicum Caesareum* included star charts which were probably derived from the earlier works of Durer. Apian’s charts were drawn in the form of an eight-sided astrolabe, complete with handles (Figure 13). Apian’s star charts introduced many star names which were taken from Arabic sources. Apian wrote in his book that he knew al-Ṣūfī’s book on the constellations and he mentioned al-Ṣūfī by the name of ‘Azophi’. An earlier star chart also produced by Apian in 1533 depicts the figure of the constellation Ursa Major as three female figures in front of another woman sitting on a chair. This constellation in Arabic tradition was referred to as ‘*Banāt Na‘esh’* (The Daughters of the Bier or Coffin). Durer’s work was the source that Apian used for drawing this constellation (Kunitzsch, 1987). Therefore, Apian as well as Durer before him must definitely have had original Arabic copies of al-Ṣūfī’s book which they extensively utilized in their astronomical work and star charts.

k) Christian Ludwig Ideler

Christian Ludwig Ideler was a German chronologist and astronomer. He was born near Perleberg in Germany on the 21st of September 1766 and died in Berlin on the 10th of August 1846. In 1825 he published his great work, *Handbuch der mathematischen und technischen Chronologie* in two volumes. It was re-edited in 1831 as Lehrbuch der Chronologie. Ideler's other work, which deals with the history of astronomy, was his important book Untersuchungen über den Ursprung und die Bedentung der Sternnamen: Ein Beytrag zur Geschichte des gestirnten Himmels which he published earlier in 1809. As the title implies, this is an investigation on the origin of the names of stars and a history of the celestial sky. Ideler mentions al-Ṣūfī and his work as many as 30 times in this major reference on the history of stellar astronomy. Kunitzsch (1979) who is the best know authority on ancient stellar nomenclature, believes Ideler's book to be the best written reference on this subject. This is despite the fact that many other works were written later on the origin of stellar names, including the famous book by Richard Hinckly Allen (*Star Names and their Meanings*) which also utilized the work of al-Ṣūfī.

l) Friedrich Wilhelm August Argelander

Friedrich Wilhelm August Argelander was a Prussian astronomer known for his work on determinations of stellar brightness, positions and distances. He was born in the city of Memel in the Kingdom of Prussia (now in Lithuania) on the 22nd of March 1799 and died in Bonn on the 17th of February 1846. Between 1852 and 1859 Argelander together with A. Kruger and E. Schonfeld produced the famous star catalog known as the *Bonner Durchmusterung* which gave the positions and magnitudes for more than 324,000 stars. This catalog is considered to be the last major star map published without the use of photography. In the French translation of al-Ṣūfī's book Schjellerup makes a comparison between the stellar magnitudes of Ptolemy, al-Ṣūfī and Argelander which were the most up-to-date values at that time.

m) Peters and Knobel

Christian Heinrich Friedrich Peters was a German-American astronomer and one of the first astronomers to discover asteroids. He was born on the 25th of September 1813 and died on the 18th of July 1890. Edward Ball Knobel was an English businessman and amateur astronomer. He was born in London on the 21st of October 1841 and died on the 25th of July 1930. He was the President of both the British Astronomical Association and the Royal Astronomical Society. Peters and Knobel were interested in the works of Ptolemy and the early Arabic and Persian astronomers. In 1915, after Peters' death, Knobel published a collated study of Ptolemy's star catalog and in 1917 Knobel again published a collated study of Ulugh Beg's star catalog, both of which were based on Peters' earlier unpublished notes and studies. In his study of Ulugh Bēg's star catalog Knobel identifies two important works on observational astronomy which the Arabs left to posterity. The first was the *Hakemite Tables* of Ibn Yūnus, the other was the *Uranometria* of 'Abd al-Raḥmān al-Ṣūfī which, as he mentioned, must be considered a work of the highest value.

3.6 A Crater on the Moon and a Main Belt Asteroid Named al-Ṣūfī

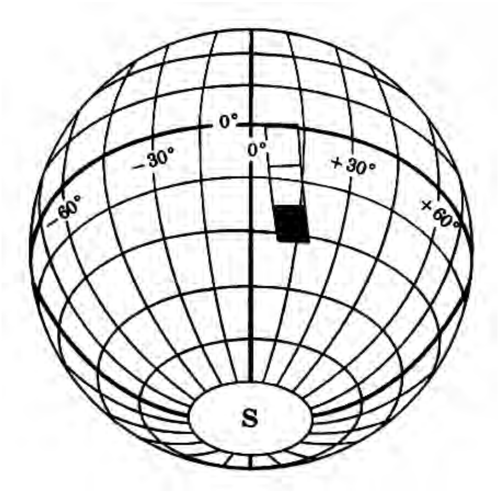
Finally, to end this section on al-Ṣūfī's biography and bibliography on a light note, I include below a brief description on the crater on the Moon named 'Azophi' and the main belt asteroid designated as '12621 al-Ṣūfī'.

a) A Crater on the Moon Named 'Azophi'

In 1651 Johann Baptist Riccioli published one of the first detailed maps of the Moon the *Almagestum Novum* (Sky&Telescope, April 2009). Riccioli adopted the names of 247 scientist and philosophers for the lunar craters most of which we still in use today. He named one of the craters 'Azophi' (Figure 14). In 1935 the International Astronomical Union's Committee on Lunar Formations published their report in which they re-confirmed the name of the crater 'Azophi' to commemorate the name of this important astronomer in the history of astronomy. The members of this committee were: Mary, Blagg; K. Müller; W. H.Wesley; S.A Saunder and Franz, J. London. Their report was published by P. Lund, Humphries and Co. in 1935.

Figure 14 Riccioli map of the Moon with Azophi name highlighted in red.

I have identified the location of the 'Azophi' lunar crater in Figure 15 and included below is a modern photograph of it in Figure 16.



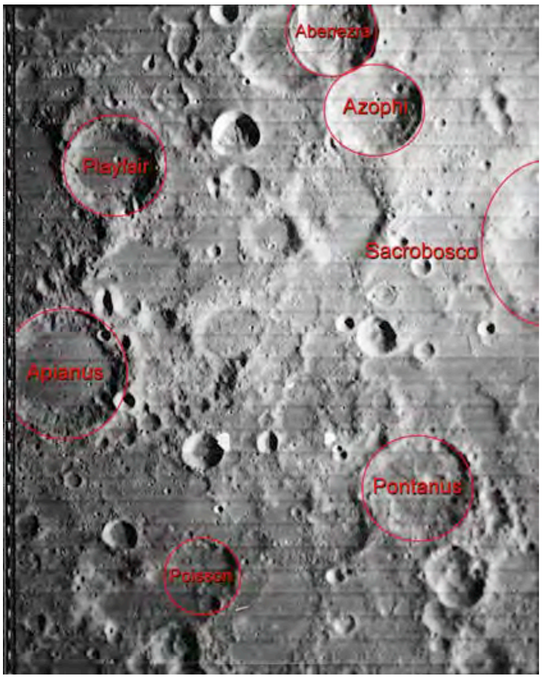


Figure 15 Location of the Azophi Moon Crater Figure 16 Modern Picture of Azophi Crater

b) The Main-Belt Asteroid “12621 al-Ṣūfī”

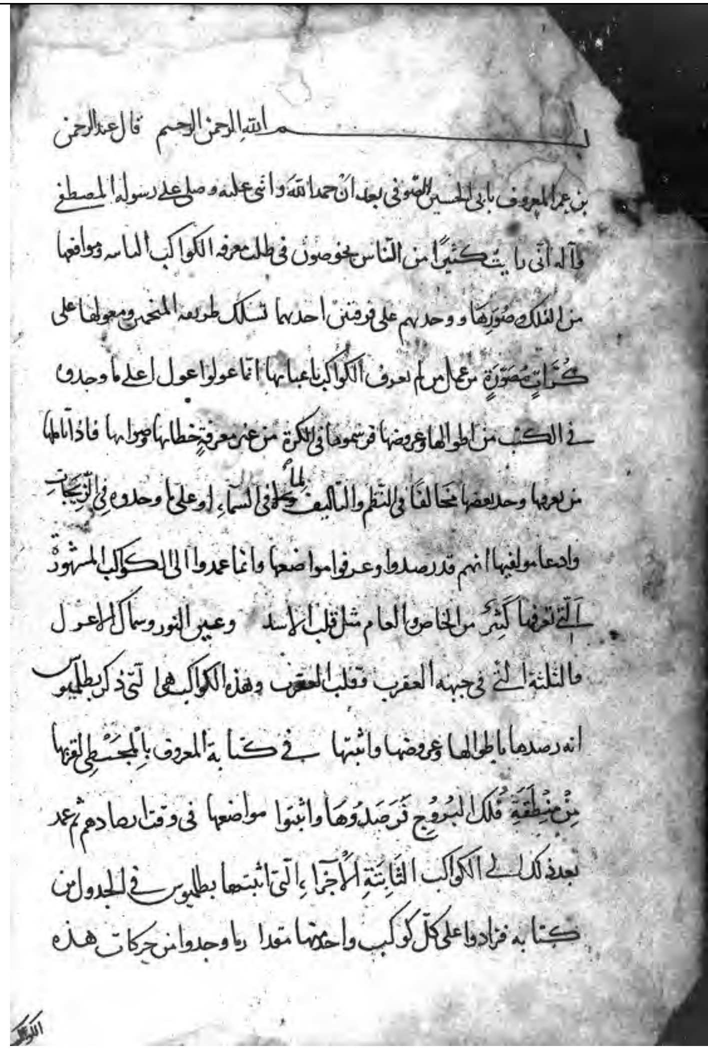
In 24th of September 1960 C.J. van Houten and I. van Houten-Groeneveld discovered on a Palomar Schmidt plate taken by T. Gehrels a minor planet which was designated ‘6585 P-L’. It was later called ‘12621 al-Ṣūfī’ by the International Astronomical Association (IAA). ‘12621 al-Ṣūfī’ is a main-belt asteroid with an orbital period of 1998.1141133days (5.47years). (Nasa website ttp://ssd.jpl.nasa.gov/sbdb.cgi?sstr=12621)

4.1 al-Sufi Introductory chapter

Folio 1 (Manuscript: Marsh 144)

In the name of Allah, the most Gracious most Merciful.

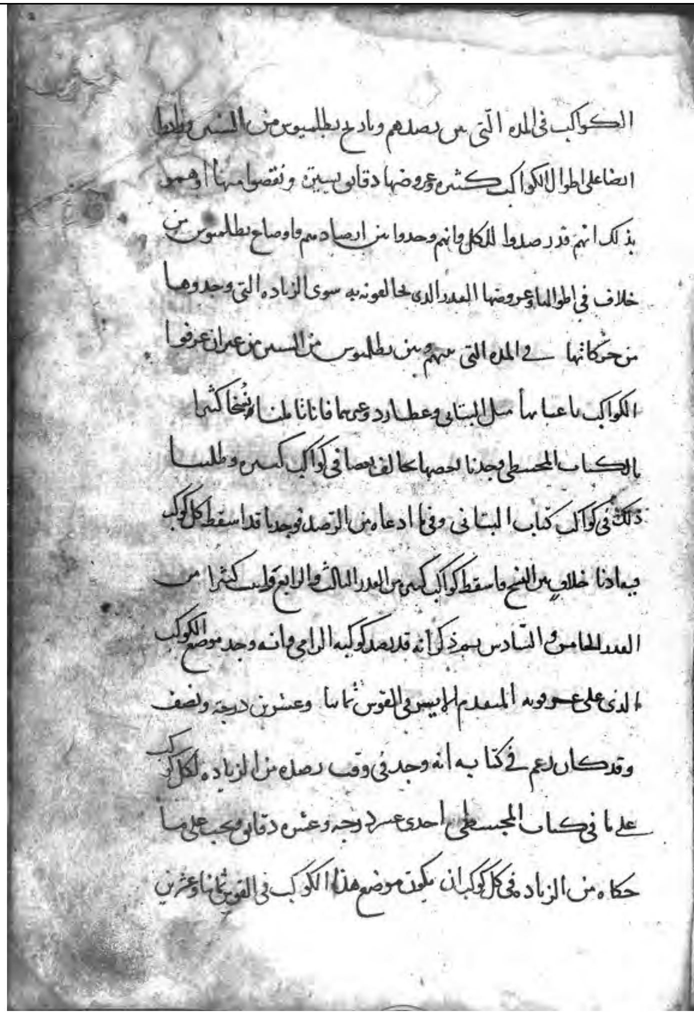
ʹAbd al-Raḥmān Ibn ʻUmar better known as Abū al-Ḥusaīn al-Ṣūfī said after he thanked Allah (God) and praised him and prayed for the blessing and peace on his prophet (Muḥammad) *al-Muṣṭafa* (the chosen).
I have seen many people delve into the knowledge of the fixed stars, their positions and their (constellation) images and I found them to be two groups:
The first (group) took the road of the *Munajjimīn* (astronomers) utilizing picturesque celestial globes constructed by those who did not observe the stars with their own eyes. However they adopted the latitudes and longitudes which they found in books. They drew them on the globe without knowing which was false and which was true.
If somebody who knows (these stars) he will find that some are incorrectly drawn and composed from what is to be found in the sky or from what is to be found in the astronomical tables (*Zījāt*). Those composers claimed that they have observed them and that they know their positions. However they have relied on the famous stars which are known by many people like *Qalb al-Asad* (Regulus), *ʻAin al-Thawr* (Aldebaran), *al-Simāk al-A'zal* (Spica) as well as the three stars on the forehead of Scorpio (HR5984, 5953, 5944). All these stars have been mentioned by Ptolemy who said that he observed their latitudes and longitudes and confirmed this in his famous book *Almagest* to be close to the zodiac region. They (*Munajjimīn)* claimed to have observed and authenticated these positions at the time of their observation. They turned then to the other fixed stars which had been determined by Ptolemy in the tables of his book. They added on every one of these stars the difference in years for the movement of the stars……



Folio 2

…..from the date of their observation and the date of Ptolemy. They also added or subtracted several minutes from the latitudes and longitudes of many stars in order to make the illusion that they observed all these (stars) themselves. They claimed that they found from their own observations differences in latitudes and longitudes from those of Ptolemy's in addition to the yearly (precession) movement between their time and the time Ptolemy. However, these (astronomers) such as *al-Battānī*, *'Utāred* and others, did not observe those stars by their own eyes.

We have seen many copies of the book of the *Almagest* and we found (the positions) of many stars (in these copies) contradict each others. We then looked in *al-Battānī's* book, and what he claimed to have observed himself, and we found that he dropped those stars which had the slightest difference in the various copies (of the *Almagest*). Therefore he dropped many stars of the 3rd and 4th magnitudes while he kept many in the 5th and 6th magnitudes. He also mentioned that he observed the constellation Sagittarius and he found the coordinate of the star which is on the forward left hock to be twenty-eight and a half deg. And then he claimed in his book that he found at the time of his observation that the addition (due to precession) on every star on what was in Ptolemy's *Almagest* to be eleven deg and ten min. Based on what he (*al-Battānī*) said, with the addition on every star, the coordinate of this star at the time of his observation should have been twenty-eight deg and fifty min.

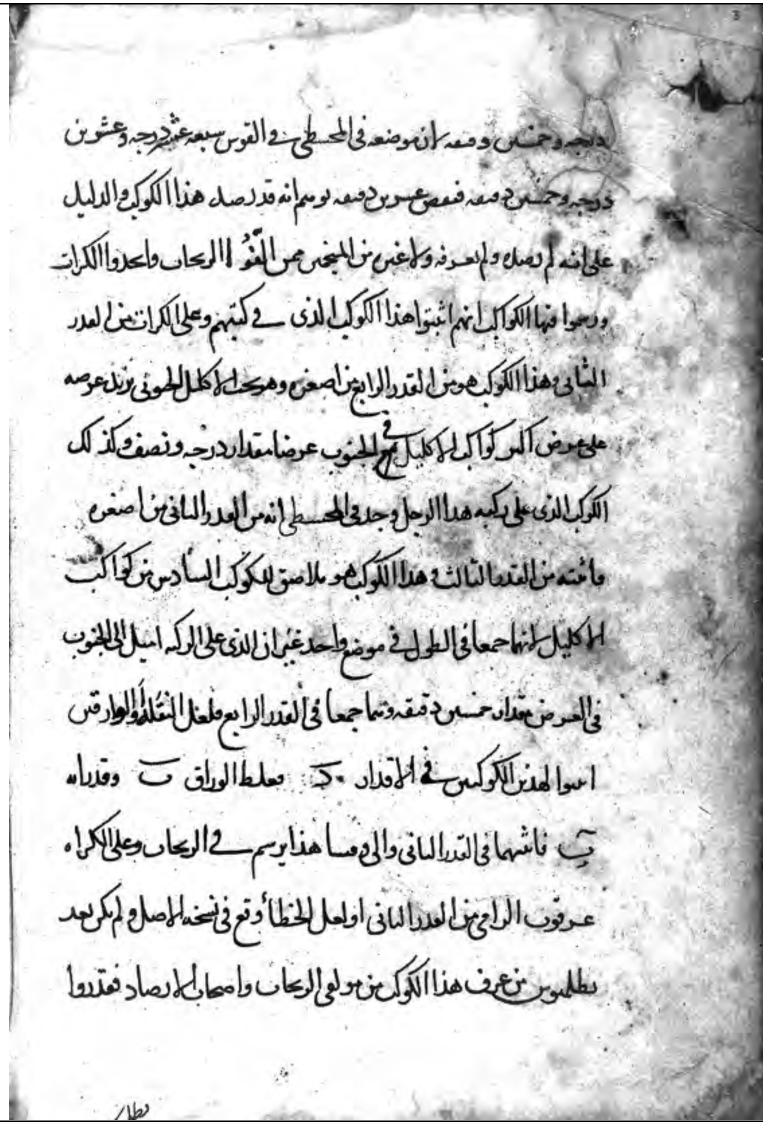


Folio 3

This is because its coordinates in the *Almagest* is seventeen deg and forty min in Sagittarius. By reducing these twenty min he (*al-Battānī*) makes the illusion that he observed this star. The (other) proof that neither he nor the other astronomers, who wrote astronomical tables and constructed and drew on the celestial globes, observed this star is that they confirmed in their books and on the globes that it is of the 2nd magnitude. However this star is less then the 4th magnitude. This star is under the constellation Corona Australis and its latitude is greater than the latitude of the southernmost star in the constellation Corona Australis by one and a half deg.

Also the star on the knee of this man (Sagittarius) is found in the *Almagest* to be less then the 2nd magnitude but was confirmed (by *al-Battānī*) as the 3rd magnitude. This star is close to the sixth star in the constellation of Corona Australis and they are all on the same latitude however this star which is on the knee is closer to the south in latitude by fifty min. All those stars are of the 4th magnitude.

Possibly the copiers and book-makers confirmed these two stars to be of the 4th magnitude but a copier made a mistake and set them to be of the 2nd magnitude. Until today the star of the left hock of Sagittarius is still copied and drawn on the celestial globes as the 2nd magnitude. However, the mistake was perhaps made in re-copying the original (*Almagest*) whereby compilers of tables and observers who came after Ptolemy did not know this star but they merely copied Ptolemy's (magnitude) and set this star to be of the 2nd magnitude.


درجه وخمسين دقيقه لان موضعه في المجسطي في القوس سبعة عشر درجه وعشرين
درجه وخمسين دقيقه فنقص عشرين دقيقه يوهم انه قد رصد هذا الكوكب والدليل
على انه لم يرصده ولم يعرفه ولا غيره من المنجمين ممن الفوا الزيجات وعملوا الكرات
ورسموا فيها الكواكب انهم اثبتوا هذا الكوكب الذي في كتبهم وعلى الكرات من القدر
الثاني وهذا الكوكب هو من القدر الرابع بل اصغر وهو تحت الاكليل الجنوبي ويزيد عرضه
على عرض الكواكب التي في الاكليل في الجنوب عرضا مقدار درجه ونصف وكذلك
الكوكب الذي على ركبه هذا الرجل وجد في المجسطي انه من القدر الثاني بل اصغر
واثبته من القدر الثالث وهذا الكوكب هو ملاصق للكوكب السادس من كواكب
الاكليل لانهما جميعا في الطول في موضع واحد غير ان الذي على الركبه اميل الى الجنوب
في العرض مقدار خمسين دقيقه وهما جميعا في القدر الرابع ولعل النقله والوراقين
اثبتوا هذين الكوكبين في الاقدار د فغلط الوراق ب وقدراه
ب فاثبتهما في القدر الثاني والى وقتنا هذا يرسم في الزيجات وعلى الكرات
عرقوب الرامي من القدر الثاني او لعل الخطأ وقع في نسخة الاصل ولم يكن بعد
بطلميوس من عرف هذا الكوكب من مؤلفي الزيجات واصحاب الارصاد فقلدوا

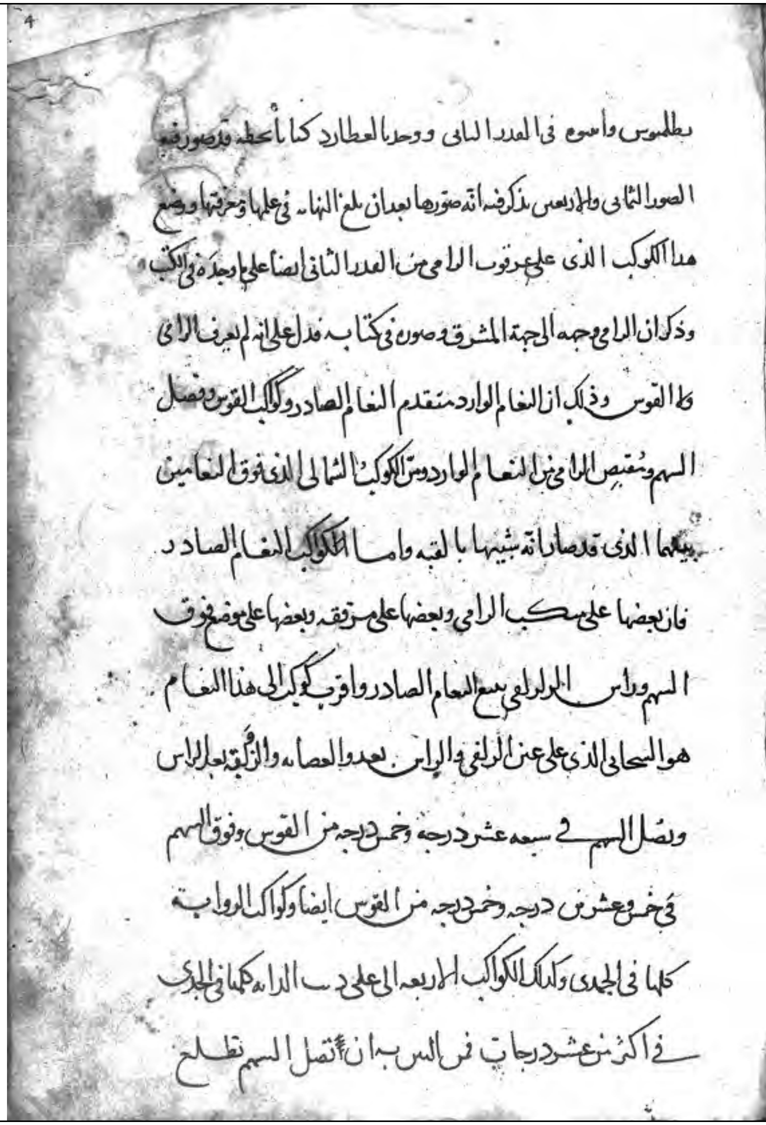
Folio 4

We found a book written by ‘*Utāred* in his own handwriting where he drew the forty-eight constellations stating that he drew these after he reached the highest level in this science and knowledge. He (also) placed this star on the hock of Sagittarius in the 2nd magnitude from what he found in books.

He (‘*Utāred*) mentioned that Sagittarius faces the east and he drew it in his book as such. This shows that he did not know Sagittarius nor the (stars) of the Bow (HR6859, 6879, 6913) because *al-Na‘ām al-Wārid* (asterism containing the Bow and the Arrow) is in front of *al-Na’ām al-Ṣādir* (asterism on the chest of Sagittarius). And the stars of the Bow, the star on the point of the Arrow (HR6746) and the star on the hand of Sagittarius (HR6859) are all part of *al-Na’ām al-Wārid* and are part of the northern star (HR6812) which resembles *al-Qubba* (a dome) which is above and between the two *Na’ām*.

Moreover, the stars of *al-Na’ām al-Ṣādir* are on the elbow of Sagittarius, some on the palm and some in a position above the arrow. The head of Sagittarius comes after *al-Na’ām al-Ṣādir*. The closest star to this *Na’ām* (*al-Ṣādir*) is a nebulae located in the eye of Sagittarius. It is followed by the head (of Sagittarius) then *al-‘Isāba* (an asterism in Sagittarius). After the head comes *al-Thuāba* (an asterism in Capricorn).

The star on the point of the Arrow (HR6746) is located seventeen and a fifth (12 min) of a deg in the Bow. The star above the arrow is located twenty-five and a half deg in the bow. The stars of *al-Thuāba* are all part of the constellation Capricorn. The four stars on the tail of *al-Thuāba* are also all in Capricorn as far as ten deg. Therefore it is obvious that the star on the point of the Arrow rises before the star above the Arrow and the star above the Arrow (rises) before *al-Thuāba* and the head (of Sagittarius rises) before the tail.


بطلميوس واسوع في العدد الثاني ووجدنا العطارد كتابا بخطه فيه صور
الصور الثماني والاربعين يذكر فيه انه صورها بعد ان بلغ النهاية في علمها ومعرفتها ووضع
هذا الكوكب الذي على عرقوب الرامي من العدد الثاني ايضا على ما وجده في الكتب
وذكر ان الرامي وجهه الى الجهة المشرقية وصوره في كتابه فدل على انه لم يعرف الرامي
ولا القوس وذلك ان النعام الوارد متقدم النعام الصادر وكواكب القوس ونصل
السهم وقبض الرامي من النعام الوارد ومن الكوكب الشمالي الذي فوق النعامين
بينهما الذي قد صار انه شبيها بالقبة واما الكواكب النعام الصادر
فان بعضها على مرفق الرامي وبعضها على مرفقه وبعضها على موضع فوق
السهم ورأس الرامي يتبع النعام الصادر واقرب كوكب الى هذا النعام
هو السحابي الذي على عين الرامي والرأس يتبعه العصابة والذؤابة بعد الرأس
ونصل السهم في سبعة عشر درجة وخمس درجة من القوس وفوق السهم
في خمس وعشرين درجة وخمس درجة من القوس ايضا وكواكب الذؤابة
كلها في الجدي وكذلك الكواكب الاربعة التي على ذنب الذؤابة كلها في الجدي
في اكثر من عشر درجات من البين ان يتصل السهم يطلع

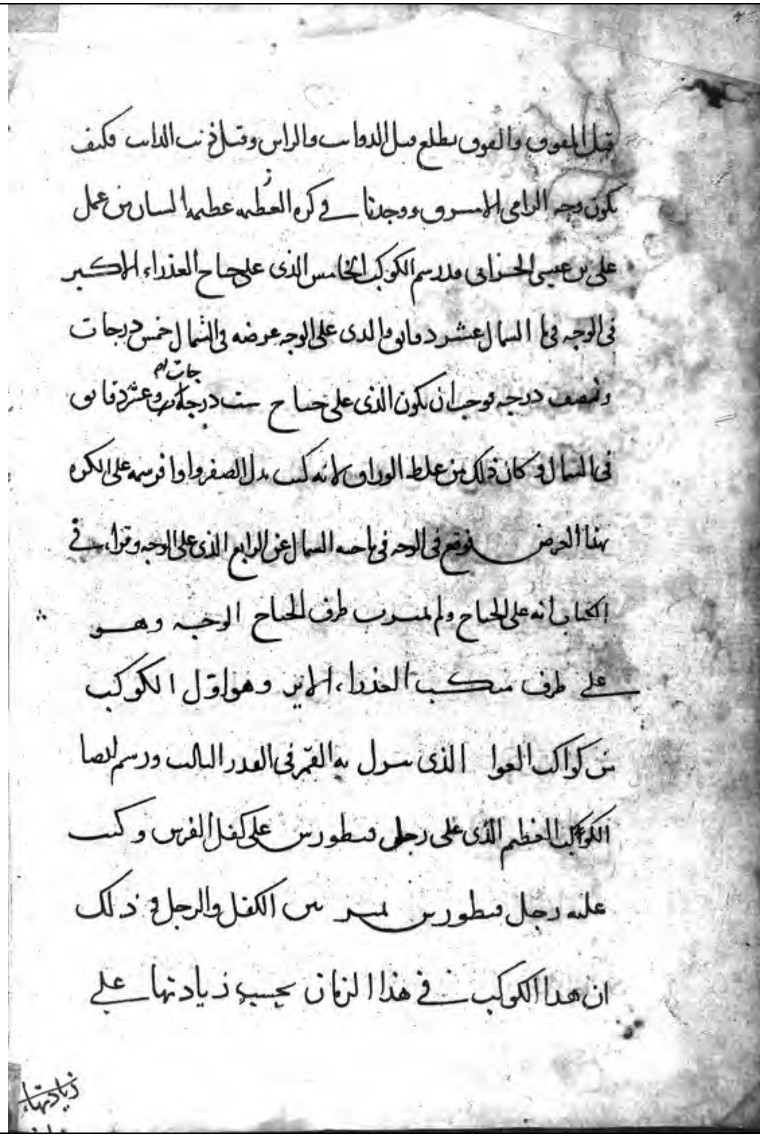
Folio 5

So how can the head of the Sagittarius face the east?

We also found on a large celestial globe, which was made by *'Alī Ibn-'Isa al-Harrānī,* that the fifth star on the left wing of Virgo was drawn on the face (of Virgo) and north of the fourth star on the face (of Virgo). This is wrong because the latitude of this star which is located on the wing is ten deg in the northern direction while the latitude of the star on the face is five and a half deg towards the north. Therefore the star which is on the left wing should be south of the star which is on the face by a distance of five and a third of a degree.

He (*'Alī Ibn-'Isa al-Harrānī*) found in a copy of Ptolemy's book, which was translated by *al-Hajjāj*, the latitude of the star on the wing to be six deg and ten minutes towards the north. This is a mistake by the copier because he wrote (the letter) *wāw* (و) (*wāw*=8) instead of zero. He then transferred this on the globe with this latitude which corresponded to the position on the face in the north close to the fourth star on the face of Virgo. He read in the book that it is on the wing but he did not distinguish between the tip of the wing and the face. This (star) is close to the left hand of Virgo and it is the first star of the constellation *al-'Awwā* (Bootes) which is a Lunar mansion. It is of the third magnitude.

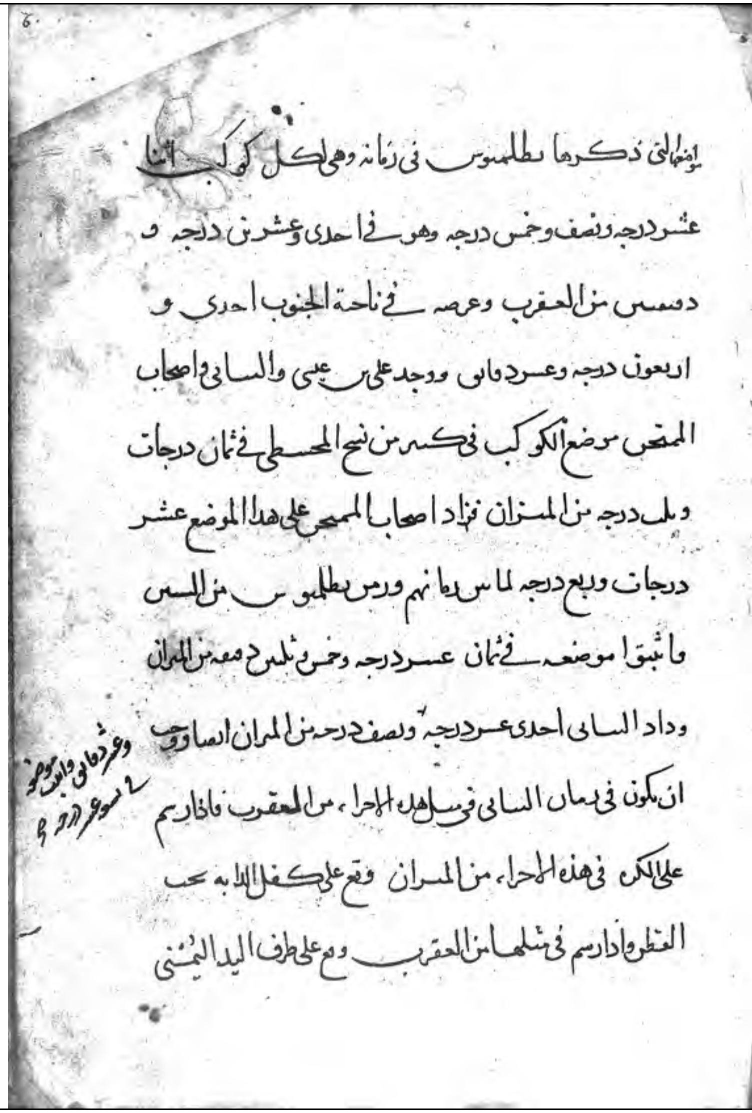
He ((*'Alī Ibn-'Isa al-Harrānī*) also drew the bright star which is on the Leg of Centauries on the End of Pegasus and he wrote on it the leg of Centauries and he did not distinguish between the (location of the) End and the Leg.



Folio 6

Because the (coordinate) of this star in our time, after we take what was mentioned by Ptolemy in his time and add an amount of twelve and a half deg and a fifth of a deg, becomes twenty-one deg and two min in the constellation of Scorpio and its latitude towards the south is forty-one deg and ten min.

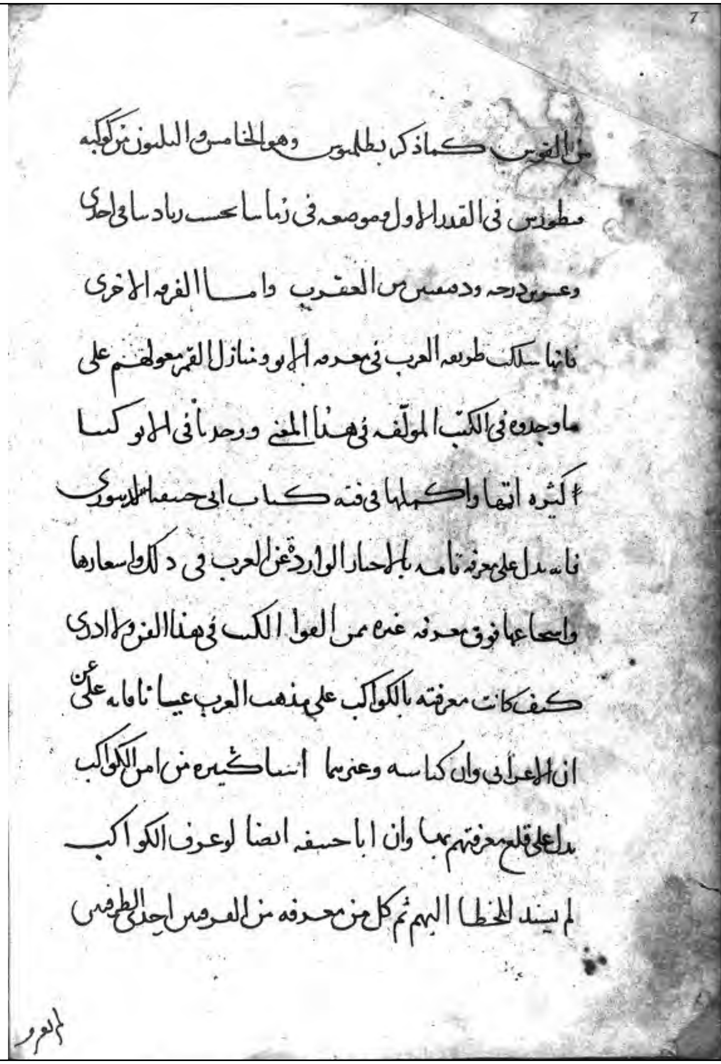
‘*Alī Ibn-‘Isa*, *al-Battānī* and the authors of *al-Mumtaḥen* tables all found the position of this star in many copies of the *Almagest* to be eight and a third of a deg in the constellation Libra. The authors of *al-Mumtaḥen* added to this position ten and a quarter of a deg accounting for the difference in year between their time and the time of Ptolemy. They confirmed its position to be eighteen deg and thirty-five min in the constellation Libra. While al-Battānī added eleven deg and ten min and confirmed the position at nineteen deg and a half in Libra also. However it is supposed to be at the time of al-Battānī at the same coordinates but in Scorpio because its position at the time of Ptolemy was eight and a third of a deg in Scorpio. Therefore if it is drawn on the globe on the constellation Libra it falls on the End the animal under the horse. And if it is drawn in Scorpio it will fall on the edge of the right hand of the constellation Sagittarius as mentioned by Ptolemy.



Folio 7

It is the thirty-fifth star in the constellation of Centauries. It is of the 1st magnitude and its position in our time after our addition is twenty-one deg and two minute in Scorpio.

Whereby the other group took the Arab method of the sciences of *al-Anwā’* and the Lunar mansions relying on what they found in books in these fields. We have found in the science of *al-Anwā’* many books, the best and most complete in this art was the book by Abū Ḥanīfa al-Daīnawari. This (book) shows his complete knowledge of Arab poetry and prose as was reported by the Arabs, more than any other writer who had written in this art. However I do not know how was his knowledge in the Arab method by way of star observation. Because he (al-Daīnawari) reports from Ibn al-Ā’rabī, Ibn Kunāsa and others many things about the stars which showed their little knowledge in this field. Therefore if Abū Ḥanīfa also knew about these stars then he would not re-copy the mistakes from them.


7

من القوس كما ذكر بطلميوس وهو الخامس والثلثون من كوكبة
مطورس في القدر الاول وموضعه في زماننا بحسب زيادتنا احدى
وعشرون درجة ودقيقتين من العقرب واما الفرقة الاخرى
فانها سلكت طريقة العرب في معرفة الانواء ومنازل القمر معولهم على
ما وجدوه في الكتب المؤلفة في هذا المعنى ووجدنا في الانواء كتبا
كثيرة اتمها واكملها في فنه كتاب ابي حنيفة الدينوري
فانه يدل على معرفة تامة بالاخبار الواردة عن العرب في ذلك واشعارها
واسجاعها فوق معرفة غيره من المؤلفين الكتب في هذا الفن ولا ادري
كيف كانت معرفته بالكواكب على مذهب العرب عيانا لانه عن
ابن الاعرابي وابن كناسة وغيرهما اشياء كثيرة من امر الكواكب
يدل على قلة معرفتهم بها وان ابا حنيفة ايضا لو عرف الكواكب
لم ينسب الخطأ اليهم ثم كل من عرفه من العرب احدى الطرفين

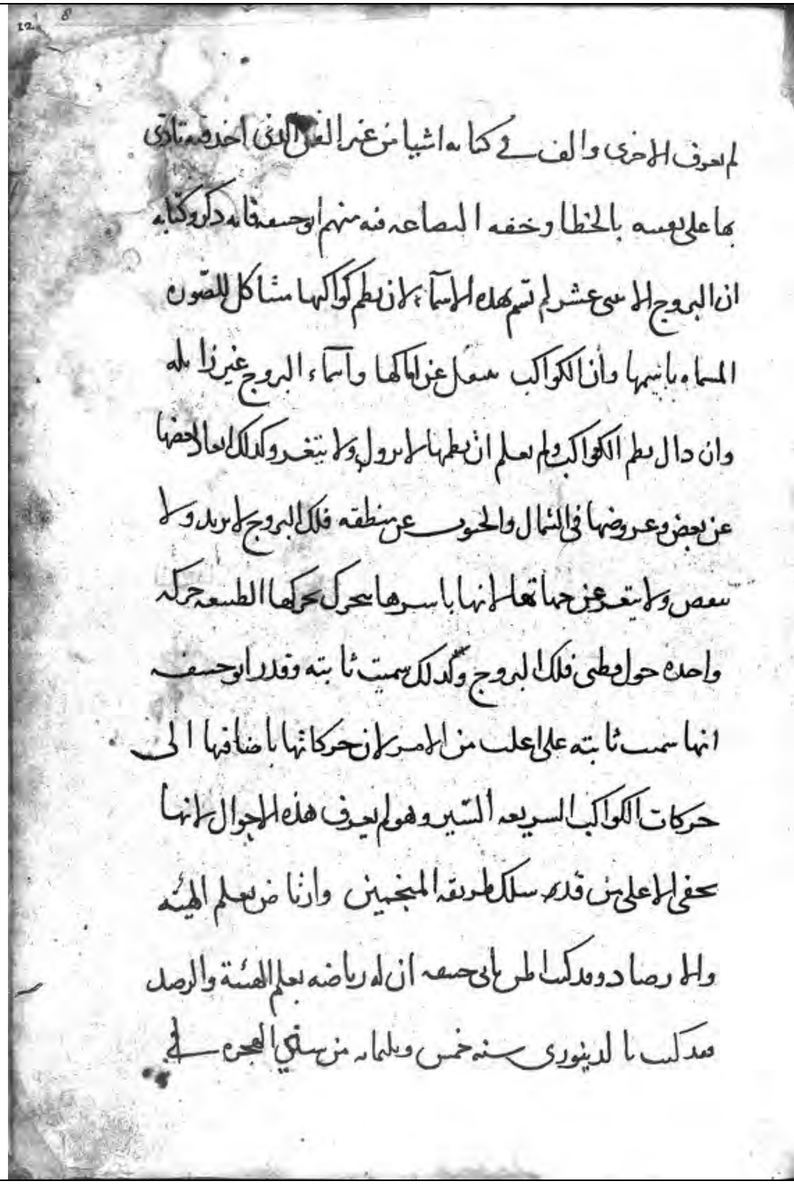
Folio 8

Who ever knew from the two groups (*Munajjimīn* or the Arabs) about one (scientific) method did not know the other. When they wrote in their books things not of their art they brought about on themselves the mistakes and showed their little understanding in this field.

One of those was Abū Ḥanīfa because according to his book he did not know that the twelve constellations of the zodiac were called by these names because they formed images (in the sky) of the same name. The stars move from their positions where as the names of these constellations do not change even when the stars change position. He did not know that the (constellation) formation do not change or disappear nor do the star positions change relative to each other. The star's latitude in the north and south from the zodiac also do not increase or decrease or change because (the stars) normally move in their entirety with one movement around the two ecliptical poles that is why they were called fixed (stars).

Abū Ḥanīfa must have thought that they were named fixed stars because their movements are slow compared to the movements of the fast moving planets. He did not know this information because it is only known to those who have taken the way of the astronomers and accepted the science of astronomy and observation.

I always had the impression that Abū Ḥanīfa knew the science of astronomy and observation for I visited Daīnawar in the year H.A. 335


لم يعرف الأخرى وألف في كتابه أشياء من غير الفن الذي أخذ فيه تأدى
بها على نفسه بالخطأ وخفة البضاعة فيه منهم أبو حنيفة فإنه ذكر في كتابه
أن البروج الاثني عشر لم تسم بهذه الأسماء لأن نظم كواكبها مشاكل للصور
المسماة بأسمائها وأن الكواكب تنتقل عن أماكنها وأسماء البروج غير زائلة
وإن زال نظم الكواكب ولم يعلم أن نظمها لا يزول ولا يتغير وكذلك أبعاد بعضها
عن بعض وعروضها في الشمال والجنوب عن منطقة فلك البروج لا تزيد ولا
تنقص ولا تتغير عن حالها لأنها بأسرها تتحرك حركتها الطبيعية حركة
واحدة حول قطبي فلك البروج ولذلك سميت ثابتة وقدر أبو حنيفة
أنها سميت ثابتة على الأغلب من الأمر لأن حركاتها بالإضافة إلى
حركات الكواكب السريعة السير وهو لم يعرف هذه الأحوال لأنها
تخفى إلا على من قد سلك طريقة المنجمين وارتاض بعلم الهيئة
والأرصاد وقد كنت أظن بأبي حنيفة أن له رياضة بعلم الهيئة والرصد
فقد كنت بالدينور سنة خمس وثلثمائة من سني الهجرة

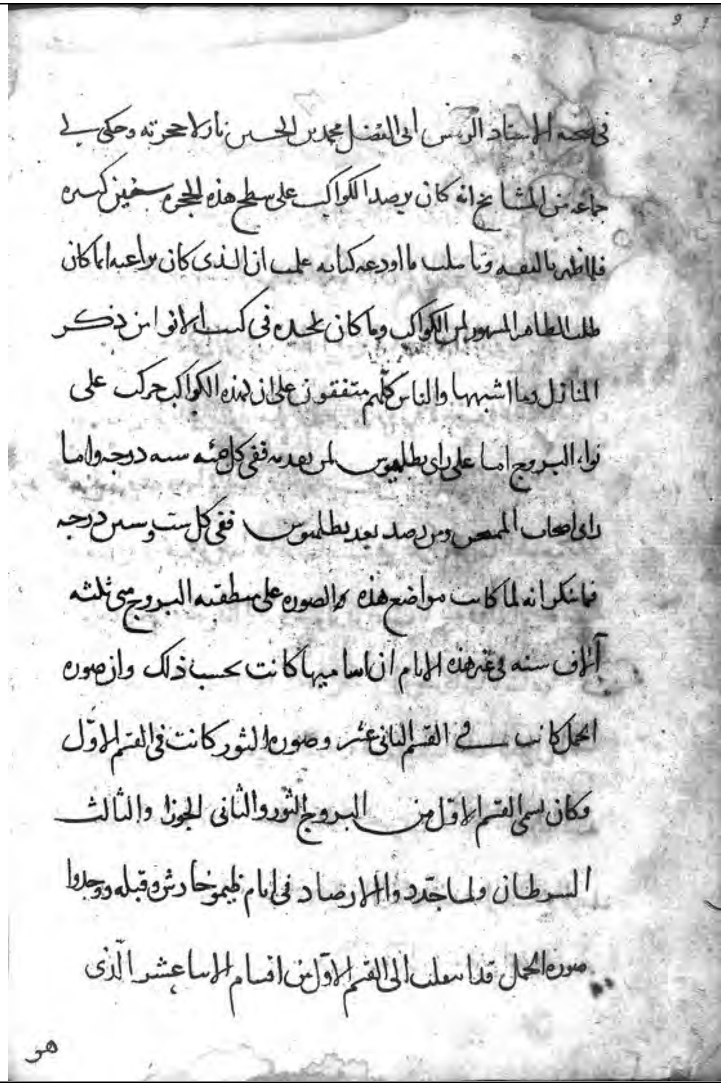
Folio 9

…..with the company of the grand professor Abū al-Faḍel Muḥammad Ibn al-Ḥusaīn, God prolong his life, and he was staying at his (Abū Ḥanīfa*)* house. I was told by some old people that Abū Ḥanīfa used to make his observation of the stars for many years from the roof of this house. However when his book was known and I saw what it contained, I realized that his only concern was what was famous and obvious of the stars as well as what he found in the books of *al-Anwā'* which mentioned the Lunar mansions and what was related to them.

Every body agrees that the stars move with respect to the ecliptic. According to Ptolemy and those who came before him they believed it (precession movement) was 1 deg every 100 years. However the authors of *al-Mumtaḥen* tables and those who came after Ptolemy confirmed it to be 1 deg every 66 years.

It is obvious that the divisions of the zodiac constellations 3000 years ago were not the same as today therefore their names were not the same. Therefore the constellation Aries was in the twelfth division and constellation Taurus was in the first division. The first division of the zodiac was named Taurus and the second was Gemini and the third Cancer.

When the star observations were renewed at the time of Timocharis and before, they (early Greek astronomers) found that the constellation Aries has shifted position to the first of the 12 zodiac divisions which is after the intersection point.


في صحبة الاستاذ الرئيس ابي الفضل محمد بن الحسين نازلا حجرته وحكى لي
جماعة من المشايخ انه كان يرصد الكواكب على سطح هذه الحجرة سنين كثيرة
فلما ظهر بالفقه وتاملت ما اودعه كتابه علمت ان الذي كان يراعيه انما كان
طلب الظاهر المشهور من الكواكب وما كان يجده في كتب الانواء من ذكر
المنازل وما اشبهها والناس كلهم متفقون على ان هذه الكواكب تتحرك على
توالي البروج اما على راي بطلميوس ومن تقدمه ففي كل مائة سنة درجة واما
على راي اصحاب الممتحن ومن رصد بعد بطلميوس ففي كل ست وستين درجة
فلا ينكر انه لما كانت مواضع هذه الصور على منطقة البروج منذ ثلثة
آلاف سنة على غير هذه الايام ان اساميها كانت بحسب ذلك وان صورة
الحمل كانت في القسم الثاني عشر وصورة الثور كانت في القسم الاول
وكان يسمى القسم الاول من البروج الثور والثاني الجوزا والثالث
السرطان ولما تجدد الارصاد في ايام طيموخارس وقبله وجدوا
صورة الحمل قد انتقل الى القسم الاول من اقسام الاثني عشر الذي
هو

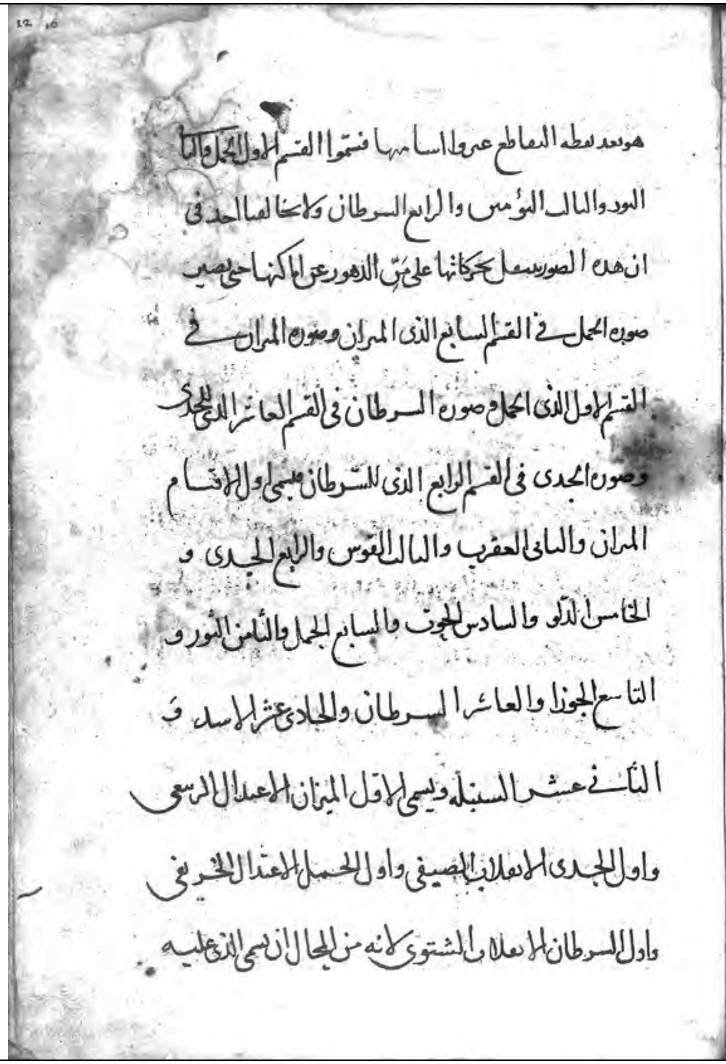
Folio 10

They renamed the first division Aries, the second Taurus, the third Gemini and the fourth Cancer.

And nobody disagrees with us that these constellations moved entirely through the ages from their positions until the constellation Aries fell in the seventh division which was originally for Libra, the constellation Libra fell in the first division which was for Aries, the constellation Cancer fell in the tenth division which was for Capricorn and the constellation Capricorn fell in the fourth division which was for Cancer.

Thereby if the first division is to be renamed Libra, the second Scorpio, the third Sagittarius, the fourth Capricorn, the fifth Aquarius, the sixth Pisces, the seventh Aries, the eighth Taurus, the ninth Gemini, the tenth Cancer, the eleventh Leo and the twelfth Virgo, then the beginning of Libra is to be renamed the spring Equinox, and the beginning of Capricorn the Summer Solstice and the beginning of Aries the spring equinox and the beginning of Cancer the winter Solstice.

However it is impossible to call the division which contains the constellation Capricorn as Cancer and the division which contains the constellation Cancer as Capricorn.


هو بعد قطع المقاطع غيروا اساميها فسموا القسم الاول الحمل والثاني
الثور والثالث التوأمين والرابع السرطان ولا خلاف لنا احد في
ان هذه الصور بتسلسل حركاتها على مر الدهور عن اماكنها حتى يصير
صورة الحمل في القسم السابع الذي للميزان وصورة الميزان في
القسم الاول الذي للحمل وصورة السرطان في القسم العاشر الذي للجدي
وصورة الجدي في القسم الرابع الذي للسرطان فيسمى اول الاقسام
الميزان والثاني العقرب والثالث القوس والرابع الجدي و
الخامس الدلو والسادس الحوت والسابع الحمل والثامن الثور و
التاسع الجوزا والعاشر السرطان والحادي عشر الاسد و
الثاني عشر السنبلة ويسمى اول الميزان الاعتدال الربيعي
واول الجدي الانقلاب الصيفي واول الحمل الاعتدال الخريفي
واول السرطان الانقلاب الشتوي لانه من المحال ان يسمى الذي عليه

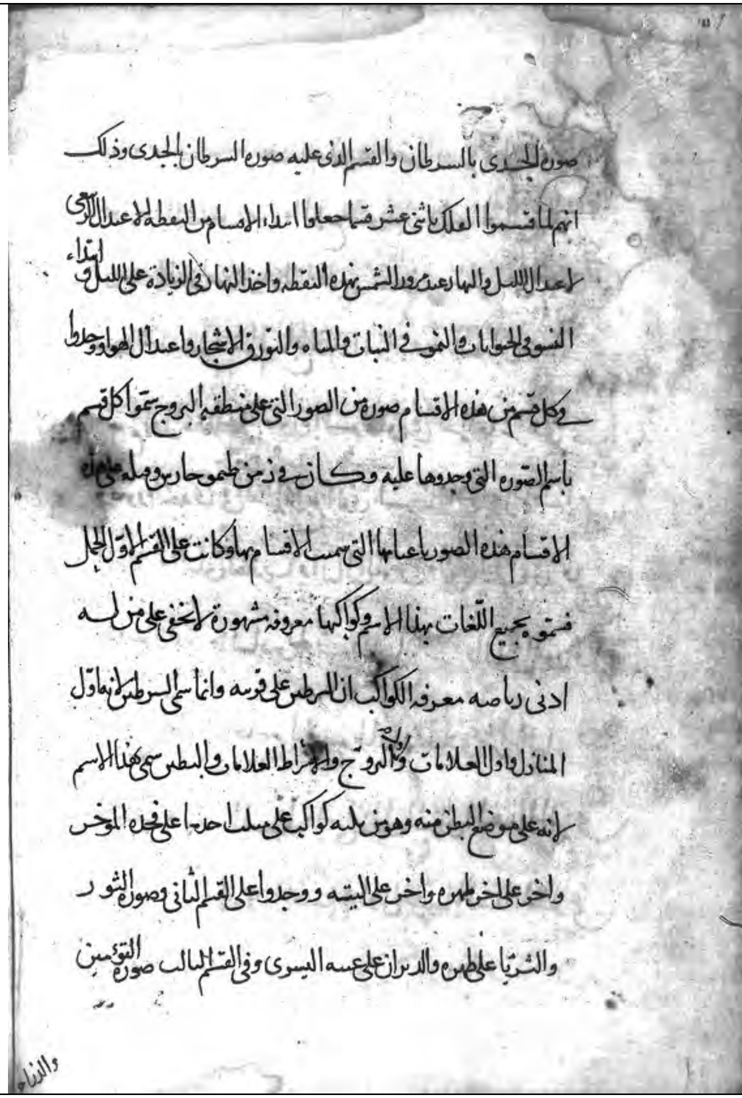
Folio 11

For when they divided the zodiac into the 12th divisions they made the beginning of these divisions at the spring Equinox. When the Sun passes this point, the night and day are equal. The day starts to exceed the night and the animals start mating and the plants and water grow and the leaves blossom and the air stabilize.

They (early Greek astronomers) also found in every division of the zodiac a constellation image and they named every division by the name of the image which was found in it. At the time of Timocharis and before him these divisions were the same as the constellations which were named after it. The first division contained the constellation Aries so they named it in all languages by this name. This is because its stars are well known and famous.

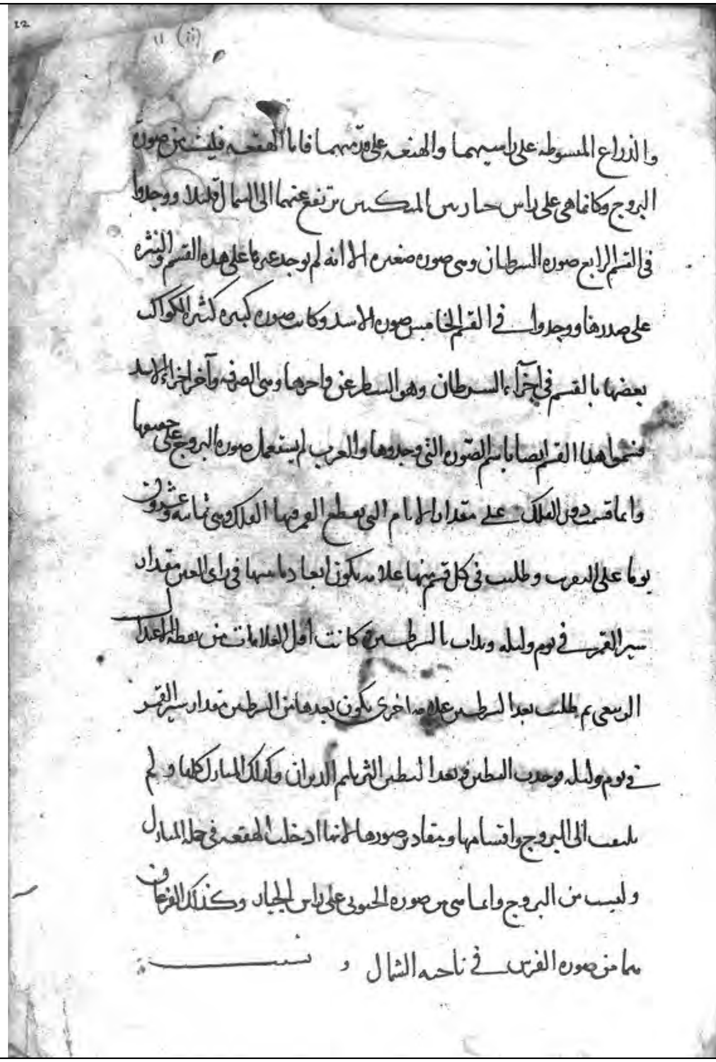
There is no doubt that whoever has any slight knowledge of the stars knows that *al-Sharaṭān* (*Anwā'* asterism) is on its (Aries) horn. It was named *al-Sharaṭān* because it is the first Lunar mansion and the first sign and the first zodiac constellation. For *al-Ashrāt* means "Sign" (in Arabic).

The *al-Buṭain* (*Anwā'* asterism) was named by this name because it was located on the stomach of Aries and it consists of three stars forming a triangle one on the rear thigh and another at the end of this back and the other on the tail.
They also found in the second division the constellation Taurus with *al-Thurayyā* (Pleiades) on its back and *al-Dabarān* on the left eye.



Folio 11 (ii)

In the third division they found the constellation Gemini and the *al-Dhirā’ al-Mabsūṭa* (*Anwā’* asterism) on their (Gemini) heads and the *al-Han’a* on their feet. As for the *al-Haq‘a* it is not found in the zodiac constellation for it is on the head of Orion between the shoulders a little higher to the left. They found in the fourth division the constellation Cancer. It is a small constellation but there is no other in that division. *Al-Nathra* (*Anwā’* asterism) is on the chest (of Cancer). They found in the fifth division the constellation Leo. It is a large constellation with many stars. *Al-Ṭarf* (*Anwā’* asterism) is located in this division and at the edge of Cancer and *al-Ṣarfa* is located at the other end and at the edge of Leo. They named this division also by the name of the constellation image they found in it.
The Arabs did not realistically use the zodiac constellation however they divided the ecliptic into the days the Moon crosses this orbit which is approximately 28 days. They assigned a sign for every division whereby the distance between these signs is equals to the progress of the Moon every day and night starting with *al-Sharaṭān* which was the first of these signs at the time of the equinox.
They tried then to located another sign after *al-Sharaṭān* whereby its distance from *al-Sharaṭān* is equal to the Moon progress in one day and one night and they found *al-Buṭain* then after *al-Buṭain al-Thurayyā* (Pleiades) then *al-Dabarān* and so on for are all the other Lunar mansions. They were not concerned with the zodiac constellations, their divisions and images. They included *al-Haq‘a* to be of the Lunar mansions and not of the zodiac because it is part of the southern constellations located on the head Orion. This is also done for *al-Farghān* which is found in the constellation Equuleus towards the north.



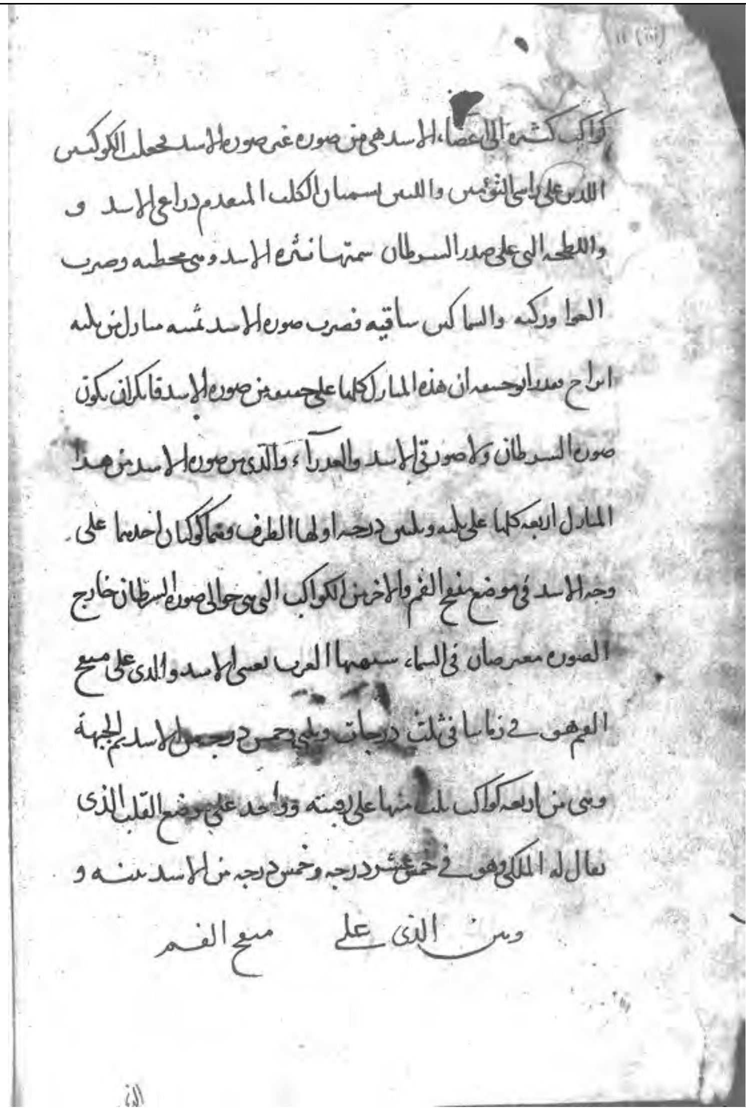
Folio 11 (iii)

They also included many stars to be part of Leo; however these are not in the constellation Leo. They (Arabs) located the two stars which are on the head of Gemini and which are called *al-Kalb al-Mutakadem* (the front dog) to be on the arms of Leo, and they named the nebulae on the chest of Cancer, *Nathrat al-Asad*. They assigned (the asterism) *al-'Awwā*, *Rakih* and *al-Simākain* on his (Leos) legs. Therefore they assigned to (the constellation) Leo eight mansions covering three constellations.

Abū Ḥanīfa considered all these mansions to be part of constellation Leo and he did not consider this image to be divided into three constellations every one with its own distinct name. He did not recognize the constellation Cancer, or the constellations Leo and Virgo.

There are four mansions which are in the constellation Leo spread within 30 deg. The first is *al-Ṭarf* (*Anwā'* asterism) which consists of two stars. The first star is on the face of Leo situated on the mouth. The other star is close to the constellation Cancer outside of the constellation (Leo), spread apart in the sky whereby the Arabs compared them to the eyes of a Lion. The coordinates of the star on the mouth in our time is 3 and 3/5 of a deg in Leo.

Then we have *al-Jabha* (*Anwā'* asterism) which consists of four stars. Three stars are located on the neck (of Leo) and one on the heart. This (last) star is called *al-Malikī* which is located 15 and 1/5 of a deg in Leo. The distance between it and the star in the mouth of Leo is 11 and 1/3 of a deg.


كواكب كثيرة الى اعضاء الاسد هي من صورة غير صورة الاسد فجعلت الكوكبين
اللذين على راسي التوءمين واللذين يسميان الكلب المتقدم ذراعي الاسد و
واللطخة التي على صدر السرطان سمتها نثرة الاسد وهي مخطمه وضرب
العوا وركبه والسماكين ساقيه فضرب صورة الاسد ثمنية منازل من ثلثة
ابراج وعد ابو حنيفة ان هذه المنازل كلها على جسمه من صورة الاسد فانكر ان يكون
صورة السرطان ولا صورتي الاسد والعذراء والذي من صورة الاسد من هذه
المنازل اربعة كلها على ثلثين درجة اولها الطرف وهما كوكبان احدهما على
وجه الاسد في موضع منخر الفم والاخر من الكواكب التي هي حوالى صورة السرطان خارج
الصورة معترضان في السماء شبهها العرب بعيني الاسد والذي على منخر
الفم هو في زماننا في ثلث درجات وثلثة اخماس درجة من الاسد ثم الجبهة
وهي من اربعة كواكب ثلثة منها على رقبته وواحد على موضع القلب الذي
يقال له الملكي وهو في خمس عشرة درجة وخمس درجة من الاسد بينه و
وبين الذي على منخر الفم

Folio 12

Then we have *al-Zubra* which consists of two stars located on the back (of Leo). The distance between *al-Malki* and the brighter of the two stars of *al-Zubra* is a distance of 11 and 2/3 deg. It is 26 and 3/5 of a deg in Leo.
al-Sarfa consist of the bright stars on the tail (of Leo). It is 7 and 1/5 of a deg in Virgo. The distance between it and the brighter of the two stars of *al-Zubra* is 10 and 1/3 of a deg. All these locations are close to each other. The distance between each of them is approximately the angle the Moon travels in one day and one night.
As for *al-'Awwā* it consists of five stars located on the wing of Virgo. *Al-Simāk* is one of them which is a lone star on the left hand of Virgo. *Al-Rāmiḥ* is between the thighs of Bootes and is called *al-Ṣannāj* but it is not in and is not part of the main image of the constellation of Virgo.

He (Abū Ḥanīfa) thought that the sixth zodiac is part of the constellation Leo and he called the group of stars which are above the tail of Leo as the constellation Virgo. It was called by some astronomers *al-Ḍafira* because it looks like a *Sunbula* (leaf). He also mentioned something similar in the constellation Sagittarius where a similar asterism was named the Bow. However because there is a constellation named the Bow it was not named as such.

Folio 13

He named these stars which are in front of Sagittarius by this name because they looked like a Bow and which the Arabs call *al-Qilāda*. He did not know the Bow or the arrow or Sagittarius or any of the stars as per the method of the astronomers.

He also called the *al-'Awā'idh* and the most of what can be mentioned in this regards is that the astronomers call it the Head of the Dragon. They also called *al-Ridf* the tail of Cygnus. However since he (Abū Ḥanīfa) did not recognize the image of the constellation Cygnus, he described *al-Fawāris* but he did not know that it is of the same constellations and located on its wing.

He also mentioned that *Banāt Na'esh al-Kubra* (The Great Daughters of the Bier or Coffin) consist of seven stars similar to the smaller (sisters). The astronomers call them the Great Bear. However he did not know that they are part of the constellation Ursa Major. He (also) mentioned that between '*Arsh al-Simāk al-A'zal* and *al-Zubānain*, and below them, there are bright stars randomly grouped called *al-Shamārīkh*. He was mentioning here the stars in the constellation Centaurs and Lupus. Then he mentioned *Hiḍār* and *al-Wazn* and that they were called *Muḥlifain* however he did not know that they were part of *al-Shamārīkh*. He (also) mentioned *al-Dhanbain* but he did not know that they are part of the constellation Draco.

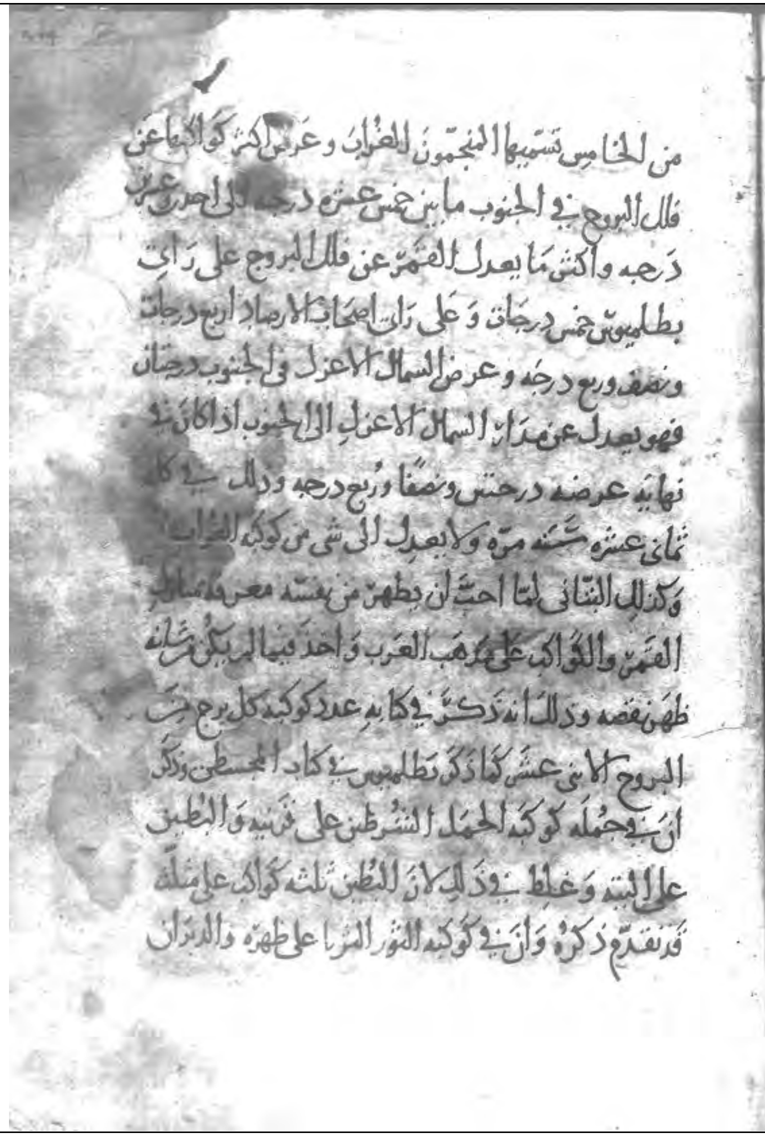
He (Abū Ḥanīfa) also mentioned '*Arsh al-Simāk al-A'zal* relating from *Ibn Kunāsa* that the orbit of the Moon might come close to Leo where '*Arsh al-Simāk* is located. The number of these stars (of '*Arsh al-Simāk)* is seven. Five of which are bright and are of the 3rd magnitude……


على ذوابة الرامي التي تسميها العرب القلادة ولم يعرف القوس
والسهم والرامي ولا شيئا من الكواكب على طريقة المنجمين وذلك
انه وصف العوائذ واكثر ما قال فيها انها عند المنجمين راس
التنين وانهم يسمون الردف ذنب الدجاجة ولم يعرف صورة
الدجاجة ووصف الفوارس ولم يعلم انها من صورتها ايضا على
جناحيها وذكر ان بنات نعش الكبرى سبعة كواكب ايضا
على مثال الصغرى وان المنجمين يسمونها الدب الاكبر ولم يعلم
انها من صورة الدب وذكر ان فيما بين عرش السماك الاعزل وبين
الزبانين اسفل منهما كواكب نيرة مجتمعة على غير نظم تسمى الشماريخ
اراد بذلك كواكب صورتي قنطورس والسبع ثم ذكر بعد ذلك
حضار والوزن وانهما يسميان محلفين ولم يعلم انهما من جملة
الشماريخ وذكر الذنبين ولم يعلم انهما من جملة كوكبة التنين
وذكر عرش السماك الاعزل وحكى عن ابن كناسة ان القمر ربما
عدل فنزل بعجز الاسد وهو عرش السماك وهذه الكواكب عددها
سبعة خمسة منها نيرة في القدر الثالث وواحد في القدر الرابع وواحد

Folio 14

…..one of the 4th magnitude and one of the 5th magnitude. The astronomers call them *al-Ghurāb* (constellation Corvus). He mentioned that the latitude of the furthest of these stars from the ecliptic towards the south is between 15 to 21 deg. However according to the opinion of Ptolemy the maximum the orbit of the Moon drifts from the ecliptic is 5 deg. And according to the opinion of (*al-Mumtaḥen*) observers it is 4 and ½ and ¼ of a deg. The latitude of *al-Simāk al-A'zal* south (of the ecliptic) is 2 deg. Therefore (the Moon's) orbit is furthest from *al-Simāk al-A'zal* towards the south by 2 and ½ and ¼ of a deg. This occurs once in every 18 years. Therefore (the Moon) does not come close to the constellation Corvus.

Thus *al-Battānī* when he wanted to show that he knew the Lunar mansions and the stars as per the Arab method, he went into what was not his field which showed his weakness. He (*al-Battānī*) mentioned in his book the number of stars in the entire twelve zodiac constellation as were mentioned by Ptolemy in his book *Almagest*. He also mentioned that in the constellation Aries *al-Sharaṭān* is on the head and *al-Buṭain* is on the hand. However he was mistaken because *al-Buṭain* consists of three stars forming a triangle as was mentioned before.
(He mentioned) that al-Thurayyā is in the constellation Taurus located on its back and that *al-Dabarān* is located on its tail.


من الخامس تسميها المنجمون الغراب وعرض اكثر كواكبها عن
فلك البروج في الجنوب ما بين خمس عشرة درجة الى احدى عشرين
درجه واكثر ما يعدل القمر عن فلك البروج على راي
بطليموس خمس درجات وعلى راي اصحاب الارصاد اربع درجات
ونصف وربع درجة وعرض السماك الاعزل في الجنوب درجتان
فهو يعدل عن مدار السماك الاعزل الى الجنوب اذا كان في
نهاية عرضه درجتين ونصفا وربع درجه وذلك في كل
ثماني عشرة سنة مرة ولا يعدل الى شي من كواكب الغراب
وكذلك البتاني لما احب ان يظهر من نفسه معرفة منازل
القمر والكواكب على مذهب العرب واخذ فيها بما لم يكن من شانه
ظهر نقصه وذلك انه ذكر في كتابه عدد كواكب كل برج من
البروج الاثني عشر كما ذكر بطلميوس في كتاب المجسطي وذكر
ان في جملة كواكب الحمل الشرطين على قرنيه والبطين
على اليته وغلط في ذلك لان البطين ثلثة كواكب على مثلث
قد تقدم ذكره وان في كواكب الثور الثريا على ظهره والدبران

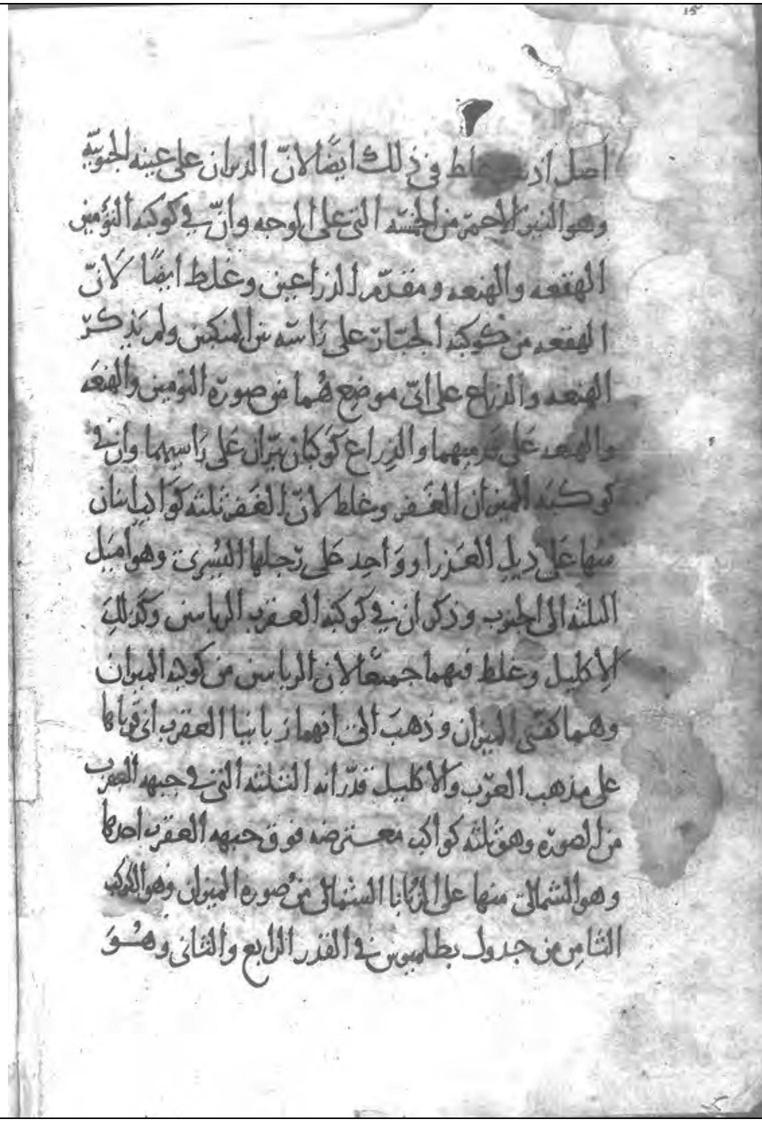
Folio 15

However he was mistaken in that also because *al-Dabarān* is located on its southern eye. It is the red and the brightest of the five stars on the face.

And (he mentioned) that in the constellation Gemini there are *al-Haq'a* and *al-Han'a* and the most forward of the two *al-Dhirāin*. However he was mistaken in this also because *al-Haq'a* is in the constellation Orion located on the head and between its shoulders. He did not mention the position of *al-Han'a* and *al-Dhirā'* in the constellation of Gemini. *Al-Han'a* and *al-Haq'a* are two stars on the feet (of Gemini). The *al-Dhirāin* are two bright stars on their heads.

Then he (*al-Battānī*) mentioned that in the constellation Libra there is *al-Ghafr*, but he was mistaken because *al-Ghafr* consist of three stars two of which are on the tail of Virgo and one on its left leg. (The last) is the one most oriented towards the south of the three stars (of *al-Ghafr*)

He also mentioned that in the constellation Scorpio there are the two *al-Zubānā* and *al-Iklīl* and he was mistaken in all those because the two *al-Zubānā* are located in the constellation Libra. They are on the shoulder of Libra. He went on saying that the two *al-Zubānā* are part of Scorpio and are located on its horn as per the method of the Arabs. We estimate that *al-Iklīl* consists of the three stars located on the horns and which are on the forehead of Scorpio and part of the main image of the constellation. These are the three stars crossing above the forehead of Scorpio. The first is the northernmost (star) on the northern arms in the constellation of Libra. It is the eighth star in Ptolemy's catalog and it is of the 4th magnitude.


اصل اد... غلط في ذلك ايضا لان الدبران على عينه الجنوبية
وهو النير الاحمر من الخمسة التي على الوجه وان في كوكبة التوأمين
الهقعة والهنعة ومقدم الذراعين وغلط ايضا لان
الهقعة من كوكبة الجبار على راسه بين المنكبين ولم يذكر
الهنعة والذراع على اي موضع هما من صورة التوأمين والهنعة
والهقعة على قدميهما والذراع كوكبان نيران على راسيهما وان في
كوكبة الميزان الغفر وغلط لان الغفر ثلثة كواكب اثنان
منها على ذيل العذرا وواحد على رجلها اليسرى وهو اميل
الثلثة الى الجنوب وذكر ان في كوكبة العقرب الزبانين وكذلك
الاكليل وغلط فيهما جميعا لان الزبانين من كوكبة الميزان
وهما كفتي الميزان وذهب الى انهما زبانيا العقرب اي قرناها
على مذهب العرب والاكليل قدرنا انه الثلثة التي في جبهة العقرب
من الصورة وهي ثلثة كواكب معترضة فوق جبهة العقرب احدها
وهو الشمالي منها على الزبانا الشمالي من صورة الميزان وهو الكوكب
الثامن من جدول بطلميوس في القدر الرابع والثاني وهو

Folio 16

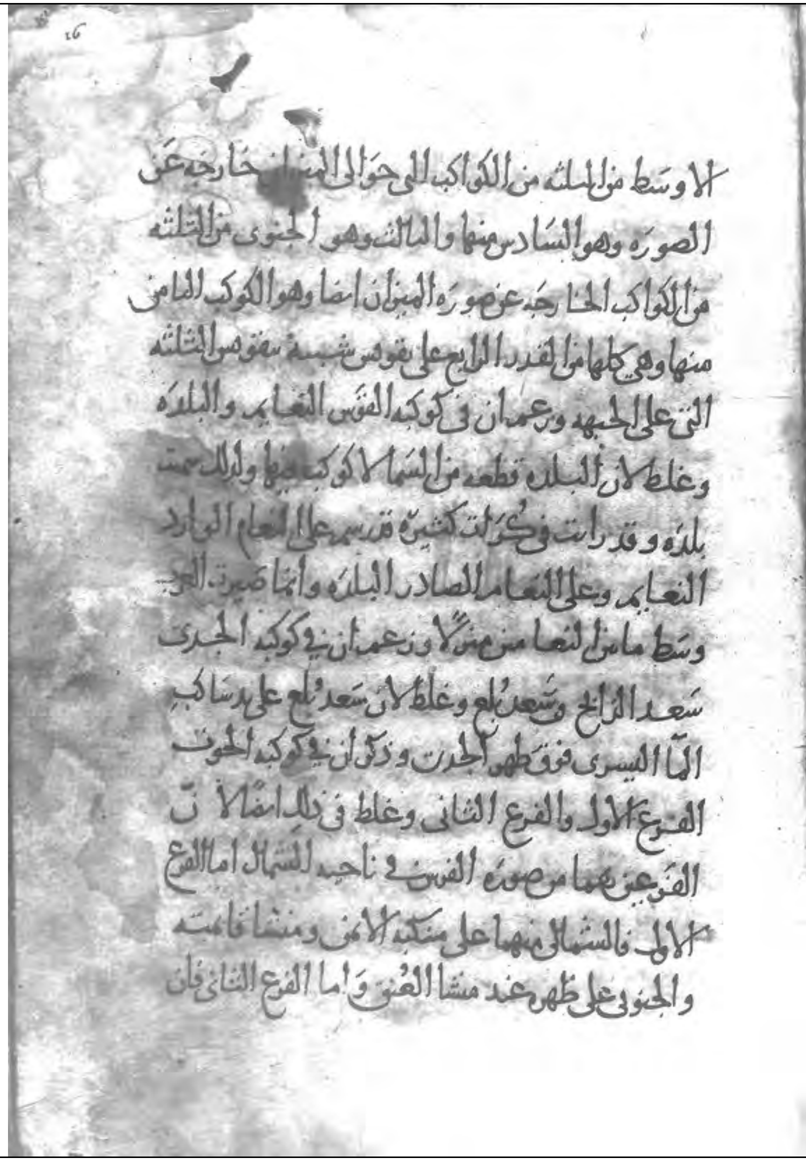
The second (star) is in the middle of the three and it is the sixth star around Libra outside of the constellation The third is the southernmost of the three and is the eighth of the stars outside of the constellation Libra also. They are all of the 4th magnitude forming an arc similar to the arc formed by the three (stars) on the forehead of Scorpio.

He (*al-Battānī*) pointed out that in the constellation Sagittarius there are *al-Na'ām* and *al-Balda* and he was mistaken because *al-Balda* is part of the sky which does not contain any star. That is why it was called *al-Balda*. I saw in many globes that *al-Na'ām* was drawn as *al-Na'ām al-Wārid* and *al-Na'ām al-Ṣādir* as *al-Balda.* The Arabs have assigned between the two *al-Na'ām* another mansion.

He mentioned that in the constellation Capricorn there is *Sa'd al-Dhābiḥ* and *Sa'd al-Bula'*, and he was mistaken because *Sa'd al-Bula'* is on the left arm of Aquarius above the constellation of Capricorn.

He (*al-Battānī*) mentioned that in the constellation Pisces there are *al-Fargh al-Awwal* and *al-Fargh al-Thānī* and he was mistaken in that also because those two *al-Fargh* are in the north of the constellation Pegasus.

As for *al-Fargh al-Awwal*, the northernmost (star of this asterism) is located on the beginning of the right leg and the southernmost star is located on the back on the beginning of the neck.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الاوسط من المثلثه من الكواكب التي حوالي الميزان خارجة عن
الصوره وهو السادس منها والثالث وهو الجنوبي من الثلثه
من الكواكب الخارجة عن صورة الميزان ايضا وهو الكوكب الثامن
منها وهي كلها من القدر الرابع على قوس شبيهة بقوس الثلثه
التي على الجبهة وزعم ان في كوكبة القوس النعايم والبلده
وغلط لان البلده قطعة من السما لا كوكب فيها ولذلك سميت
بلده وقد رايت في كرات كثيرة قد رسم على النعام الوارد
النعايم وعلى النعام الصادر البلده وانما صيرت العرب
وسط ما بين النعامين منزلا وزعم ان في كوكبة الجدي
سعد الذابح وسعد بلع وغلط لان سعد بلع على يد ساكب
الما اليسرى فوق ظهر الجدي وزعم ان في كوكبة الحوت
الفرغ الاول والفرغ الثاني وغلط في ذلك ايضا لان
الفرغين هما من صورة الفرس في ناحية الشمال اما الفرغ
الاول فالشمالي منها على منكبه الايمن ومنشا قائمته
والجنوبي على ظهره عند منشا العنق واما الفرغ الثاني فان

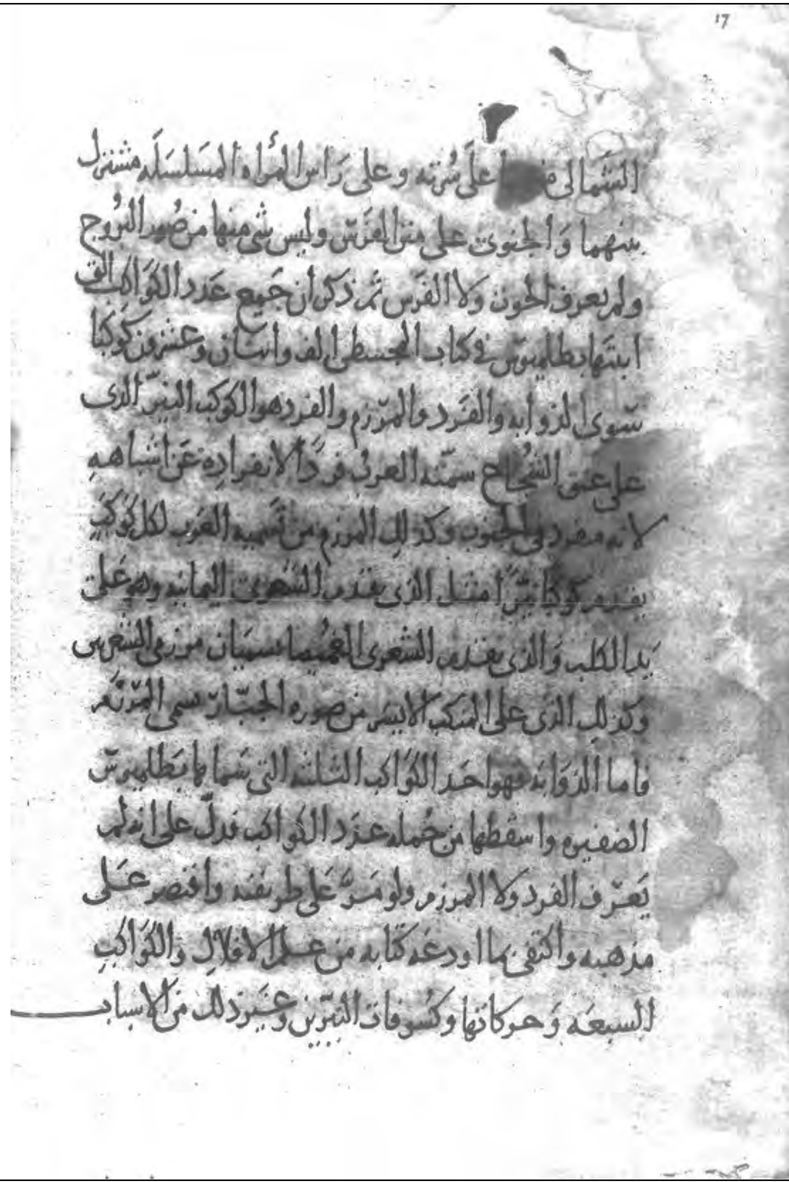
Folio 17

As for *al-Fargh al-Thānī* the northernmost star is located in the middle (of Pegasus) and on the head of Andromeda. It is the common (star) between them. The southernmost star is located in Pegasus. Neither of these two (asterism) are part of the zodiac constellation. He did not know the constellation of Pisces nor of Pegasus. Then he (*al-Battānī*) mentioned that the number of all the stars confirmed by Ptolemy in his *Almagest* are 1022 stars without (the asterism of) *al-Thuāba* and *al-Fard* and *al-Mirzam*.

Al-Fard is the bright star on the neck of (the constellation) Hydra. The Arabs call it *al-Fard* because it is remote from its fellow (stars) and it is on its own in the south. As for *al-Mirzam*, the Arabs call this name to every star which precedes a bright star. This is similar to the star which precedes the star *al-Shi'ra al-Yamāniya* (Sirius) located on the paw of Canis. The star which precedes the bright *al-Shi'ra* is also called *Mirzam al-Shi'ra*, and so is the star on the left hand of Orion is also called *al-Mirzam.*

As for *al-Thuāba* it is one of three stars that Ptolemy called *al-Dhafīra* and which was not mentioned as part of the number of stars.

This shows that he (*al-Battānī*) did not know *al-Fard* or *al-Mirzam.* If he stayed in his field and kept to what his book mentioned on the science of obits, the movements of the seven planets, the eclipse of the Sun and the Moon and the other matters of the stars….


17

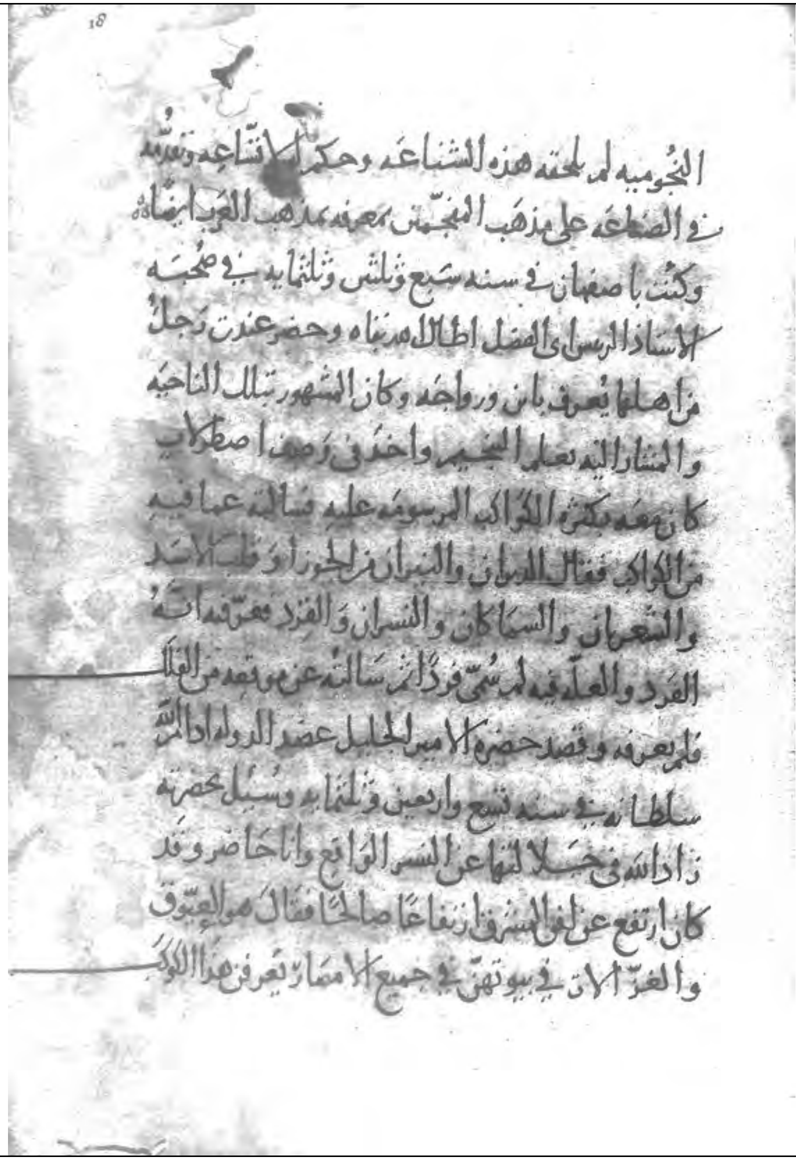
الشمالي [illegible] على سرته وعلى رأس المرأة المسلسلة مشترك
بينهما والجنوبي على متن الفرس وليس شيء منها من صور البروج
ولم يعرف الحوت ولا الفرس ثم ذكر أن جميع عدد الكواكب التي
أثبتها بطلميوس في كتاب المجسطي ألف واثنان وعشرون كوكبا
سوى الذوابة والفرد والمرزم والفرد هو الكوكب النير الذي
على عنق الشجاع سمته العرب فردا لانفراده عن أشباهه
لأنه منفرد في الجنوب وكذلك المرزم من تسمية العرب لكل كوكب
يتقدم كوكبا نيرا مثل الذي يتقدم الشعرى اليمانية وهو على
يد الكلب والذي يتقدم الشعرى الغميصاء يسميان مرزمي الشعريين
وكذلك الذي على المنكب الأيسر من صورة الجبار يسمى المرزم
فأما الذوابة فهو أحد الكواكب الثلاثة التي سماها بطلميوس
الضفيرة وأسقطها من جملة عدد الكواكب فدل على أنه لم
يعرف الفرد ولا المرزم ولو مر على طريقته واقتصر على
مذهبه واكتفى بما أودعه كتابه من علم الأفلاك والكواكب
السبعة وحركاتها وكسوفات النيرين وغير ذلك من الأسباب

Folio 18

….he would not have been tainted with all this dreadful things and he would have kept his wide knowledge and importance in this science in the method of astronomers and not in the method of the Arabs.

I was in Isfahan in the year (A.H.) 337 in the company of the grand teacher *Abu al-Faḍel*, may God prolong his life. A man from that city known as Ibn Rawāha came to me. He was known in that area in the science of astrology. He started to describe in detail an Astrolabe which was with him and the stars which were drawn in it. I asked him what stars were drawn on it (the astrolabe) and he said *al-Dabarān*, the two bright stars of *al-Jauzā'* (Orion), *Qalb al-Asad* (Antares), the two *al-Shi'ra* (Sirius and Proycon), the two *al-Simāk,* the two *al-Nasr* and *al-Kurd*. I immediately knew that he was mentioning *al-Fard*. His mistake was that he did not name it as *al-Fard.* Then I asked him about its (*al-Fard's*) position in the sky but he did not know it.

In the year A.H. 349, he (Ibn Rawāha) was visiting the grand prince 'Aḍud al-Dawla, may God prolong his life, while I was present. He was asked in his presence about *al-Nasr al-Wāqi'* which had risen well above the eastern horizon and he said it was *al-'Ayyūk*. However every woman in their homes in all the countries knows this star and they call it *al-Athāfī.*



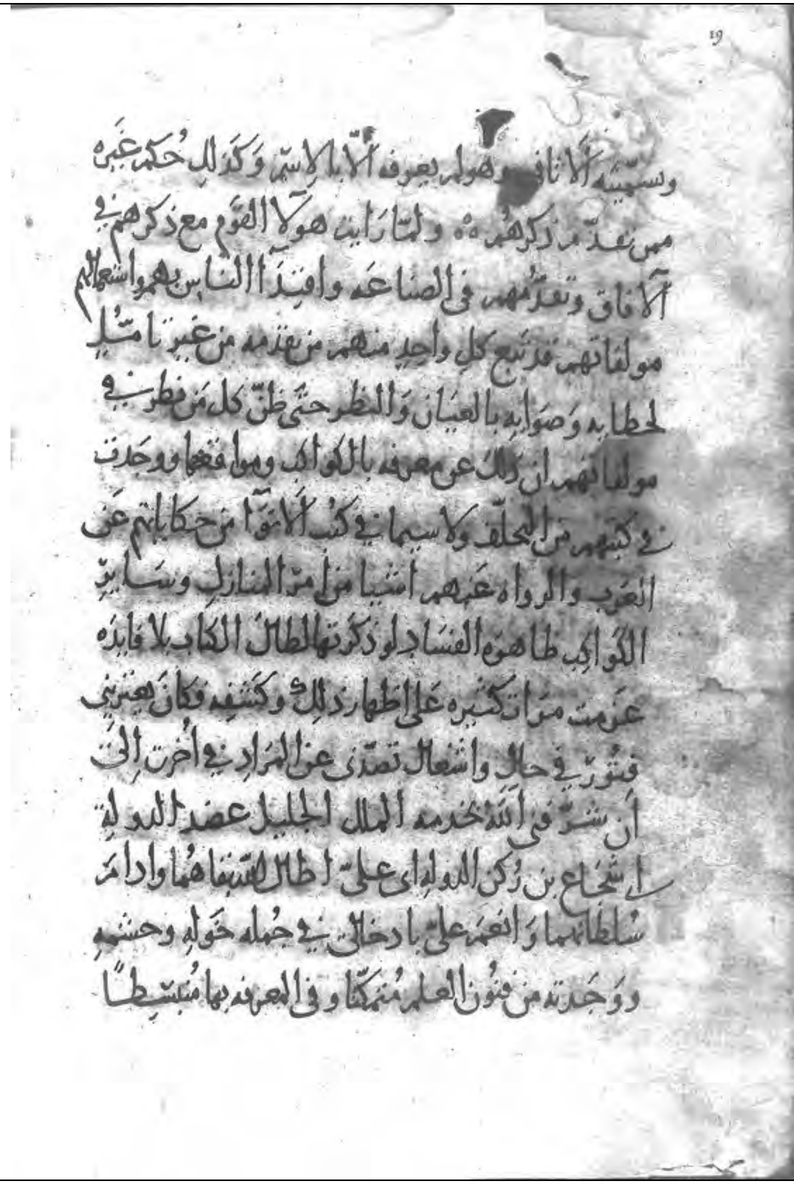
Folio 19

However he did not know it by name.

Such is the condition of all those people which were mentioned earlier. Therefore I saw that all these people who were well known and are leaders in this science and people follow them and use their books without knowing the right from wrong with respect to observation. Every body who read their books believed that they are well versed in the knowledge of the stars and their positions.

However I found in their books many errors especially in the books of *al-Anwā’* and the stories which they obtained from the Arabs, and those who copied from them. I found many bad things about the Lunar mansions and the rest of the stars which if I mention here I would prolong this book uselessly.

I wanted many times to reveal this and expose it but I either felt sluggish or I had many things which occupied me from this task until God honored me with serving the benevolent king ‘Aḍud al-Dawla Abū Shuja’ Rukn al-Dawla Abū ‘Alī may God prolong their lives and their rule and (God) privileged me by accepting me in his (‘Aḍud al-Dawla) patronage. I found him to be capable in all fields of science and strong in its knowledge….



19

وتسميته الا انه ... لا يعرفه الا بالاسم وكذلك حكم غيره
ممن تقدم ذكرهم ولما رايت هولا القوم مع ذكرهم في
الافاق وتقدمهم في الصناعة واقتدا الناس بهم واستعمالهم
مولفاتهم قد تبع كل واحد منهم من تقدمه من غير تامل
لخطايه وصوابه بالعيان والنظر حتى ظن كل من نظر في
مولفاتهم ان ذلك عن معرفة بالكواكب ومواقعها ووجدت
في كتبهم من الخلف ولا سيما في كتب الانوا من حكاياتهم عن
العرب والرواة عنهم اشيا من امر المنازل وساير
الكواكب ما هو الفساد لو ذكرتها لطال الكتاب بلا فايده
عزمت مرات كثيرة على اظهار ذلك وكشفه فكان يعترضني
فتور في حال واشغال تصدني عن المراد في اخرى الى
ان شرفني الله بخدمة الملك الجليل عضد الدولة
ابي شجاع بن ركن الدولة ابي علي اطال الله بقاهما وادام
سلطانهما وانعم علي بادخالي في جملة خوله وحشمه
فوجدته من فنون العلم متمكنا وفي المعرفة بها منبسطا

Folio 20

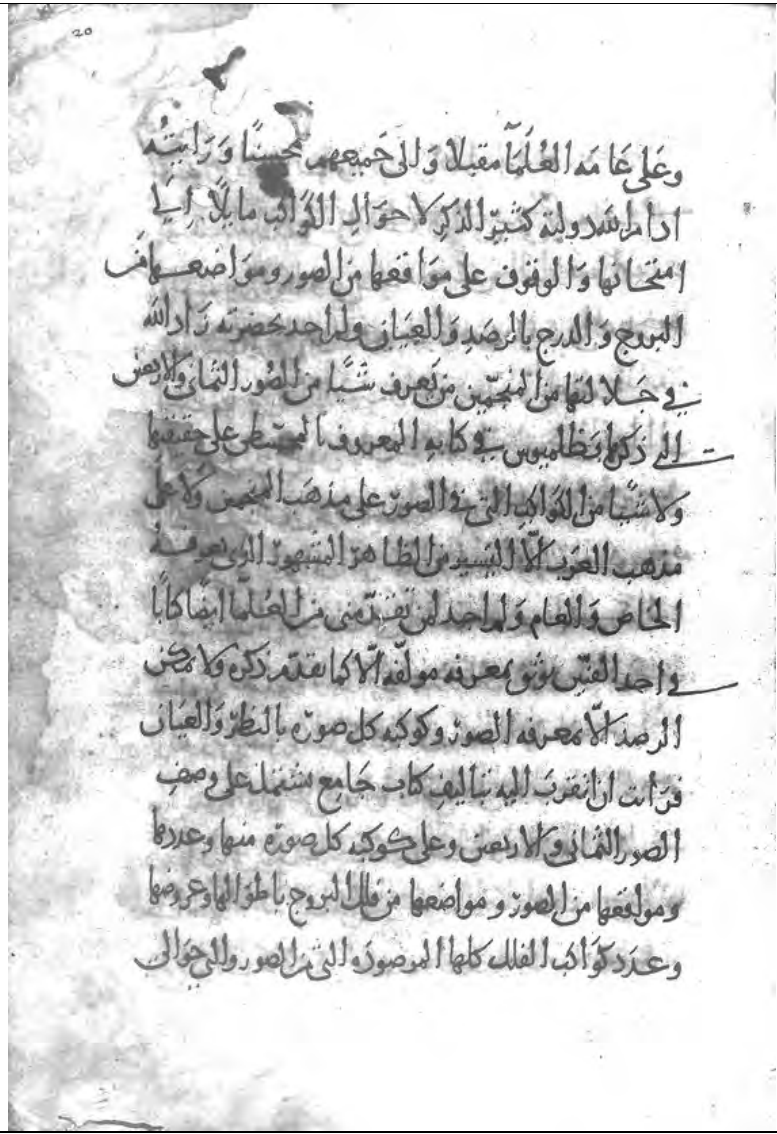
….and open and generous to all scientists.

I saw him, may God prolong his reign, always mentioning the stars leaning towards questioning and locating their positions in the constellations and their location on the zodiac by performing exact astronomical observation.

However I did not find in his presence, may God increase his signifance, any astronomers who knew any thing about the 48 constellations which Ptolemy mentioned in his well known book of the *Almagest*. Nor (did I find) any (who knew) of the stars that were mentioned by the astronomers or any (who knew of the stars) as per the method of the Arabs except the least bit of information which is well known to all the normal and expert people.

I also did not find from any of those scientist who came before me any book in either of the two arts of this science which confirms the knowledge of its writer except those that I mentioned before. And it is impossible to make any observation until the constellations and the stars in every constellation are known and confirmed by observation.

Therefore I saw fit to approach him (‘Aḍud al-Dawla) by writing a comprehensive book describing the 48 constellations, the number and location of each star in these constellations, their celestial positions in latitude and longitude as well as the total number of observed stars in the sky which form the main image of the constellations….


٢٠
وعلى عامة العلما مقبلا والى جميعهم محسنا ورايته
ادام الله دولته كثير الذكر لاحوال الكواكب مايلا الى
امتحانها والوقوف على مواقعها من الصور ومواضعها من
البروج والدرج بالرصد والعيان ولم اجد بحضرته زاد الله
في جلالها من المنجمين من يعرف شيا من الصور الثماني والاربعين
التي ذكرها بطلميوس في كتابه المعروف بالمجسطي على حقيقتها
ولا شيا من الكواكب التي في الصور على مذهب المنجمين ولا على
مذهب العرب الا اليسير من ظاهر المشهور الذي يعرفه
الخاص والعام ولم اجد لمن تقدمني من العلما ايضا كتابا
في احد الفنين يوثق بمعرفة مولفه الا كما تقدم ذكره ولا يمكن
الرصد الا بمعرفة الصور وكواكب كل صورة بالنظر والعيان
فرايت ان اتقرب اليه بتاليف كتاب جامع يشتمل على وصف
الصور الثماني والاربعين وعلى كواكب كل صورة منها وعددها
ومواقعها من الصورة ومواضعها من فلك البروج باطوالها وعروضها
وعدد كواكب الفلك كلها المرصودة التي في الصور والتي حوالي

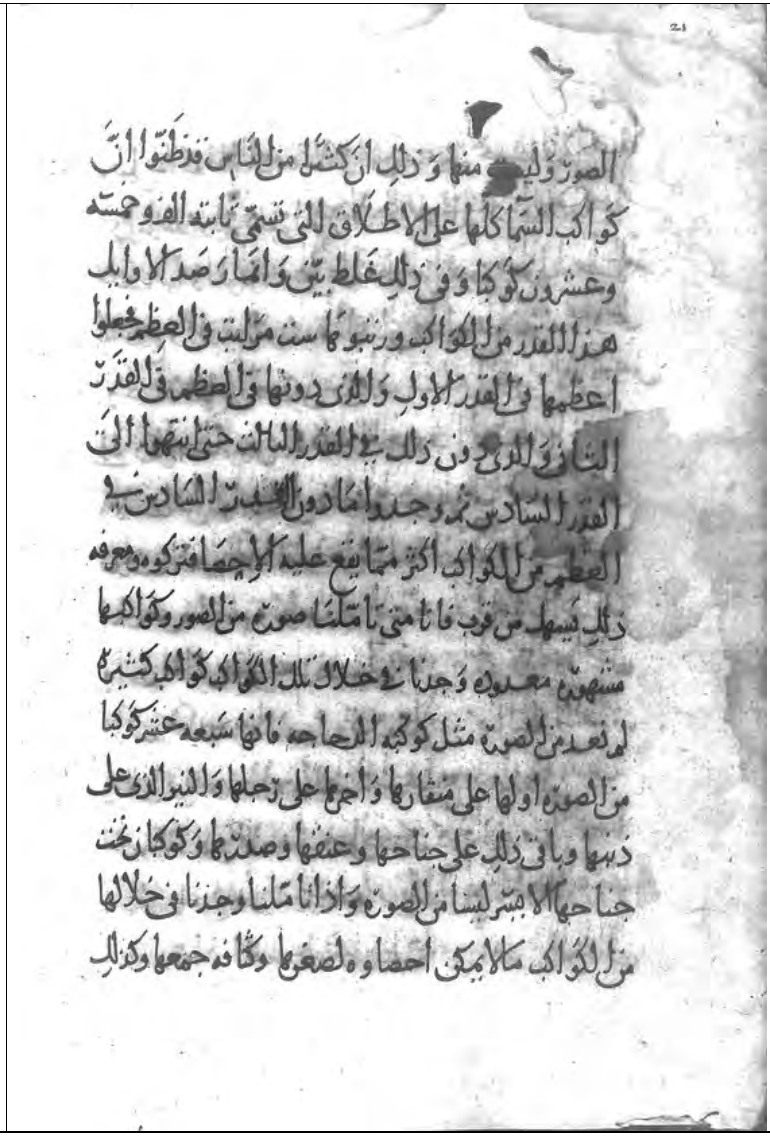
Folio 21

…..and those that surround them but are not part of them.

Many people believe that the total number of stars in the sky, which are called fixed stars, is 1025 stars. However this is an obvious mistake because ancient astronomers observed this number of stars and they divided them into 6 divisions of brightness.

They made the brightest as the 1st magnitude and those a little fainter in the 2nd magnitude then the one below that in the 3rd magnitude until they reached up to the 6th magnitude. They found the number of stars below the 6th magnitude more than they could count so they left them.
This fact can be confirmed when we look at any of the constellation and its well known stars. We find around those stars many other stars which were not counted and which are part of the same constellation.

For example in the constellation Cygnus there are 17 stars forming the constellation. The first (star) is on its beak and the last is the bright star on its leg and on its tail. The rest (of the stars) are on its wings, on its neck and on its chest. There are two stars under the left wing which are not part of the constellation. Therefore when we look closely we find many stars which we can not count because of their small sizes and their closeness together. This applies to all the other constellations.


21
الصور وليس منها وذلك ان كثيرا من الناس فظنوا ان
كواكب السما كلها على الاطلاق التي تسمى ثابتة الف وخمسة
وعشرون كوكبا وفي ذلك غلط بين وامارة ذلك ان الاوايل
رصدوا هذا القدر من الكواكب ورتبوها ست مراتب في العظم فجعلوا
اعظمها في القدر الاول والذي دونها في العظم في القدر
الثاني والذي دون ذلك في القدر الثالث حتى انتهوا الى
القدر السادس ثم وجدوا ما دون القدر السادس في
العظم من الكواكب اكثر مما يقع عليه الاحصا فتركوه ومعرفة
ذلك يسهل من قرب فانا متى تاملنا صورة من الصور وكواكبها
المشهورة المعدودة وجدنا في خلال تلك الكواكب كواكب كثيرة
لم تعد من الصورة مثل كوكبة الدجاجة فانها سبعة عشر كوكبا
من الصورة اولها على منقارها واخرها على رجلها والنير الذي على
ذنبها وباقي ذلك على جناحيها وعنقها وصدرها وكوكبان تحت
جناحها الايسر ليسا من الصورة واذا تاملنا وجدنا في خلالها
من الكواكب ما لا يمكن احصاوه لصغرها وكثافة جمعها وكذلك

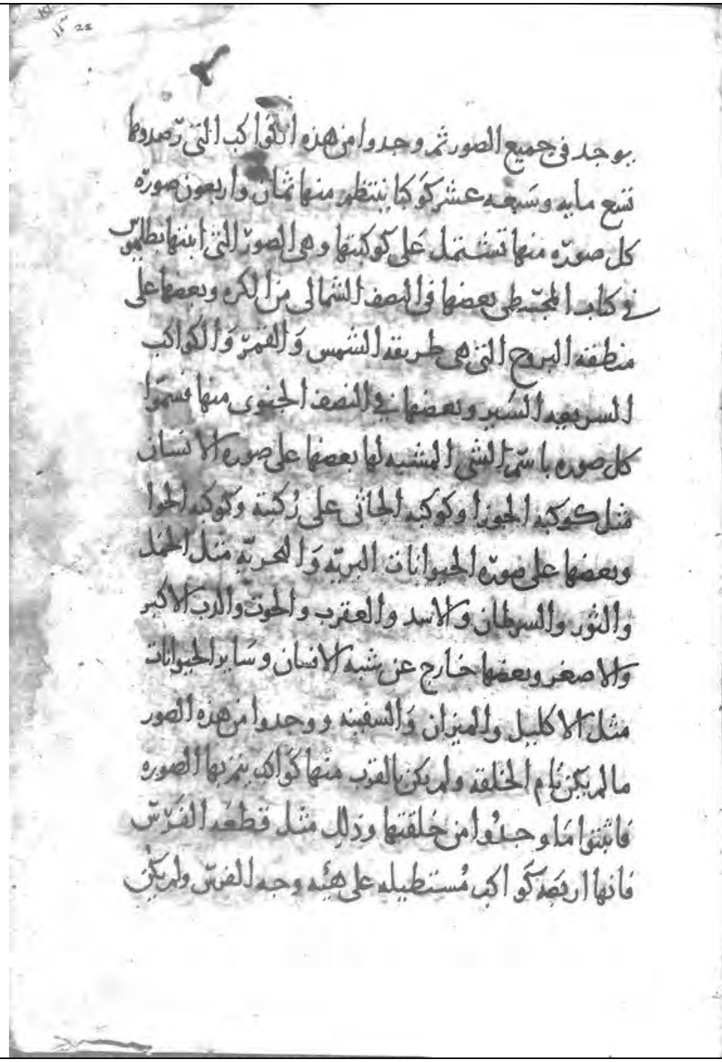
Folio 22

Then they (ancient astronomers) found that the number of observed stars is 917 stars which form the 48 constellations. Every constellation contains its own stars and these are the constellations which Ptolemy confirmed in the book *Almagest*.

Some (of these stars) are in the northern half of the sphere, some on the area of the zodiac which is on the path of the Sun, Moon and the fast moving stars (Planets), and some on the southern half of it (sphere).

They named every constellation according to what it resembles. some (they named) in the form of humans like the constellation Gemini, Hercules and Ophiuchus, some in the form of wild or marine animals such as Aries, Taurus, Cancer, Leo, Scorpio, Pisces and Ursa Major and Minor, and some not resembling Human beings and other animals such as The Corona, Libra and Argo Navis.

They (also) found that some of these constellations do not form complete images and there were no other surrounding stars to complete the image of the constellation. Therefore they confirmed what they found of its form. Such is the example of (constellation) Equuleus which consists of 4 stars forming a rectangle resembling the face of a horse.


بوجد في جميع الصور ثم وجدوا من هذه الكواكب التي رصدوها
تسع مايه وسبعه عشر كوكبا ينتظم منها ثمان واربعون صورة
كل صورة منها تشتمل على كواكبها وهي الصور التي اثبتها بطليوس
في كتاب المجسطي بعضها في النصف الشمالي من الكرة وبعضها على
منطقة البروج التي هي طريقة الشمس والقمر والكواكب
السريعه السير وبعضها في النصف الجنوبي منها سموا
كل صورة باسم الشي المشبه لها بعضها على صورة الانسان
مثل كوكبة الجوزا وكوكبة الجاثي على ركبته وكوكبة الحوا
وبعضها على صورة الحيوانات البريه والبحريه مثل الحمل
والثور والسرطان والاسد والعقرب والحوت والدب الاكبر
والاصغر وبعضها خارج عن شبه الانسان وساير الحيوانات
مثل الاكليل والميزان والسفينه ووجدوا من هذه الصور
ما لم يكن تام الخلقه ولم يكن القرب منها كواكب يتم بها الصورة
فاثبتوا ما وجدوا من خلقتها وذلك مثل قطعه الفرس
فانها اربعه كواكب مستطيله على هيئه وجه الفرس ولم يكن

Folio 23

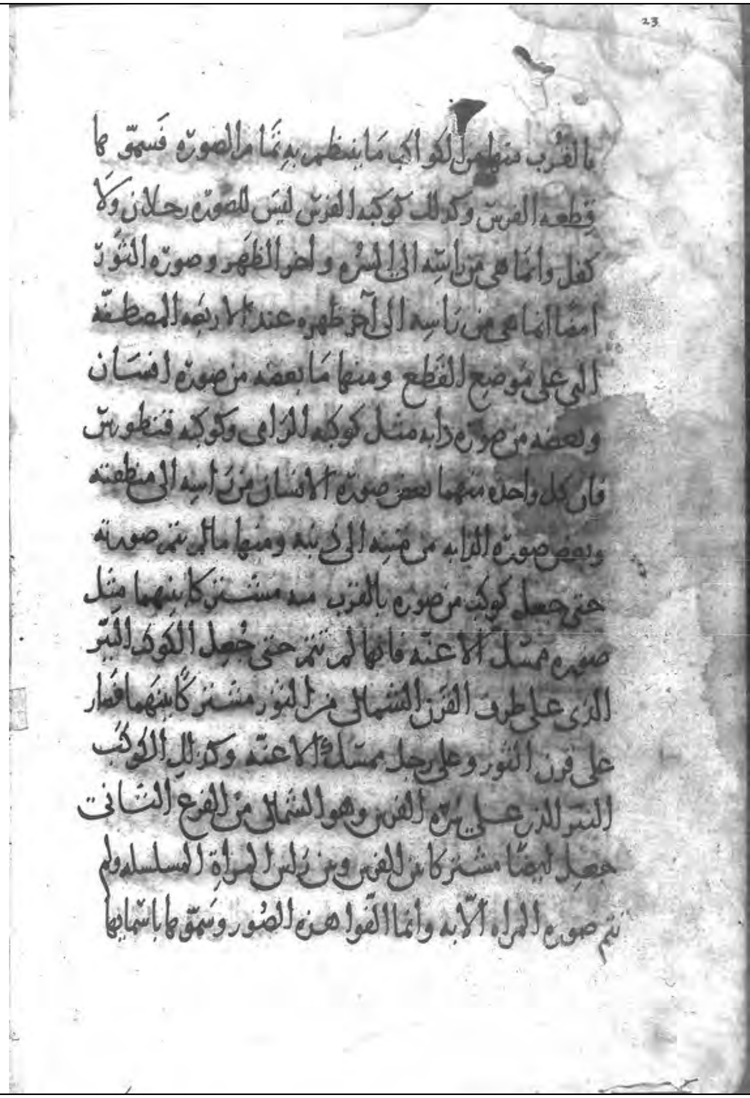
There were no surrounding stars to complete the image of the constellation so they named it Equuleus (section of a horse).

Another example is the constellation Pegasus because the image of this constellation does not include any legs or hind. It starts from its head until the navel reaching to the end of its back. The image of Taurus also starts from its head until the end of its back up to the four aligned stars on the cut-off section.

Some (constellations also) consist of part human form and part beast such as the constellations of Sagittarius and Centaurus. Because each one of these (constellations) consists of two parts the first is a human from which starts from its head until the middle and the second part resembles a beast which starts from its stomach until the tail.

Some (constellations) do not form a complete image until another star from another surrounding constellation is shared between the two. Such is the case of constellation Auriga because it is not complete until the bright star on the end of the northern horn of Taurus is shared between the two (constellations). Therefore it (the common star) is to be found on the horn of Taurus and on the leg of Auriga. Another example is the bright star on the middle of Pegasus which is the northern star of *al-Fargh al-Thānī*. This (star) is also shared between Pegasus and the head of Andromeda. This is because the image of the woman (Andromeda) is not complete without it.

When they (ancient astronomers) made up these constellations they named them by distinct names……

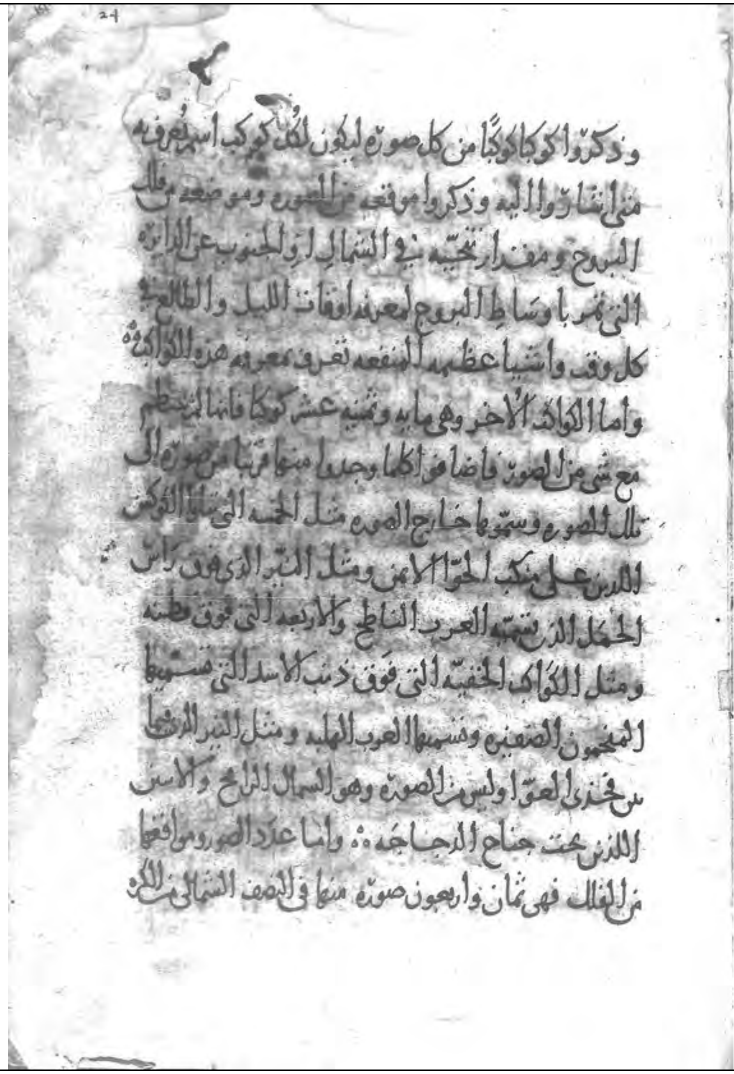


Folio 24

….. and they mentioned every star in each of these constellation so that every star can be individually recognized by its name when they need to point to it or when they mention its location in the constellation or its location on the zodiac or the deg of its movement from the north or the south from the circle which crosses the middle of the zodiac. This is done in order to know the time at night and the rising of the stars every day as well as many other great things which could be known by the knowledge of these stars.

As for the other stars they consist of 118 stars. They did not belong to any of the constellations. However they combined them with the constellations when ever they found them close to these constellations and they referred to them as outside of the constellations. Such is the example of the five (stars) which come after the two stars on the hand of Orion. Another example is the bright (star) which is above the head of Aries which the Arabs call *al-Nāṭiḥ* and the four (stars) above its stomach. Another example is the dim stars which are above the tail of Leo which are called by astronomers *al-Ḍafira* to which the Arabs call *al-Halba*. Another example is the bright star which is above the thighs of Bootes. It is not part of the constellation and is called *al-Simāk al-Rāmiḥ* as well as the two (stars) under the wings of Cygnus.

As for the number of constellations and their location on the sphere, for they are 48 constellations, …..


وذكروا كوكبا كوكبا من كل صورة ليكون لكل كوكب اسم يعرف به
متى اشاروا اليه وذكروا موقعه من الصورة وموضعه من فلك
البروج ومقدار تنحيه في الشمال او الجنوب عن الدائرة
التي تمر باوساط البروج لمعرفة اوقات الليل والطالع في
كل وقت واشياء عظيمة المنفعة تعرف بمعرفة هذه الكواكب
واما الكواكب الاخر وهي مائة وثمانية عشر كوكبا فانها لم تنتظم
مع شيء من الصور فاضافوا كلما وجدوا منها قريبا من صورة الى
تلك الصورة وسموها خارج الصورة مثل الخمسة التي تتلوا الكوكبين
اللذين على منكب الجوزا الايمن ومثل النير الذي فوق راس
الحمل الذي تسميه العرب الناطح والاربعة التي فوق بطنه
ومثل الكواكب الخفية التي فوق ذنب الاسد التي تسميها
المنجمون الضفيرة وتسميها العرب الهلبة ومثل النير الذي فيما
بين فخذي العوا وليس من الصورة وهو السماك الرامح والاثنين
اللذين تحت جناح الدجاجة . واما عدد الصور ومواقعها
من الفلك فهي ثمان واربعون صورة منها في النصف الشمالي من الكرة

Folio 25

……21 of which are on the northern part of the sphere and they are named:

Ursa Minor, Ursa Major, Draco, Cepheus, Bootes, Corona Borealis, Hercules, Lyra, Cygnus, Cassiopeia, Perseus, Auriga, Ophiuchus, Serpens, Sagitta, Aquila, Dephinus, Equuleus, Pegasus, Andromeda and Triangulum.

The numbers of stars which are part of these constellations are 331. The number of stars surrounding these constellations and which are not considered part of these constellations are 29 stars. Therefore all the stars which are in this part of the sphere are 360 stars.

The number of (constellations) which are on the ecliptic are 12 constellations and they are named:

Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricorn, Aquarius and Pisces.


احدى وعشرون صورة واسماوها ∴ الدب الاصغر ∴
والدب الاكبر ∴ والتنين ∴ وقيفاوس ∴ والعوا الذى
يقال له الصايح ∴ والاكليل الشمالى وهو الفكة ∴ والجاثى
على ركبته ∴ والسلياق وهو النسر الواقع ∴ والطاير
وهو الدجاجه ∴ وذات الكرسى ∴ وبرشاوش وهو حامل
راس الغول ∴ وممسك الاعنة ∴ والحوا الذى يمسك
الحية ∴ وحية الحوا ∴ والسهم ∴ والعقاب وهو النسر
الطاير ∴ والدلفين ∴ وقطعة الفرس ∴ والفرس الثانى
والمراة المسلسلة ∴ والمثلث ∴ وعدد كواكب هذه الصور
التى من نفس الصور ثلثمايه واحد وثلثون كوكبا والتى حوالى
الصور وليست من الصور تسعه وعشرون كوكبا ∴ فجميع الكواكب
التى فى هذا النصف من الكره ثلثمايه وستون كوكبا ∴
ومنها على فلك البروج اثنا عشر صورة واسماوها ∴
الحمل ∴ والثور ∴ والتوامان ∴ والسرطان ∴ والاسد ∴
والعذرا ∴ والميزان ∴ والعقرب ∴ والرامى ∴ والجدى ∴

Folio 26

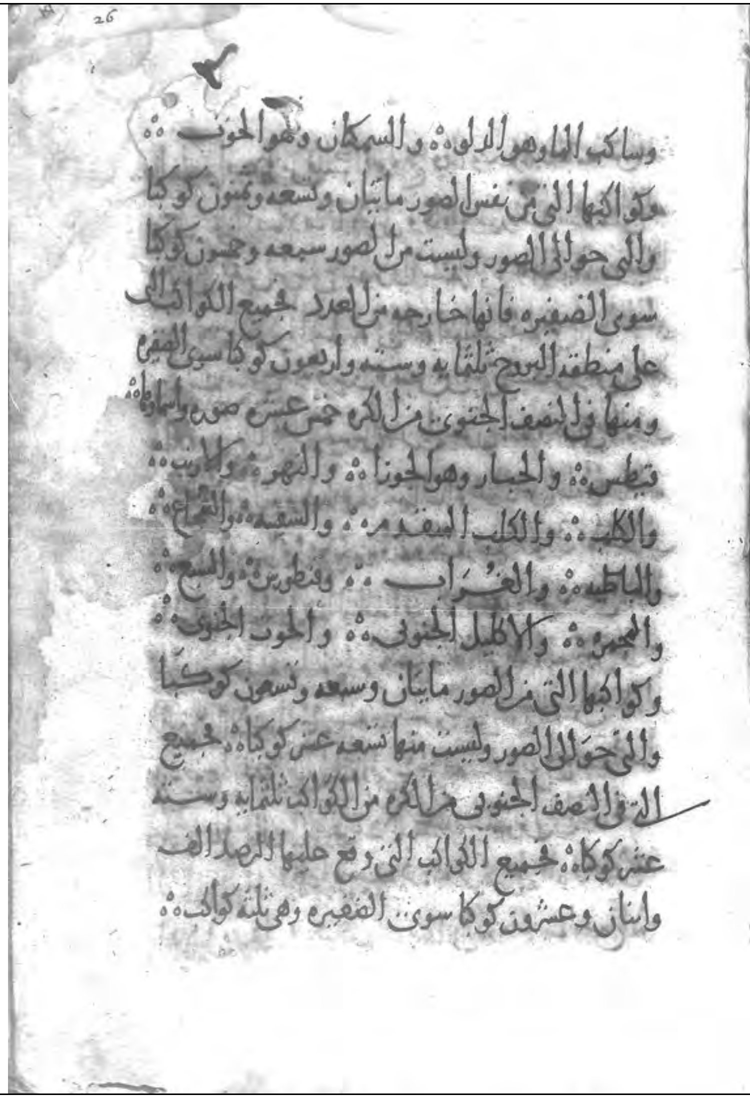
The numbers of stars which are part of these constellations are 289 stars. The number of stars surrounding these constellations and which are not considered parts of these constellations are 57 stars except (the stars of) *al-Ḍafira* because they were not counted. Therefore all the stars which are on the ecliptic are 346 stars except *al-Ḍafira*.

The number of (constellations) on the southern part of the sphere are 15 constellations and they are named:

Cetus, Orion, Eridanus, Lepus, Canis Major, Canis Minor, Argo Navis, Hydra, Crater, Corvus, Centaurus, Lupus, Ara, Corona Australis and Piscis Austrinus.

The numbers of stars which are part of these constellations are 297 stars. The number of stars surrounding these constellations and are not considered part of these constellations are 19 stars. Therefore all the stars which are in the southern part of the sphere are 316 stars.

Therefore all the stars which have been observed (by ancient astronomers) are 1022 stars except *al-Ḍafira* which consist of 3 stars.


26
وساكب الما وهو الدلو ؞ والسمكان وهو الحوت ؞
وكواكبها التي من نفس الصور مايتان وتسعة وثمنون كوكبا
والتي حول الصور وليست من الصور سبعة وخمسون كوكبا
سوى الضفيرة فانها خارجة من العدد فجميع الكواكب التي
على منطقة البروج ثلثماية وستة واربعون كوكبا سوى الضفيرة
ومنها في النصف الجنوبي من الكرة خمس عشرة صورة واسماوها ؞
قيطس ؞ والجبار وهو الجوزا ؞ والنهر ؞ والارنب ؞
والكلب ؞ والكلب المتقدم ؞ والسفينة ؞ والشجاع ؞
والباطية ؞ والغراب ؞ وقنطورس ؞ والسبع ؞
والمجمرة ؞ والاكليل الجنوبي ؞ والحوت الجنوبي ؞
وكواكبها التي من الصور مايتان وسبعة وتسعون كوكبا
والتي حول الصور وليست منها تسعة عشر كوكبا ؞ فجميع
التي في النصف الجنوبي من الكرة من الكواكب ثلثماية وستة
عشر كوكبا ؞ فجميع الكواكب التي وقع عليها الرصد الف
واثنان وعشرون كوكبا سوى الضفيرة وهي ثلثة كواكب ؞

Folio 27

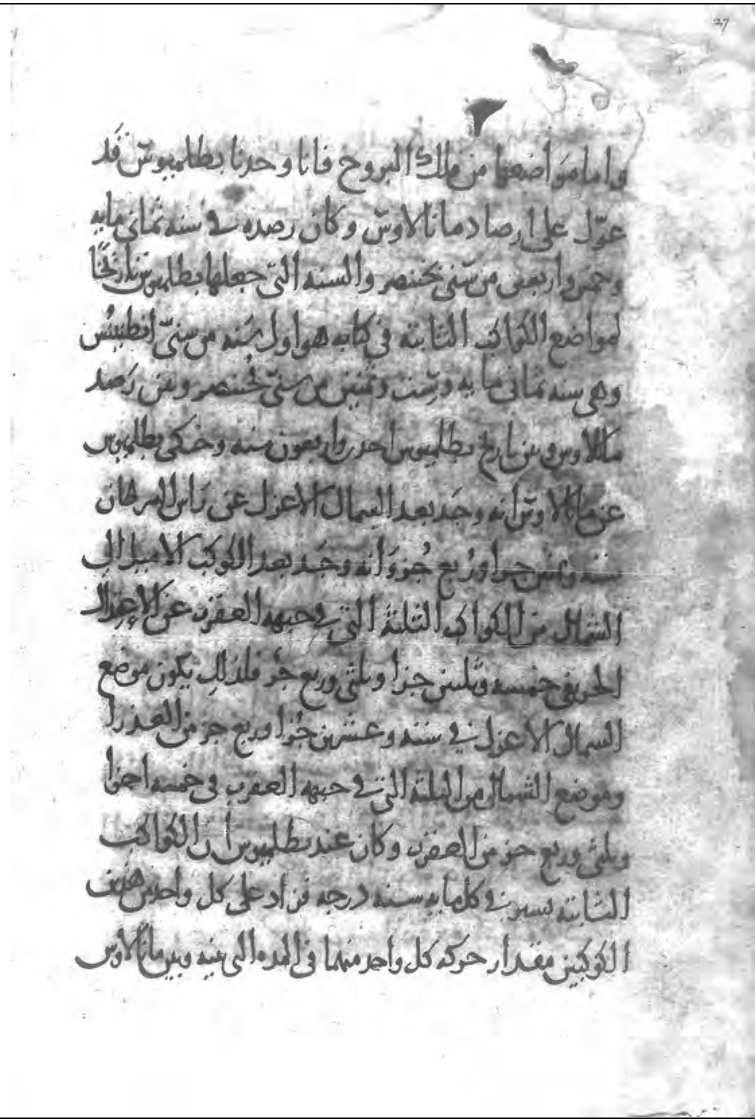
As for their locations on the ecliptic we have found that Ptolemy used the observations of Menelaus who made his observations in the year 845 of the year of *Naboukhat Nassar* (Nabonassar).

The year that Ptolemy made as reference for the location of the fixed stars in his book is the first year of the era of Antoninus (Roman emperor A.D. 138-161) which is in the year 886 of the era of *Naboukhat Nassar*.

The time difference between the observations of Menelaus and the date of Ptolemy is 41 years.

Ptolemy referred to Menelaus as saying that he found the distance between *al-Simāk al-A'zal* and the head of Cancer to be 68 and ¼ of a deg. And he found the distance of the northernmost star of the three (stars) on the forehead of Scorpio to the autumnal equinox to be 35 and 2/3 and ¼ of a deg. Therefore the position of *al-Simāk al-A'zal* should be 26 and ¼ of a deg in Virgo, and the position of the northernmost star of the three (stars) on the forehead of Scorpio is 5 and ¼ in Scorpio.

Ptolemy mentioned that the fixed stars move every 100 years by one deg. Therefore he added on every one of these stars the yearly amount for the (precession) movement between his own time and that of Menelaus…..


واما مواضعها من فلك البروج فانا وجدنا بطلميوس قد
عول على ارصاد مانالاوس وكان رصده في سنة ثماني مائة
وخمس واربعين من سني بختنصر والسنة التي جعلها بطلميوس تاريخا
لمواضع الكواكب الثابتة في كتابه هو اول سنة من سني انطنيس
وهي سنة ثماني مائة وست وثمانين من سني بختنصر وبين رصد
منالاوس من تاريخ بطلميوس احدى واربعون سنة وحكى بطلميوس
عن منالاوس انه وجد بعد السماك الاعزل عن راس السرطان
ستة وستين جزءا وربع جزء وانه وجد بعد الكوكب الاشمالي
الشمالي من الكواكب الثلثة التي في جبهة العقرب عن الاعتدال
الخريفي خمسة وثلثين جزءا وثلثي وربع جزء فلذلك يكون موضع
السماك الاعزل في ستة وعشرين جزءا وربع جزء من العذراء
وموضع الشمالي من الثلثة التي في جبهة العقرب في خمسة اجزاء
وثلثي وربع جزء من العقرب وكان عند بطلميوس ان الكواكب
الثابتة تسير في كل مائة سنة درجة فزاد على كل واحد من هذين
الكوكبين مقدار حركة كل واحد منهما في المدة التي بين زماني مانالاوس

Folio 28

…….which is approximately 41 years and 25 minutes.

Therefore he placed *al-Simāk al-A'zal* at 26 and 2/3 of a deg in Virgo and the position of northernmost star on the forehead of Scorpio at 6 and 1/3 of a deg in Scorpio. Then he added this difference to all the stars which he cataloged in the book *Almagest*.

Then the authors of *al-Mumtaḥen* (tables) observed (the stars) and they found that they have moved from the positions which where mentioned by Menelaus by one deg every 66 years which was the time difference in years between their observations and the observation of Menelaus.

The time difference in years which we have adopted as reference for the position of the stars in this book, starting from the beginning of the year 1276 in the era of *Thū al-Qarnaīn* (Alexander the Great) (A.D. 964) and between the observations of Menelaus was 866 years.

The amount of the movement of the stars in these years is approximately 13 deg and 7 min every 66 years. Therefore if we subtracted from this the amount which Ptolemy added on every star which is 25 min……


من السنين وهي لاحدى واربعين سنة خمس وعشرون دقيقة
بالتقريب فوضع موضع السماك الاعزل في ست وعشرين
درجة وثلثي درجة من العذرا وموضع الكوكب الشمالي الذي في
جبهة العقرب في ست درجات وثلث درجة من العقرب ثم زاد
هذه الزيادة على جميع الكواكب ووضعها في كتاب المجسطي في
الجدول ثم رصد اصحاب الممتحن فوجدوها قد
تحركت عن مواضعها التي ذكرها ماناالاوس في كل ستة وستين
سنة درجة في المدة التي بين ارصادهم وارصاد ماناالاوس
من السنين وكان بين الوقت الذي جعلناه تاريخا لمواضع الكواكب
في هذا الكتاب وهو اول سنة الف ومايتين وست وسبعين من سني
ذي القرنين وبين رصد ماناالاوس من السنين ثمانمائة وستة
وستون سنة فيكون حركات الكواكب في هذه السنين على ان
حركتها في كل ستة وستين سنة درجة ثلث عشر درجة وسبع
دقايق بالتقريب فاذا نقصنا من ذلك مقدار ما قد زاده بطليموس
على كل كوكب وهو خمس وعشرون دقيقة بقي ما يجب ان زاد

Folio 29

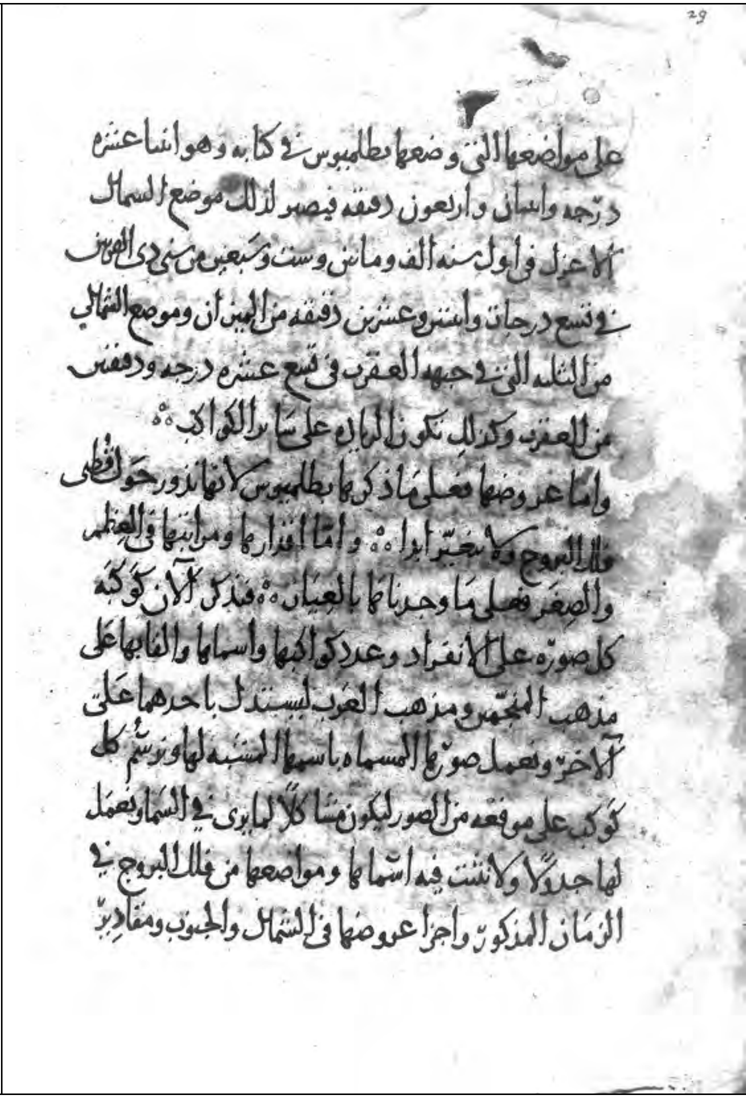
…..we are left with what is supposed to be added to the positions (of the stars) in Ptolemy's book which is 12 deg 42 min.

Therefore the position of *al-Simāk al-A'zal* in the beginning of the year 1276 in the era of *Thū al-Qarnaīn* becomes 9 deg 22 min in Libra, and the position of the northernmost star of the three on the forehead of Scorpio becomes 19 deg and 2 min in Scorpio. This is the addition which should be applied to all the stars.

As for the latitudes, as Ptolemy mentioned, since they rotate around the poles of the ecliptic therefore they do not ever change.

As for the magnitudes (of the stars) and their level of brightness and dimness, which we observed our self, we will mention every constellation separately and the number of stars it contains and their names and aliases as per the method of astronomers and the Arabs so you can distinguish one from the other.

We will make images which correspond to their names. We will draw every star in the constellation as it is seen on the sky. We will compile for this a table which shows their names and location on the ecliptic at the time (see above) which includes the deg of the north and south latitudes as well as their magnitudes.


على مواضعها التي وضعها بطلميوس في كتابه وهو اثنا عشر
درجة واثنان واربعون دقيقة فيصير لذلك موضع السماك
الاعزل في اول سنة الف ومائتين وست وسبعين من سني ذي القرنين
في تسع درجات واثنتين وعشرين دقيقة من الميزان وموضع الشمالي
من الثلاثة التي في جبهة العقرب في تسع عشرة درجة ودقيقتين
من العقرب وكذلك تكون الزيادة على سائر الكواكب
واما عروضها فعلى ما ذكرها بطلميوس لانها تدور حول قطبي
فلك البروج ولا تتغير ابدا واما اقدارها ومراتبها في العظم
والصغر فعلى ما وجدناها بالعيان فنذكر الان كوكبة
كل صورة على الانفراد وعدد كواكبها واسمائها والقابها على
مذهب المنجمين ومذهب العرب ليستدل باحدهما على
الاخر ونعمل صورة المسماة باسماء المشبهة لها ونرسم كل
كوكب على موقعه من الصور ليكون مشاكلا لما يرى في السماء ونعمل
لها جدولا ولا نثبت فيه اسمائها ومواضعها من فلك البروج في
الزمان المذكور واجزاء عروضها في الشمال والجنوب ومقاديرها

Folio 30

We will mark for every star on the list and on the constellation image a sign written by numerical letters indicating its position so that it is made easier when we point to it.

We will start by the closest to the known poles then those that follow it, one at a time, similar to what Ptolemy arranged in his book.

We will rely on God to guide and help us and what satisfies the prominent prince ‘Aḍud al-Dawla, may God prolong his life and assist him. May God be our helper and be our sustainer.

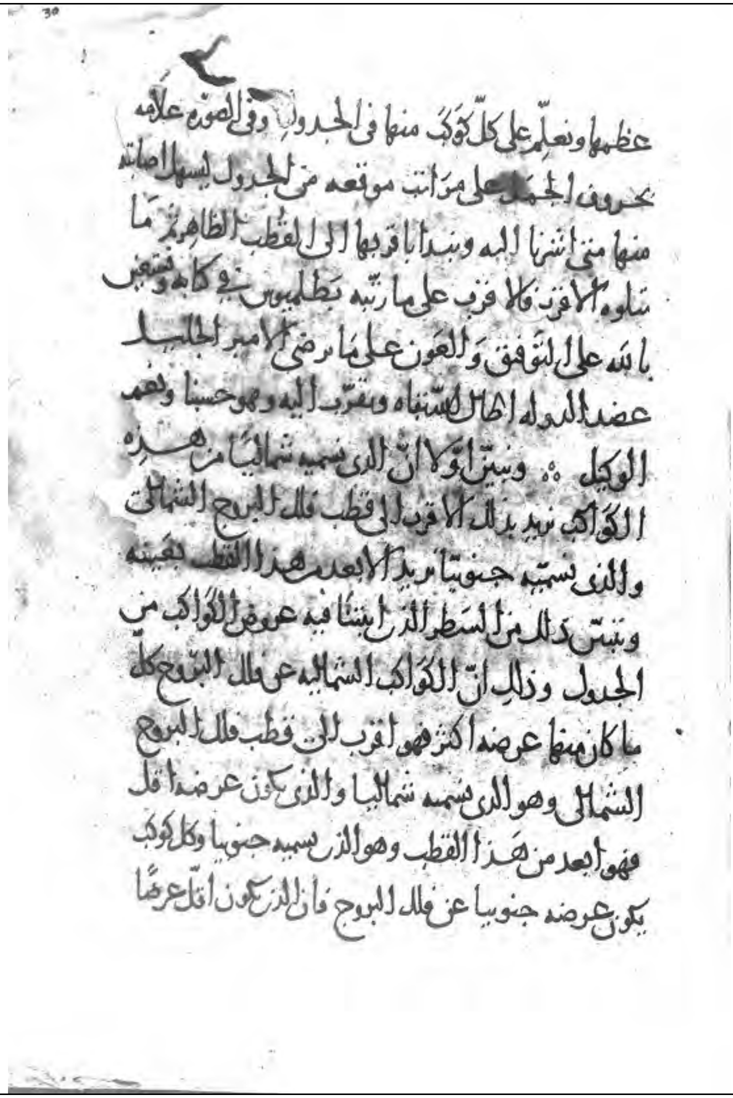
We will show first that what we refer to as north stars we mean by this the closest to the north ecliptic pole, and those we refer to as southern we mean by this the furthest from that same pole.

We will show this in the line where we mention the latitude of the stars in the table.

As for the stars to the north of the ecliptic, the more their latitude is greater then they are closer to the north ecliptic pole. We will refer to (such a star) as a northern star.

Where as those stars whose latitude is less then they are furthest from that pole. And we will refer to such a star as a southern star.

As for the star whose latitude is south of the ecliptic then the one whose latitude is less……


عظمها ونعلم على كل كوكب منها في الجدول وفي الصورة علامة
بحروف الجمل على مراتب موقعه من الجدول ليسهل اصابته
منها متى اشرنا اليه ونبدأ باقربها الى القطب الظاهر ثم ما
يتلوه الاقرب فالاقرب على ما رتبه بطلميوس في كتابه ونستعين
بالله على التوفيق والعون على ما يرضي الامير الجليل
عضد الدولة اطال الله بقاه وتقرب اليه وهو حسبنا ونعم
الوكيل ∴ ونبين اولا ان الذي نسميه شماليا من هذه
الكواكب نريد بذلك الاقرب الى قطب فلك البروج الشمالي
والذي نسميه جنوبيا نريد الابعد من هذا القطب بعينه
ونبين ذلك من السطر الذي اثبتنا فيه عروض الكواكب من
الجدول وذلك ان الكواكب الشمالية عن فلك البروج كل
ما كان منها عرضه اكثر فهو اقرب الى قطب فلك البروج
الشمالي وهو الذي نسميه شماليا والذي يكون عرضه اقل
فهو ابعد من هذا القطب وهو الذي نسميه جنوبيا وكل كوكب
يكون عرضه جنوبيا عن فلك البروج فان الذي يكون اقل عرضا

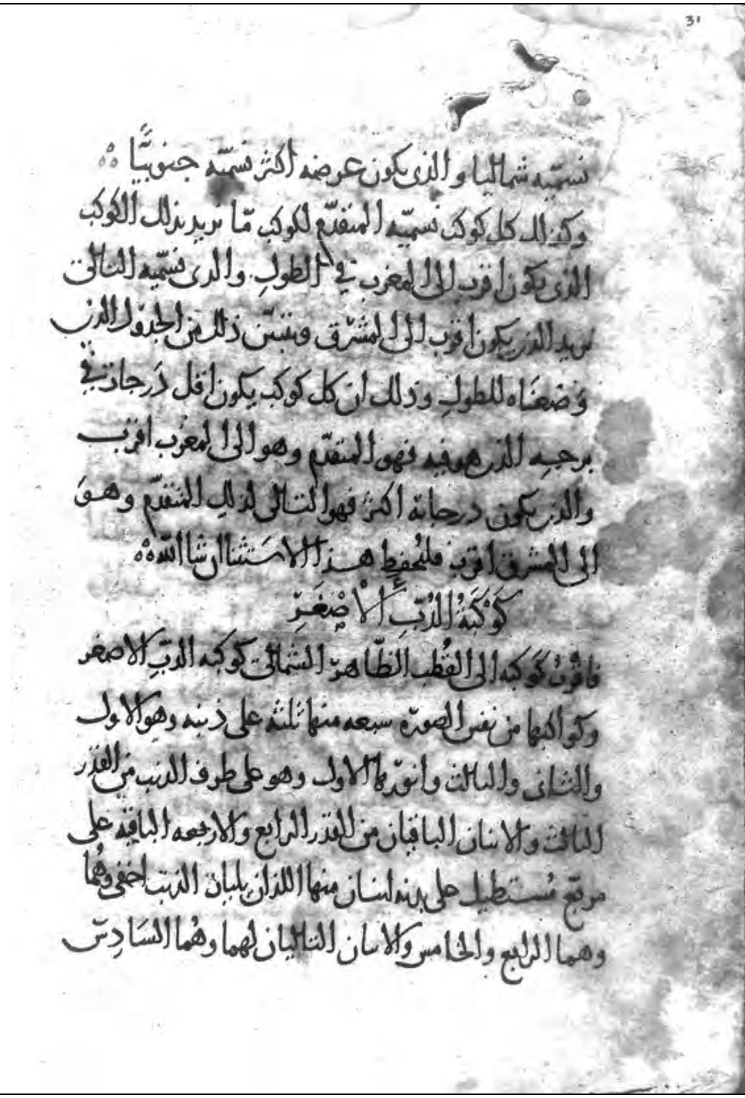
Folio 31

…….we will call northern and the one whose latitude is more then we will call southern.

As for the star we refer to as *al-Mutaqadem* (most-Advanced) to another, then this is the star that is closer to the west in longitude.
The (star) we refer to as *al-Tālī* (rear-most), we mean by this to be the (star) that is closer to the east.

We will show that in the list which we have compiled for the constellation longitude that every star which has the least number of degrees is the one that is closer to the west and the one for which the number degrees are greater is to the rear of this star and lies towards the east.

These (instructions) should be memorized by Gods will.


نسميه شماليا والذي يكون عرضه اكثر نسميه جنوبيا
وكذلك كل كوكب نسميه المتقدم لكوكب ما نريد بذلك الكوكب
الذي يكون اقرب الى المغرب في الطول والذي نسميه التالي
نريد الذي يكون اقرب الى المشرق وتبين ذلك من الجدول الذي
وضعناه للطول وذلك ان كل كوكب يكون اقل درجات في
برجه الذي هو فيه فهو المتقدم وهو الى المغرب اقرب
والذي يكون درجاته اكثر فهو التالي لذلك المتقدم وهو
الى المشرق اقرب فليحفظ هذه الاشيا ان شا الله

كوكبة الدب الاصغر

فاول كوكبة الى القطب الظاهر الشمالي كوكبة الدب الاصغر
وكواكبها من نفس الصورة سبعة منها ثلثة على ذنبه وهو الاول
والثاني والثالث وانورها الاول وهو على طرف الذنب من القدر
الثالث والاثنان الباقيان من القدر الرابع والاربعة الباقية على
مربع مستطيل على بدنه اثنان منها اللذان يليان الذنب اخفوهما
وهما الرابع والخامس والاثنان التاليان لهما وهما السادس

Folio 21 (Manuscript: MS5306)

The constellation Small Bear (*al-Dub al-Aṣghar)* (or Ursa Minor)

The closest constellation to the northern visible pole is the Small Bear constellation (Ursa Minor).
Its stars in the main picture are seven (in number). Three are on the tail: the first, second and third. The brightest is the first which is at the end of the tail and is of the 3rd magnitude. The remaining two (on the tail) are of the 4th magnitude.

The four remaining stars form a rectangle on the body. The two stars next to the tail are dimmer; these are the fourth and the fifth. The other two beyond them are the sixth and the seventh; these are brighter.

Ptolemy noted that the fourth and the fifth are both of the 4th magnitude while the sixth and seventh are of the 2nd magnitude.

However the fourth (star) is indeed of the 4th magnitude because it is similar to the two on the tail.

21

يكون درجاته أكثر فهو التالي لذلك المتقدم وهو الى المشرق
اقرب فلنحفظ هذه الاشياء ان شاء الله تعالى

كوكبة الدب الاصغر

واقرب كوكبة الى القطب الظاهر الشمالي كوكبة الدب الاصغر
وكواكبها من نفس الصورة سبعة منها ثلثة على ذنبه وهي
الاول والثاني والثالث وانورها الاول وهو على طرف الذنب
من القدر الثالث والاثنان الباقيان من القدر الرابع والاربعة
الباقية على مربع مستطيل على بدنه اثنان منها اللذان يليان
الذنب اخفى وهما الرابع والخامس والاثنان التاليان لهما وهما السادس
والسابع انور وذكر بطلميوس ان الرابع والخامس جميعا من القدر
الرابع وان السادس والسابع جميعا من القدر الثاني فأما الرابع
فهو من القدر الرابع لانه مثل الاثنين اللذين على الذنب واما

As for the fifth it is greater than the 5th magnitude, while the sixth is of the 2nd magnitude. The seventh star must be of the 3rd magnitude because the one on the end of the tail is of the 3rd magnitude, and the seventh star is less in magnitude or similar (to that). (The figure of the constellation) is not complete because it does not have a head or legs. These seven stars have been compared with the image of a bear because they are similar to the seven stars of the constellation (*al-Dub al-Akbar)* the Great Bear (Ursa Major). Three of these (stars) are also on the tail and four on the body. It has a head and legs and its shape resembles a bear. As for the Small (Bear), the Arabs call the seven (stars) of the group *Banāt Na'sh al-Ṣugrha* (The Little Daughters of the Bier or Coffin). The four on the rectangle are the *Na'sh* (bier or coffin) and the three on the tail are the *Banāt* (the daughters). (The Arabs) call the two brightest stars of the rectangle *al-Farqadain* and the bright star on the end of the tail *al-Juday;* this (star) is used to locate the *Kiblah* (= the direction of Makkah). The three stars on the tail, together with the fourth and sixth (the word "seventh" has been scratched out) form a curved line. Next to the brightest (star) of the *al-Farqadain*, which is the sixth, is a fainter star, on the same line as the *al-Farqadain* (but) not of the constellation.	 الخامس فهو من القدر الخامس من اكبره واما السادس فهو من القدر الثاني والسابع يجب ان يكون من القدر الثالث لان الذي على طرف الذنب قد جعله من القدر الثالث وهذا الكوكب السابع هو دونه في القدر او مثله وليس بتام الخلقة لانه ليس له راس ولا قوايم وانما شبهت السبعة بصورة الدب لتشبهها بالسبعة التي من صورة الدب الاكبر ثلثة منها على ذنبه ايضا واربعة على بدنه وله راس وقوايم وخلقته شبيهة بخلقة الدب فاما الاصغر فان العرب تسمي السبعة على الجملة بنات نعش الصغرى منها الاربعة التي على المربع نعش والثلثة التي على الذنب بنات وتسمي النيرين من المربع الفرقدين والنير الذي على طرف الذنب الجدي وهو الذي تنحى به القبلة وقد صارت الثلثة التي على الذنب مع الرابع والسادس والسابع من المربع على سطح مقوس ويقرب الانور من الفرقدين وهو السادس كوكب اخفى منه على استقامة الفرقدين

Folio 22

For Ptolemy mentioned it and specified it as outside the constellation, and of the 4th magnitude.

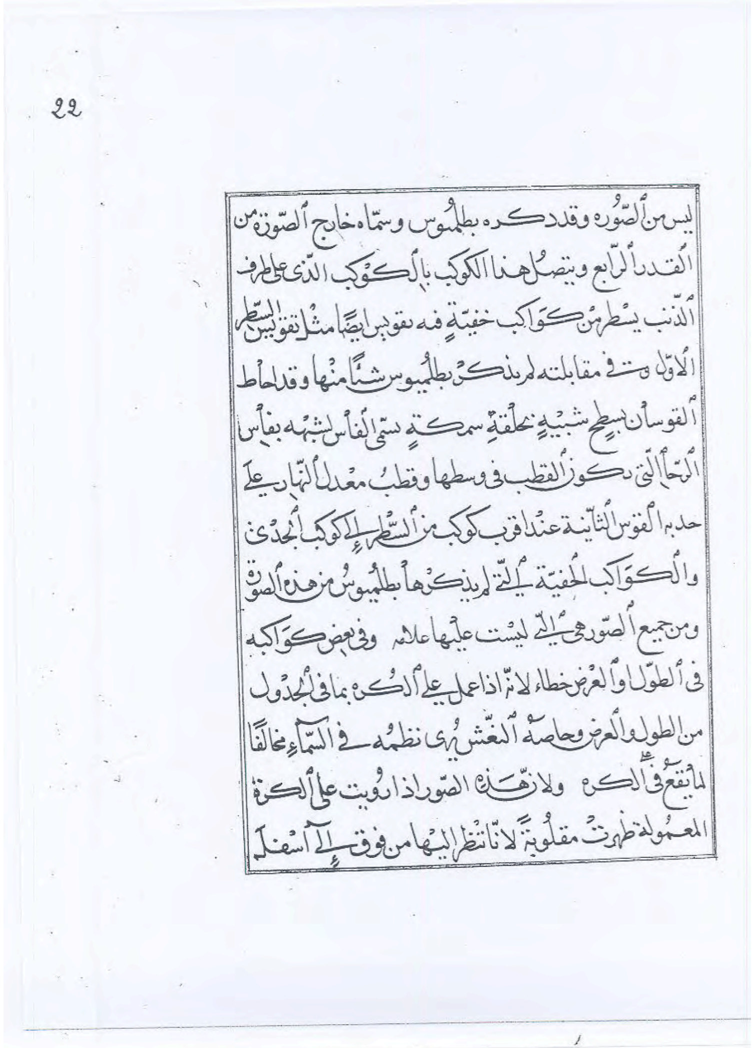
This star is connected with the star on the end of the tail, forming a line of dim stars which is curved like the first line. In his work, Ptolemy did not mention anything about this.

These two arcs enclose an area with the shape of a fish, called *al-Fa'*s; this may be compared with *Fa's al-Raḥā*, where the pole is in the middle. (However), the equatorial pole is on the outside of the second arc, close to the nearest star on the line to the star *al-Juday*

All the dim stars which Ptolemy did not include as part of this constellation as well as those in all the other constellations are all the ones which are unmarked. (al-Ṣūfī is probably referring here to the drawings of the constellation in his original book which is not extant)

In some of (Ptolemy's) stars (charts) both the latitude and longitude are incorrect. This is because if they are marked on a (celestial) globe according to (Ptolemy's) table of latitude and longitude, especially (the stars of) *al-Na'sh*, we notice that the image (of the constellation) in the heavens does not correspond with what is (seen) on the globe.

Furthermore, when these constellations are projected on the globe they are seen inverted, because we are viewing them from up towards down.


22

ليس من الصورة وقد ذكره بطلميوس وسماه خارج الصورة من
القدر الرابع ويتصل هذا الكوكب بالكوكب الذي على طرف
الذنب سطر من كواكب خفية فيه تقويس أيضا مثل تقويس السطر
الأول وست في مقابلته لم يذكر بطلميوس شيئا منها وقد أحاط
القوسان بسطح شبيه بخلقة سمكة يسمى الفأس لشبهه بفأس
الرحا التي يكون القطب في وسطها وقطب معدل النهار على
حدبة القوس الثانية عند أقرب كوكب من السطر إلى كوكب الجدي
والكواكب الخفية التي لم يذكرها بطلميوس من هذه الصورة
ومن جميع الصور هي التي ليست عليها علامة وفي بعض كواكبه
في الطول والعرض خطاء لأنه إذا عمل على الكرة بما في الجدول
من الطول والعرض وخاصة النعش يرى نظمه في السماء مخالفا
لما يقع في الكرة ولأن هذه الصور إذا رسمت على الكرة
المعمولة ظهرت مقلوبة لأنا ننظر إليها من فوق إلى أسفل

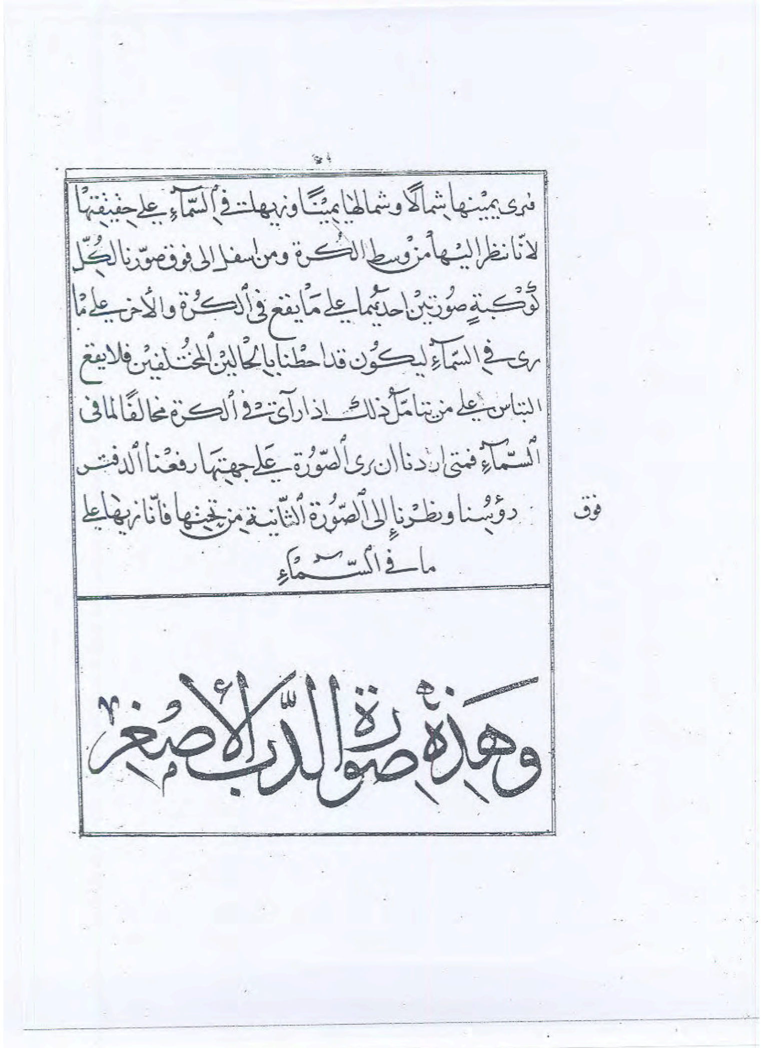
Hence we see its right as left and it’s left as right. For we see (the constellations) in the heavens as it should be because we are observing from the centre of the globe and from down towards up.

For every constellation we have drawn two pictures: one as it is projected on the globe and the other as it is seen in the heavens.

Hence we have covered both of the different cases, so there is no confusion for anyone who sees that what is viewed on the globe is different from what is in the heavens.

When we want to see the constellation as it (really) is we lift the book over our heads and we look at the second picture (in the book). From beneath (the book) we are viewing (the constellation) as it is seen in the heavens.

This is the picture of the (constellation) Small Bear (*al-Dub al-Asghar)* (Ursa Minor)


فنرى يمينها شمالا وشمالها يمينا ونراها في السماء على حقيقتها
لانا نظر اليها من وسط الكرة ومن اسفل الى فوق صورنا لكل
كوكبة صورتين احديهما على ما يقع في الكرة والاخرى على ما
يرى في السماء ليكون قد احطنا بالحالين المختلفين فلا يقع
اللبس على من يتامل ذلك اذا راى في الكرة مخالفا لما في
السماء فمتى اردنا ان نرى الصورة على جهتها رفعنا الدفتر
فوق رؤسنا ونظرنا الى الصورة الثانية من تحتها فانا نراها على
ما في السماء

وهذه صورة الدب الاصغر

Folio 23

(Constellation) As seen on the globe

east

North constellation image south

west

(Constellation) As seen in the sky

east

South constellation image North

west

Table of the constellation Ursa Minor with the addition of 12 (degrees) 42 (minutes) to what is found in the Almagest

Number	Star Name	Longitude			Lat direction	Latitude		Mag
		zodiac	deg	min		deg	min	
1	The star on the end of the tail which is *al-Juday*	2(60)	12	52	N	66	00	3
2	The one next to it on the tail	2(60)	15	12	N	70	00	4
3	The one next to that before the place where the tail joins the body	2(60)	28	42	N	74	00	4
4	The southern most of the stars in the foremost side of the rectangle	3(90)	12	22	N	75	40	4
5	The northern most of those in the same side	3(90)	16	22	N	77	40	5k
6	The southern star in the rear side which is the brightest of *al-Farqadain*	3(90)	29	52	N	72	50	2
7	The northern one in the same side which is the dimmest of *al-Farqadain*	4(120)	08	52	N	74	50	3
7 stars, 1 is of the 2nd magnitude, 2 of the 3rd magnitude, 3 of the 4th magnitude, 1 of the 5th magnitude								
The one underneath and not in the constellation								
8	The southern star parallel to *al-Farqadain*	4(90)	25	42	N	71	10	4

Folio 24 (Manuscript: MS5036)

The constellation Great Bear (*al-Dub al-Akbar)* (or Ursa Major)

Its stars are twenty seven stars in the main picture and eight around the picture. They have (all) been mentioned by Ptolemy and the stars (marked by *) are not included (in the picture).

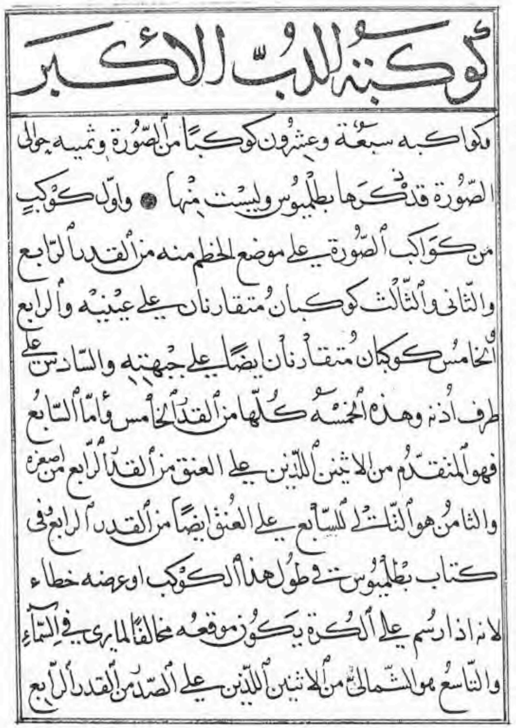
The first star of the constellation is the one on *al-Khaṭem* (the snout) and is of the 4th magnitude. The second and third are two close stars on its eyes. The fourth and fifth are also two close stars (located) on its forehead. The sixth is on the tip of its ear. All those five (stars) are of the 5th magnitude.

As for the seventh (star) it is the more advanced of the two stars in the neck which is less than 4th magnitude while the eighth follows the seventh on the neck and is also of the 4th magnitude.

In Ptolemy's book there is a mistake in the longitude or latitude of this star because if it is to be drawn on a globe its position would not correspond to what is seen in the sky.

The ninth is the northernmost of the two (stars) on the chest (and) is of the 4th magnitude.

24



كوكبة الدب الأكبر

كواكبه سبعة وعشرون كوكبا من الصورة وثمانية حول
الصورة قد ذكرها بطلميوس وليست منها • واول كوكب
من كواكب الصورة على موضع الخطم منه من القدر الرابع
والثاني والثالث كوكبان متقاربان على عينيه والرابع
والخامس كوكبان متقاربان ايضا على جبهته والسادس على
طرف اذنه وهذه الخمسة كلها من القدر الخامس واما السابع
فهو المتقدم من الاثنين اللذين على العنق من القدر الرابع من اصغره
والثامن هو التالي للسابع على العنق ايضا من القدر الرابع وفي
كتاب بطلميوس في طول هذا الكوكب او عرضه خطاء
لانه اذا رسم على الكرة يكون موقعه مخالفا لما يرى في السماء
والتاسع هو الشمالي من الاثنين اللذين على الصدر من القدر الرابع

Additionally, the tenth is the southernmost of the two and is less than 4th magnitude.

The eleventh is (the star) on the left knee and is of the 3rd magnitude.

The twelfth and thirteenth are two close stars (located) on the left paw. The twelfth is a little further to the north and they are both less than 3rd magnitude.

The fourteenth is above the right knee while the fifteenth is below the knee and these (stars) are all much greater than the 5th magnitude.

Ptolemy mentioned that these (stars) are of the 4th magnitude and in Ptolemy's book there is a mistake on the fifteenth (star) because if it is to be drawn on a globe its position would not correspond to what is seen in the sky.

The sixteenth (star) is on the back (of the constellation picture), which forms a part of a bright *al-Murabba‘ al-Mustaṭīl* (quadrilateral), and is of the 2nd magnitude.

The seventeenth (star) which forms the other point of the quadrilateral is located on *al-Mirāq* (the flank or groin). It is much greater than the 3rd magnitude; (however) Ptolemy mentioned that it is of the 2nd magnitude.

The eighteenth (star) is located on the other point of the quadrilateral facing this (previous) point. It is where the tail joins the body and is less than the 3rd magnitude.


والعاشر هو الجنوبي من الاثنين من القدر الرابع من اصغره والحادي
عشر على ركبة اليد اليسرى من القدر الثالث والثاني عشر
والثالث عشر كوكبان متقاربان على يده اليسرى احدهما وهو
الثاني عشر يميل الى الشمال قليلا وهما جميعا من القدر الثالث
من اصغره والرابع عشر فوق الركبة من اليد اليمنى والخامس عشر
تحت هذه الركبة وهما جميعا من القدر الخامس من اعظمه
وذكر بطلميوس انهما من القدر الرابع وفي الخامس عشر في كتاب
بطلميوس خطاء لانه اذا رسم في الكرة يقع مخالفا لما يرى في السماء
والسادس عشر على ظهره من المربع النير المستطيل من القدر الثاني
والسابع عشر على هذا الضلع من المربع على موضع المراق منه من القدر
الثالث من اعظمه وذكر بطلميوس انه من القدر الثاني
والثامن عشر على الضلع الاخرى المقابلة لهذه الضلع من المربع
المستطيل على آخر الظهر عند مغرز الذنب من القدر الثالث من

Folio 25

Ptolemy mentioned that it is of the 3rd magnitude.

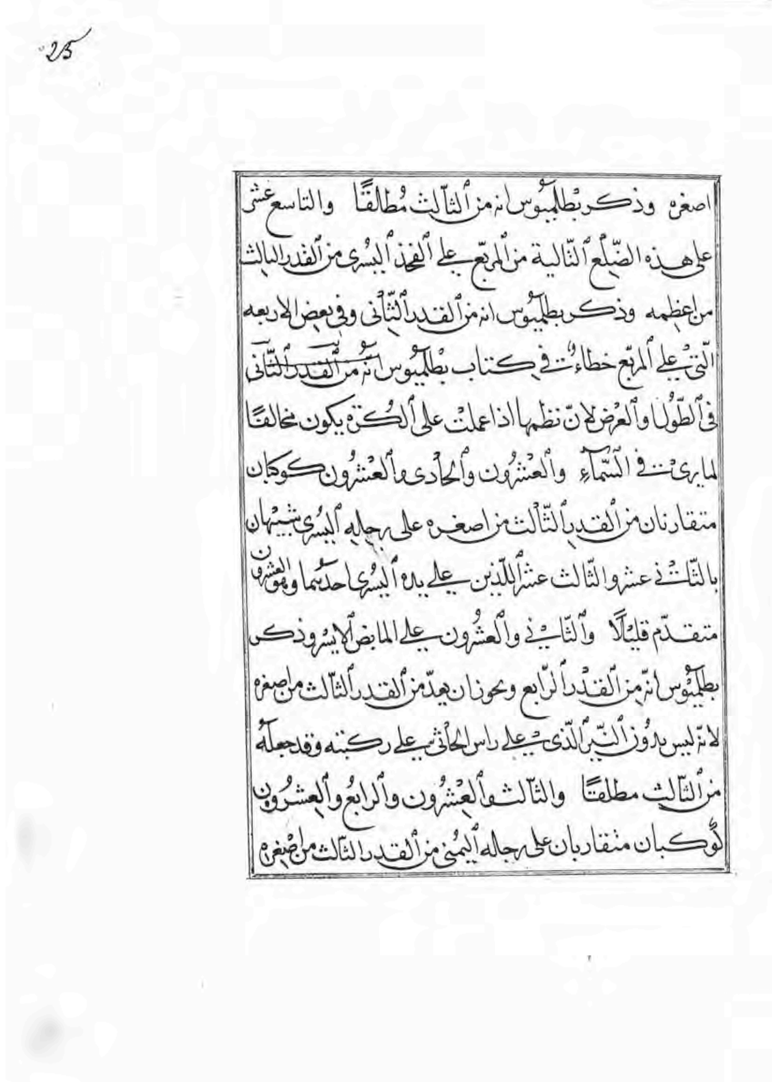
The nineteenth (star) is on the next point of the quadrilateral on the left thigh and it is much greater than the 3rd magnitude; (however) Ptolemy mentioned that it is of the 2nd magnitude.

In Ptolemy's book there are mistakes in the longitude and latitude of those stars of the quadrilateral because if they are to be drawn on a globe they would not correspond to what is seen in the sky.

The twentieth and twenty-first (stars) are two close stars (which are) less than the 3rd magnitude. They are located on the left leg (paw) and they are similar to the twelfth and thirteenth which are located on the left hind paws. The twentieth (star) is a little advanced (from the other).

The twenty-second is located on the left knee bend and Ptolemy mentioned that it is of the 4th magnitude. (However) it can be considered to be less than the 3rd magnitude because it less than the bright star on the head of (constellation) Hercules and Ptolemy made that (star) to be exactly of the 3rd (magnitude).

The twenty-third and twenty-fourth are two close stars which are located on the right hind paw (and are) less than the 3rd magnitude,



…. similar to the twelfth and thirteenth which are located on the left hind paw. The twenty-third is a little advanced to the north.

The twenty-fifth is located on the tail (and) is after the eighteenth (star) that is located where the tail joins the body.

The twenty-sixth is in the middle of the tail (while) the twenty-seventh is on the end of the tail, and these three which are on the tail are all of the 2nd magnitude.

The Arabs call the four bright (stars) on the quadrilateral and the three (stars) which are on the tail *Banāt Na'sh al-kubra* (The Great Daughters of the Bier or Coffin) or *Bani Na'sh* or *al-Na'sh*. (The clan of *al-Na'sh* or Bier)

The four (stars) on the quadrilateral, which are the sixteenth, the seventeenth, the eighteenth and the nineteenth, are (called) *al-Na'sh.*
The three (stars) on the tail are (called) *Banāt.* (daughters)
The four (stars) of *al-Na'sh* are also called, *Sarīr Banat Na'sh.* (The bed of the daughters of the Bier).
The twenty-seventh (star) on the end of the tail is called *al-Qā'īd* and the one in the middle (of the tail) *al-'Anāq*. (While) the one which follows *al-Na'sh*, and which is part of the main tail, is called *al-Jūn.*

Above *al-'Anāq* is a small star adjacent to it which the Arabs call *al-Suhā.*

شبيهان بالثاني عشر والثالث عشر اللذين على يده اليسرى
احدهما وهو الثالث والعشرون اميل الى الشمال قليلا والخامس
والعشرون على اصل ذنبه بعد الثامن عشر الذي على مغرز الذنب
والسادس والعشرون في الوسط من الذنب والسابع والعشرون
على طرف الذنب وهذه الثلثة التي على الذنب كلها من القدر
الثاني والعرب تسمي الاربعة النيرة التي على المربع المستطيل
والثلثة التي على ذنبه بنات نعش الكبرى وبني نعش وال
نعش منها الاربعة التي على المربع المستطيل وهي السادس عشر
والسابع عشر والثامن عشر والتاسع عشر نعش والثلثة التي
على الذنب بنات وتسمى ايضا الاربعة التي على النعش سرير
بنات نعش وتسمى الذي على طرف الذنب وهو السابع والعشرون
القايد والذي على وسطه العناق والذي يلي النعش وهو
الذي على اصل ذنبه الجون وفوق العناق كوكب صغير ملاصق له

Folio 26

In other Arab dialects it is (also) called by the name of: *al-Shita’* and al-*Saidaq* and *Nu’aish.* This star has not been mentioned by Ptolemy. This star is also used by people to test their eyesight, for they say I showed him *al-Suhā* and he showed me the Moon.

The six (stars) on the three feet, two stars of the same magnitude on every foot, are called *Kafazāt al-Ẓibā*. These (stars) are the twelfth and the thirteenth on the left hind paw, the twentieth and the twenty-first on the left paw, and the twenty-third and twenty-fourth on the right paw.

Each pair (of these stars) is (called) *Kafza* which are in the likeness of *Athar Zulfa al-Ẓibā* (the hoof trail or footprints of a gazelle).

The First *Kafza* is the one on the left paw. It is close to *al-Ṣarfa*, which is the bright star on the tail of (constellation) Leo, and *al-Thafīra*, which are a group of stars above *al-Ṣarfa that* are (also) named by the Arabs *al-Halba*.

The distance between *al-Halba* and the first *Kafza* is the same as the distance between the other two *Kafza.*

The Arab (folk tradition) says that when the lion hit his tail on the ground *al-Ẓibā* (the gazelle) jumped.

(*al-Kafazāt)* are also called *al-Thu’ailibān* and *al-Qarā’in.*


26
يسميه العرب السهى وفي بعض اللغات من العرب الشتا والصيدق
ونعيش ولم يذكره بطلميوس في كتابه وهو الذي يمتحن الناس
بابصارهم فيقولون اريته السهى واراني القمر وتسمى الستة التي
على الاقدام الثلثة على كل قدم منها اثنان في قدر واحد
وهي الثاني عشر والثالث عشر على اليد اليسرى والعشرون
والحادي والعشرون على رجله اليسرى والثالث والعشرون
والرابع والعشرون على رجله اليمنى قفزات الظبا كل اثنين
منها قفزة تشبه اثر ظلف الظبي والقفزة الاولى وهي التي على
الرجل اليمنى تتبعها الصرفة وهي الكوكب النير الذي على
ذنب الاسد والضفيرة وهي الكواكب المجتمعة التي فوق
الصرفة وهي التي تسميها العرب الهلبة وبين الهلبة وبين القفزة
الاولى من البعد مثل البعد بين القفزتين تقول العرب ضرب
الاسد بذنبه الارض فقفزت الظبا ويسمى ايضا الثعيلبات والقراين

The seven stars on its neck, chest and knee which are the seventh, the eighth, the ninth, the tenth, the eleventh, the fourteenth and the fifteenth, all form a semi-circle called *Sarīr Banāt Na'sh* (The bed of the daughters of the Bier) and it is (also) called *al-Hawd*.

The stars on the eyebrow, the eyes, the ears and the snout are called *al-Ẓibā* (Gazelle).

The Arab (folk tradition) says that when *al-Ẓibā* (the gazelle) jumped from *al-Halba* it reached *al-Hawd*.

As for the eight (stars) which are not part of the constellation, the first and the second are between the star called *al-Qā'īd* , which is on the tail of the Bear, and the first *Kafza*, which is on the right leg.

The first which is in advance of the two is a bright (star) of the 3rd magnitude which the Arabs call *Kibd al-Asad.*
The second is dimmer (then the first) of the 5th magnitude.
These (stars) are between *al-Halba* and the bright (star) called *al-Qā'īd.*

The remaining six (stars) are under the third *Kafza*, which is on the left hand. Three of which are bright of the 4th magnitude, and they are the third, fourth and sixth.


والكواكب السبعة التي على عنقه وعلى صدره وعلى
وعلى الركبتين وهي الثامن والتاسع والعاشر والحادي عشر
والرابع عشر والخامس عشر وهي كأنها على نصف دائرة
يسمى سرير بنات نعش ويسمى الحوض والكواكب التي على الحاجب
والعينين والأذن والخطم يسمى الظبا يقول العرب ان الظبا لما قفز
من عند الهلبة وردت الحوض واما الثمانية التي هي حوالي
الصورة وليست منها فان الاول والثاني منهما مما بين الكوكب
الذي على طرف ذنب الدب الذي يسمى القايد وبين القفزة الاولى
التي على الرجل اليمنى وهو الاول وهو التالي من الاثنين انور
من القدر الثالث يسميه العرب كبد الاسد والثاني اخفى
منه من القدر الخامس وهما بين الهلبة وبين النير الذي يسمى القايد
والستة الباقية تحت القفزة الثالثة التي على اليد اليسرى
ثلثة منها انور من القدر الرابع وهي الثالث والرابع والسادس

السابع

Folio 27

The remaining three are of the 6th magnitude.

Ptolemy mentioned that the third and the fourth are of the 4th magnitude while the remaining four which are the fifth, sixth, seventh and eighth were not considered to be 6th magnitude but are dimmer (stars).

The eighth (star) is a lone star between this *Kafza* and the open hand of Leo close to *al-Kafza*.

The third and fourth are part of *al-Ẓibā* while the remaining dim (stars) are the children of *al-Ẓibā.*

Another star of the 4th magnitude which was not mentioned by Ptolemy is located between the nineteenth star, which is on the left thigh of the stars of *Na'sh*, and the twenty-second, which is on the knee-bend. This (star) is further away to the east then the other two.

Between the first and second *Kafza* and (the stars) of *Na'sh* are (many) stars which form together with the twenty-second on the knee-bend, a circle (of stars). The brightest of these is the twenty-second which is on the knee-bend while the rest are of the 5th and 6th magnitude. Ptolemy has not mentioned any of them except the one on the knee-bend.
There are also many stars of the 5th and 6th magnitude located between and in advance of these two *Kafza*. (the first and second *Kafza*)


27

والثلثة الباقية من القدر السادس وذكر بطلميوس ان الثالث
والرابع من القدر الرابع والاربعة الباقية وهي الخامس والسادس
والسابع والثامن لم يعدها من الاقدار الستة وسماها خفية والثامن
منها هو المفرد الذي بين هذه القفزة وبين ذراع الاسد المبسوطة
يميل الى القفزة والثالث والرابع من جملة الظبا والباقية الخفية
وبين الكوكب التاسع عشر الذي على الفخذ اليسرى من كواكب
النعش وبين الثاني والعشرين الذي على المابض كوكب متأخر
عنهما الى المشرق من القدر الرابع لم يذكره بطلميوس وبين
القفزتين الاولى والثانية وبين النعش كواكب هي مع الثاني
والعشرين الذي على المابض على استدارة انورها هو الثاني والعشرون
الذي على المابض والباقي من القدر الخامس والسادس لم يذكر
شيء منها الا الذي على المابض وكذلك بين هاتين القفزتين
كواكب كثيرة متقدمة لهما فيها من القدر الخامس والسادس

اولاد الظبا

Between the second of the two (stars) outside of the constellation close to *Kibd al-Asad* and (the star) on the knee-bend is a star which is less than the 5th magnitude. It is much closer to the second (star) that is outside the constellation.

Inside *al-Hawd* is a star that forms a *Muthallath* (triangle) with the seventh and the eighth, which form together with the ninth and the tenth another *Muthallath Munfareg* (obtuse triangle).

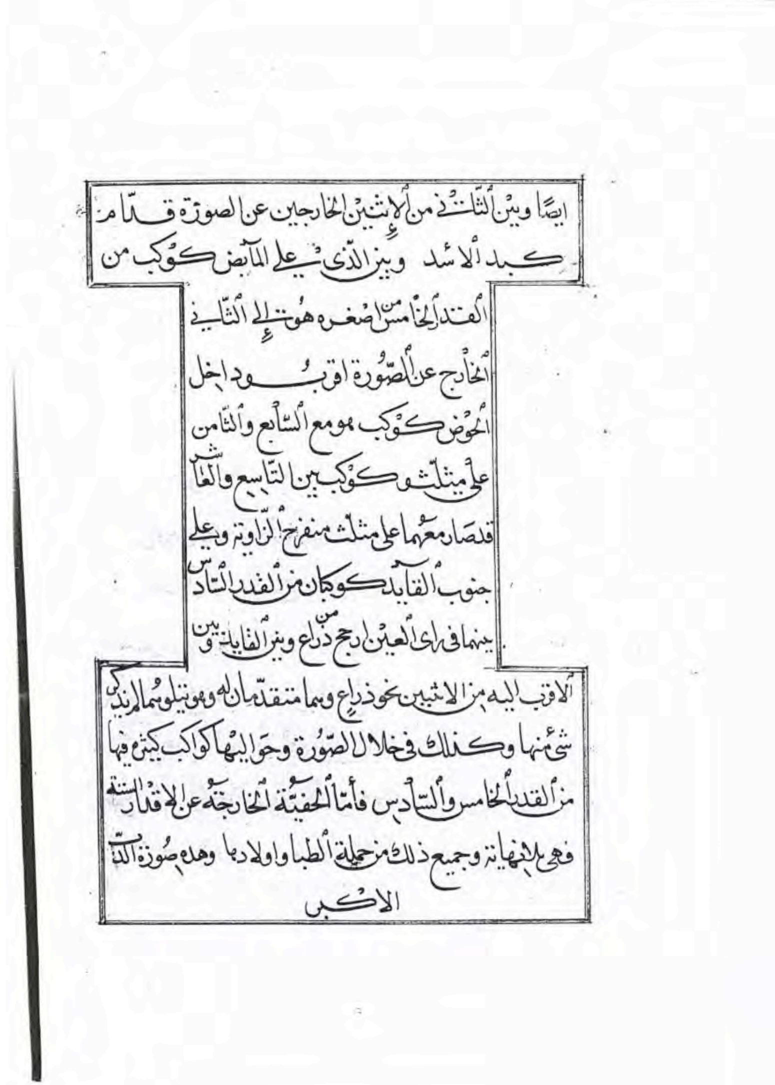
South of *al-Qā'īd* there are two stars of the 6th magnitude which were not mentioned (by Ptolemy). The distance between these two stars is estimated by eyesight to be a little more than (one) *dhirā'*. (1 *Thira* = 2 deg 20 min) The distance between *al-Qā'īd* and the closest one of the two is (also) close to a *dhirā'* and they are in advance of (*al-Qā'īd*).

Throughout (the main image of the) constellation and outside of it, there are many stars of the 5th and 6th magnitudes.

Additionally there are an infinite number of dim (stars) which are outside of the 6th magnitude (classification).

All of these can be considered to be part of *al-Ẓibā* and its children.

This is the picture of the (constellation) Great Bear (*al-Dub al-Akbar)* (Ursa Major)


ايضا وبين الثاني من الاثنين الخارجين عن الصورة قدام
كبد الاسد وبين الذي على المأبض كوكب من
القدر الخامس اصغر منه وهو الى الثاني
الخارج عن الصورة اقرب وداخل
الحوض كوكب هو مع السابع والثامن
على مثلث وكوكبين التاسع والعاشر
قد صار معهما على مثلث منفرج الزاوية وعلى
جنوب القايد كوكبان من القدر السادس
بينهما في راي العين اكثر من ذراع وبين القايد وبين
الاقرب اليه من الاثنين نحو ذراع وهما متقدمان له وهو يتلوهما لا يزيد
شي عنهما وكذلك في خلال الصورة وحواليها كواكب كثيرة فيها
من القدر الخامس والسادس فاما الخفية الخارجة عن الاقدار الستة
فهي لا نهاية وجميع ذلك من جملة الظبا واولادها وهذه صورة الدب
الاكبر

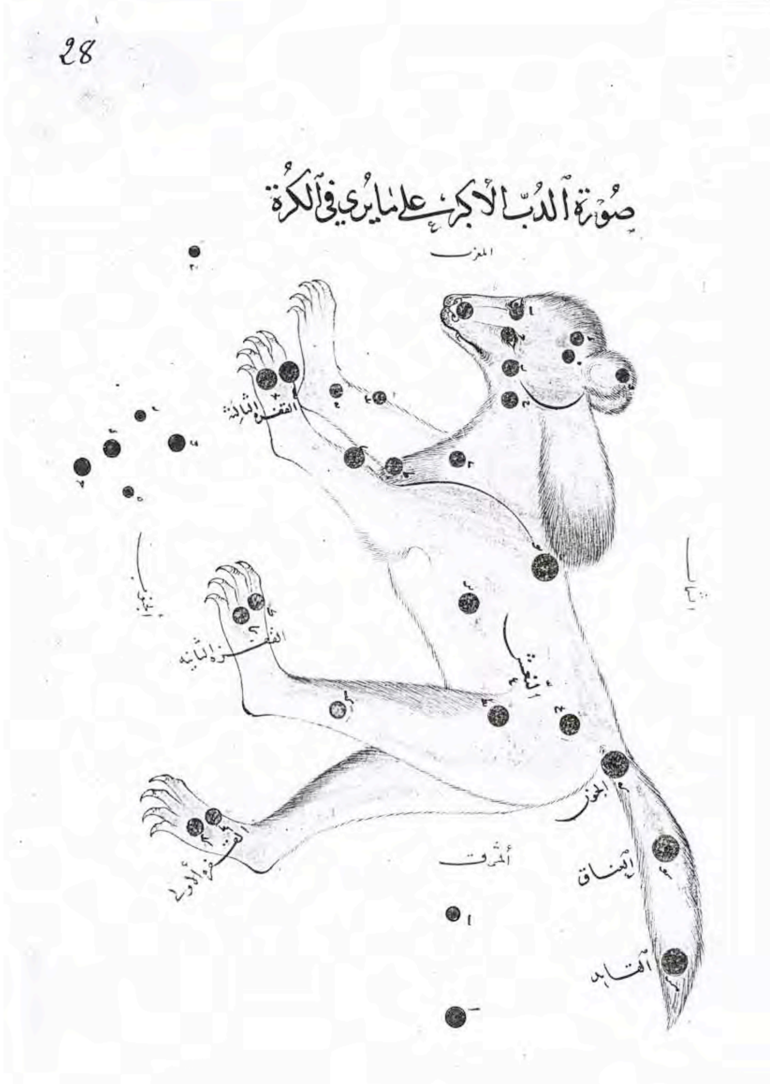
Folio 28

The Great Bear (constellation) as seen on the globe

west

south constellation image north

east



as seen in the sky

west

north constellation image south

east

Folio 29

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
Table of the constellation Ursa Major with the addition of 12 (degrees) 42 (minutes) to what is found in the Almagest								
		zodiac	deg	min		deg	min	
1	The star on the end of the snout.	3(90)	08	02	N	39	50	4
2	The more advanced of the two stars in the two eyes.	3(90)	08	32	N	43	05	5
3	The other one of the two.	3(90)	09	12	N	43	05	5
4	The more advanced of the two stars in the forehead.	3(90)	08	52	N	57	10	5
5	The other one of the two.	3(90)	09	22	N	47	05	5
6	The star on the tip of the advance ear.	3(90)	10	52	N	50	30	5
7	The more advanced of the two stars in the neck.	3(90)	13	12	N	43	50	4s
8	The other one of the two, longitude or latitude is wrong.	3(90)	15	12	N	44	20	4
9	The northern most of the two stars in the chest.	3(90)	21	42	N	42	05	4
10	The southernmost of them.	3(90)	23	42	N	44	05	4s
11	The star on the left knee.	3(90)	23	22	N	35	05	3
12	The northern most of the two in the front left paw. *al-Kafza*	3(90)	18	12	N	29	20	3s
13	The southern most of them. *al-Kafza*	3(90)	19	02	N	23	20	3s
14	The star above the right knee.	3(90)	13	22	N	36	05	5m
15	The star below the right knee.	3(90)	13	32	N	30	20	5m
16	The star on the back which is part of the quadrilateral.	4(120)	05	22	N	49	05	2
17	The one on the flank.	4(120)	04	52	N	45	30	3m
18	The one on the place where the tail joins the body.	4(120)	15	52	N	51	05	3s


جدول كواكب صورة الدب الاكبر بزيادة يب مب على ما في المجسطي

أسماء الكواكب

الذي على طرف الخطم
المتقدم من الاثنين اللذين في العينين
التالي منهما
المتقدم من الاثنين اللذين في الجبهة
التالي منهما
الذي على طرف الاذن المتقدمة
المتقدم من الاثنين اللذين في العنق
التالي منهما الطول او العرض منه غلط
أشمل الاثنين اللذين في الصدر الى الشمال
أجنوبهما الى الجنوب
الذي على الركبة اليسرى
أشمل الاثنين اللذين في القدم اليسرى المتقدمة الى الشمال
الجنوبي منهما
الذي فوق الركبة اليمنى
الذي تحت الركبة اليمنى
الذي على الظهر من التي في ذي الاربعة الاضلاع
الذي على المراق منها
الذي على مغرز الذنب منها

Remaining of the constellation Ursa Major with the addition of 12 (degrees) 42 (minutes) to what is found in the Almagest								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
19	The remaining one on the left hind thigh.	4(120)	15	42	N	46	30	3m
20	The more advanced of the two stars in the left hind paw. *al-Kafza*	4(120)	05	22	N	29	20	3s
21	The next one. *al-Kafza*	4(120)	06	52	N	28	15	3s
22	The star on the left knee bends.	4(120)	14	22	N	35	15	3s
23	The northern most of the two stars in the right hind paw. *al-Kafza*	4(120)	22	35	N	25	50	3s
24	The southernmost of them. *al-Kafza*	4(120)	23	02	N	25	00	3s
25	The first of the three stars on the tail next to the place where it joins the body. *al-Jūn*	4(120)	24	52	N	18	30	2
26	The middle one. *al-‘Anāq*	5(150)	00	42	N	55	40	2
27	The third on the end of the tail. *al-Qā'īd*	5(150)	12	32	N	54	00	2
27 stars, 4 is of the 2nd magnitude, 11 of the 3rd magnitude, 5 of the 4th magnitude, 7 of the 5th magnitude								
The one underneath and not in the constellation								
1	The star under the tail at some distance towards the south.	5(150)	10	32	N	39	45	3
2	The rather faint star in advance of it.	5(150)	02	52	N	41	20	5
3	The southernmost of the two stars between the front legs of Ursa Major and the head of Leo.	4(120)	27	42	N	17	15	4
4	The one north of it.	4(120)	26	02	N	19	10	4
5	The next of the remaining three faint stars.	4(120)	25	52	N	20	00	6
6	The one in advance of this.	4(120)	24	52	N	22	45	4
7	The one in advance again of the latter.	4(120)	23	52	N	20	20	6
8	The star between the front legs (of Ursa Major) and Gemini.	4(120)	12	42	N	22	15	6
8 stars, 1 is of the 3rd magnitude, 3 of the 4th magnitude, 1 of the 5th magnitude, 3 of the 6th magnitude								

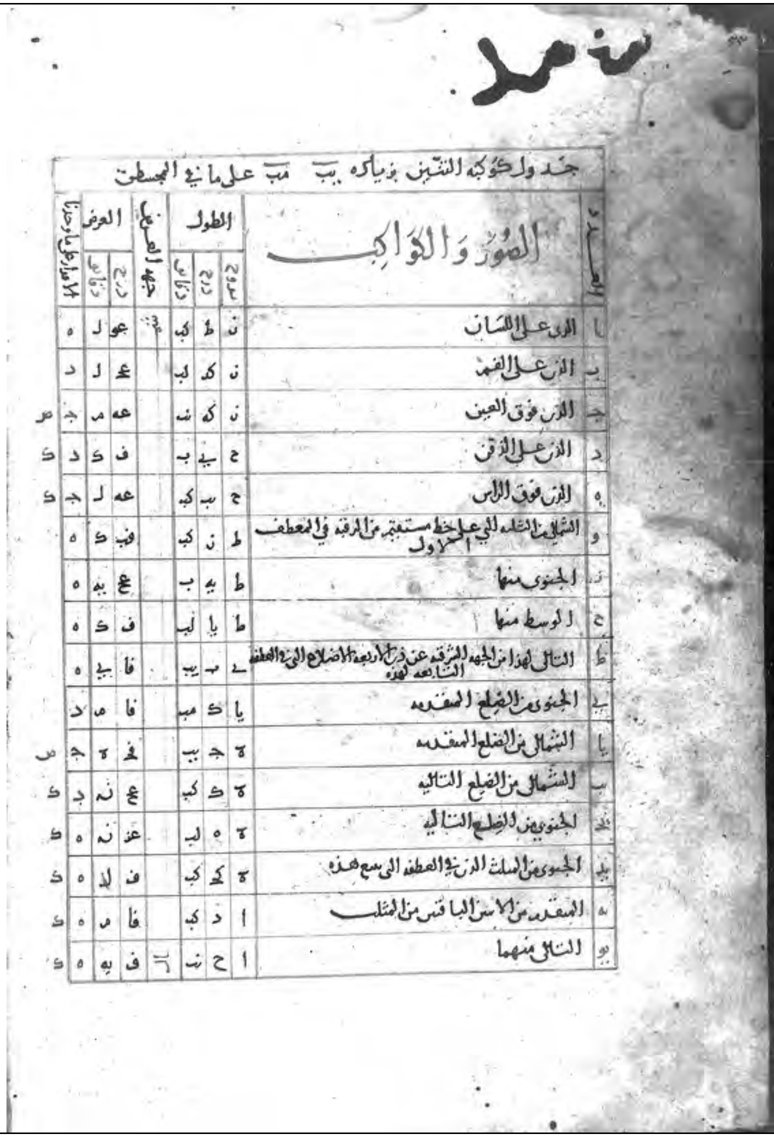

بقية كوكبة الدب الأكبر بزيادة ... على ما في المجسطي

أسماء الكواكب

Folio 55

Table of the constellation Draco (*al-Tinnīn*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star on the tongue	7(210)	9	22	N	76	30	5
2	The star on the mouth	7(210)	24	32	N	73	30	4
3	The star above the eye	7(210)	25	52	N	75	40	3(s)
4	The star on the jaw	8(240)	10	2	N	80	20	4(m)
5	The star above the head	8(240)	12	22	N	75	30	3(m)
6	The northern most of the 3 stars in a straight line in the first bend of the neck	9(270)	50	22	N	82	20	5
7	The southernmost of these	9(270)	15	2	N	78	15	5
8	The middle one	9(270)	11	32	N	80	20	5
9	The star to the rear and due east of the latter forming the advance side of the quadrilateral in the same bend	10(300)	2	12	N	81	10	5
10	The southern star of the advanced side	11(330)	20	42	N	81	40	4
11	The more northerly star of the advanced side	0	3	12	N	83	0	3(s)
12	The northern star of the rear side	0	20	22	N	78	50	4(m)
13	The southern star of the rear side	0	5	32	N	77	50	5(m)
14	The southern star of those forming the triangle in the next bend	0	23	22	N	80	30	5(m)
15	The more advanced of the other two stars of the triangle	1(30)	4	22	N	81	40	5(m)
16	The one to the rear	1(30)	8	52	N	80	15	5(m)

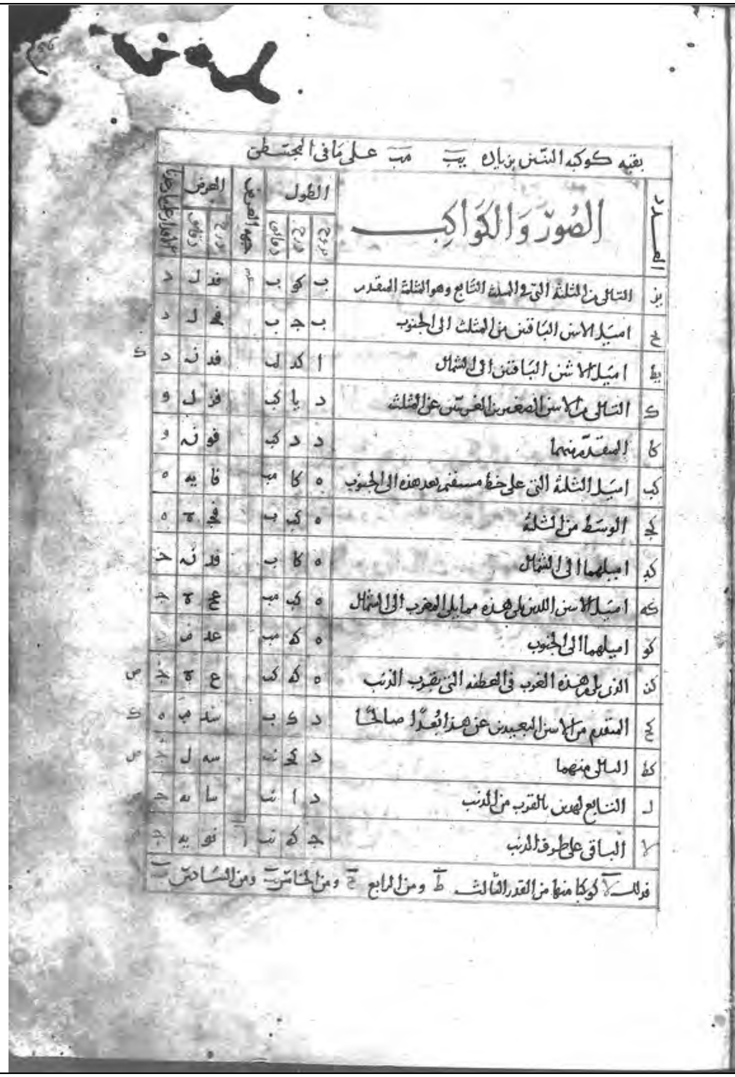
Note: the "bends" means the bends or twist of the image of the dragon.


جدول كوكبة التنين وزيادة يب مب على ما في المجسطي

الصور والكواكب

Folio 56

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
Remaining stars in the constellation Draco with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
		zodiac	deg	min		deg	min	
17	The most advanced of the three stars in the next triangle which is in advanced of the last	2(60)	26	2	N	84	30	4
18	The southernmost of the other two forming the triangle	2(60)	3	2	N	83	30	4
19	The northernmost of the other two	1(30)	24	32	N	84	50	4(m)
20	The rearmost of the two small stars to the west of the triangle	4(120)	11	22	N	87	30	6
21	The one in advance	4(120)	4	22	N	86	50	6
22	The southernmost of the next 3 stars in a straight line	5(150)	21	42	N	81	15	5
23	The middle one of the three	5(150)	22	2	N	83	0	5
24	The northernmost of them	5(150)	21	2	N	84	50	3
25	The northernmost of the next 2 to the west	5(150)	22	42	N	78	0	3
26	The southernmost of these	5(150)	25	42	N	74	40	4
27	The star to the west of these in the bend by the tail	5(150)	25	22	N	70	0	3(s)
28	The advanced star of the two some distance from the latter	4(120)	20	2	N	64	30	5(m)
29	The rear star of these two	4(120)	23	52	N	65	30	3(s)
30	The star close to these by the tail	4(120)	1	52	N	61	15	3(s)
31	The remaining star on the tip of the tail	3(90)	25	52	N	56	15	3(s)
31 stars, 9 of the 3rd magnitude, 8 of the 4th, 12 of the 5th, 2 of the 6th.								

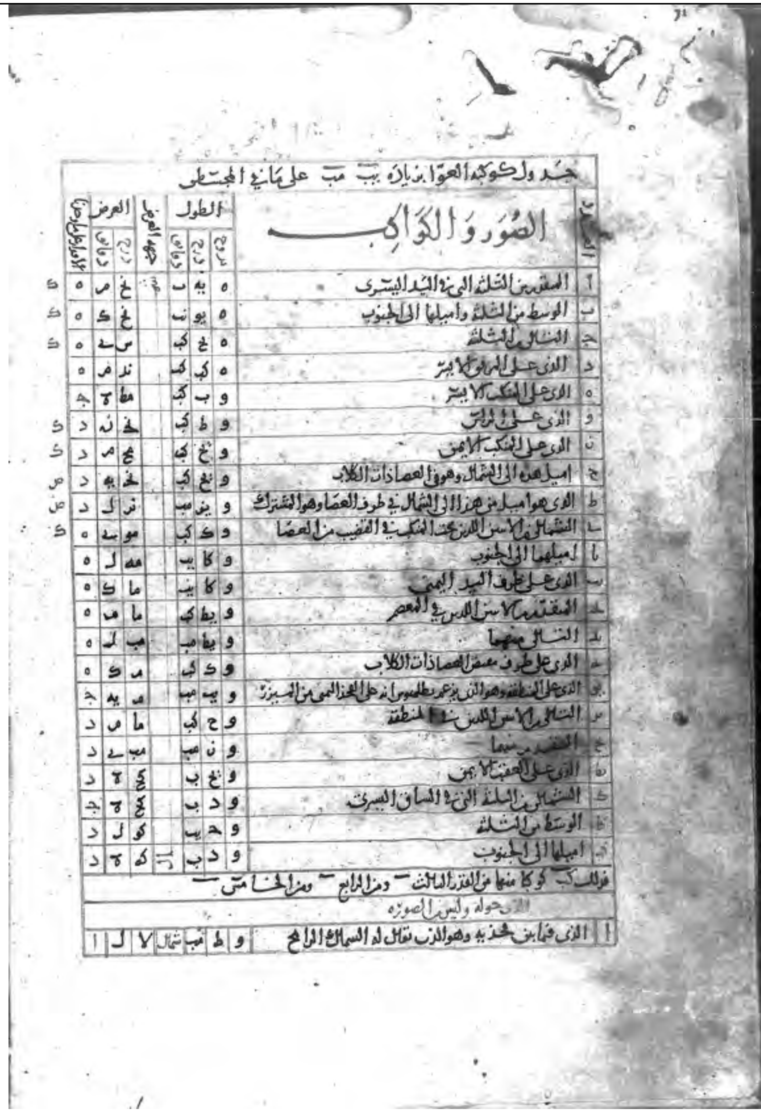


Folio 63

Constellation Cepheus (*Qīqāwūs*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star on the right leg	1(30)	17	42	N	75	90	5(m)
2	The one on the left leg	1(30)	15	42	N	64	15	4
3	The star under the belt on the right side	0	20	42	N	71	10	4(m)
4	The star over the right shoulder which touches the shoulder	11(330)	29	22	N	69	0	3
5	The star over the right elbow which touches the shoulder	11(330)	22	2	N	72	0	4
6	The one under that elbow	11(330)	22	42	N	74	0	4
7	The star in the chest	0	11	12	N	65	30	5
8	The star on the left arm	0	20	12	N	62	30	4(m)
9	The southernmost of the 3 stars on the tiara	11(330)	29	2	N	60	15	5
10	The middle one of the three	0	0	2	N	61	15	4
11	The northernmost of the three	0	1	42	N	61	20	6
11 stars, 1 is of the 3rd magnitude, 4 of the 4th magnitude, 3 of the 5th magnitude, 1of the 6th magnitude								
The ones surrounding the constellation but not in it.								
1	The one in advance of the tiara	11(330)	26	22	N	64	0	5(k)
2	The one to the rear of the tiara	0	4	2	N	59	30	4(m)
2 stars, 1 is of the 4th magnitude, 1of the 5th magnitude.								

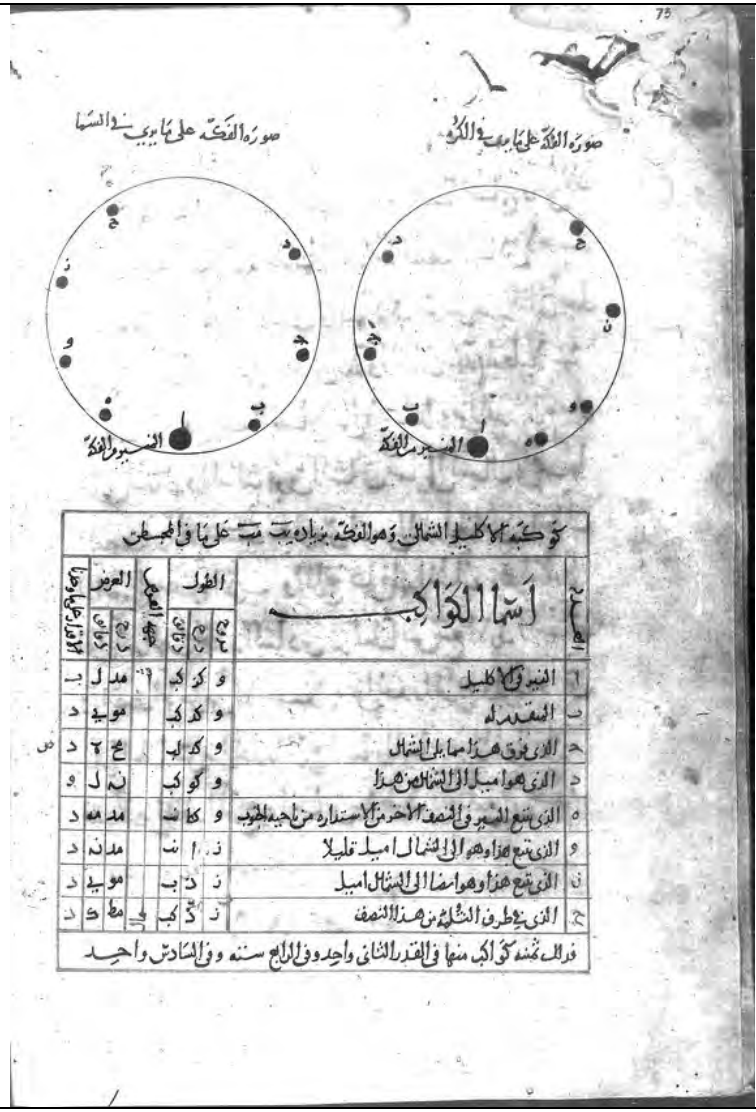
Folio 71

Table of the constellation Bootes (*al-'Awwā*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The most advanced of the three in the left arm	5(150)	15	2	N	58	40	5(m)
2	The middle and southernmost of the three	5(150)	16	52	N	58	20	5(m)
3	The rearmost of the three	5(150)	18	22	N	60	10	5(m)
4	The star on the left elbow	5(150)	22	22	N	54	40	5
5	The star on the left shoulder	6(180)	2	22	N	49	0	3
6	The star on the head	6(180)	9	22	N	53	50	4(m)
7	The star on the right shoulder	6(180)	18	22	N	48	40	4(m)
8	The one to the north of these on the staff	6(180)	18	22	N	53	15	4(s)
9	The one still farther to the north of this on the tip of the staff	6(180)	17	42	N	57	30	4(s)
10	The northernmost of the two stars below the shoulder in the club	6(180)	20	22	N	46	10	5(m)
11	The southernmost of them	6(180)	21	12	N	45	30	5
12	The star on the end of the right arm	6(180)	21	17	N	41	20	5
13	The more advanced of the two stars in the wrist	6(180)	19	22	N	41	50	5
14	The rearmost of them	6(180)	19	42	N	42	30	5
15	The star on the end of the handle of the staff	6(180)	20	22	N	40	20	5
16	The star on the right thigh in the apron	6(180)	12	42	N	40	15	3
17	The rearmost of the two stars in the belt	6(180)	8	22	N	41	40	4
18	The more advanced of them	6(180)	7	42	N	42	10	4
19	The star on the right heel	6(180)	18	2	N	28	0	4(k) or 4
20	The northernmost of the 3 stars in the left lower leg	6(180)	4	2	N	28	0	3
21	The middle one of the three	6(180)	3	12	N	26	30	4
22	The southernmost of them	6(180)	4	2	N	25	0	4
22 stars, 3 are of the 3rd magnitude, 9 of the 4th magnitude, 10 of the 5th magnitude.								
The ones surrounding the constellation but not in it.								
1	The star between the thighs called *al-Simāk al-Rāmiḥ*	6(180)	9	42	N	31	30	1



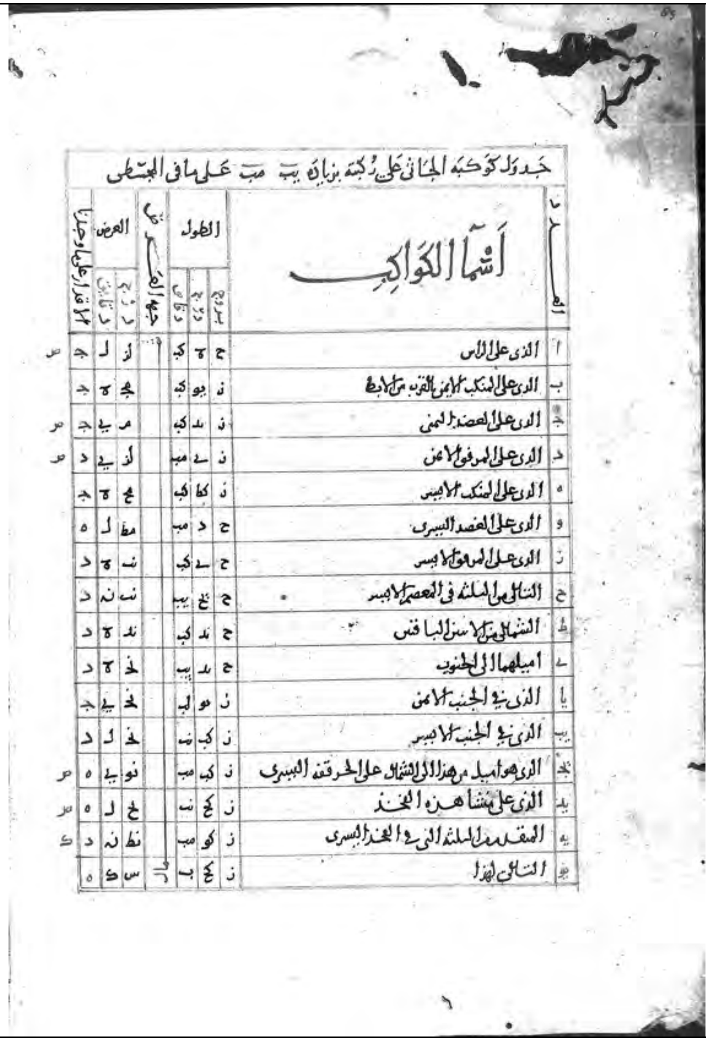
Folio 73

Constellation Corona Borealis (*al-Iklīl Al-Shamālī*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The bright star in the crown	6(180)	27	22	N	44	30	2
2	The star most in advance of all	6(180)	24	22	N	46	10	4
3	The one to the rear and to the north of this	6(180)	24	32	N	48	0	4(s)
4	The one to the rear and farther north than this	6(180)	26	22	N	50	30	6
5	The one to the rear of the bright star from the south	6(180)	29	52	N	44	45	4
6	The one farther to the rear of the latter, but close by	7(210)	1	52	N	44	50	4
7	The one farther to the rear of these	7(210)	4	2	N	46	10	4
8	The star to the rear of all the others in the crown	7(210)	4	22	N	49	20	4
8 stars, 1 is of the 2nd magnitude, 6 of the 4th magnitude, 1of the 6th magnitude								



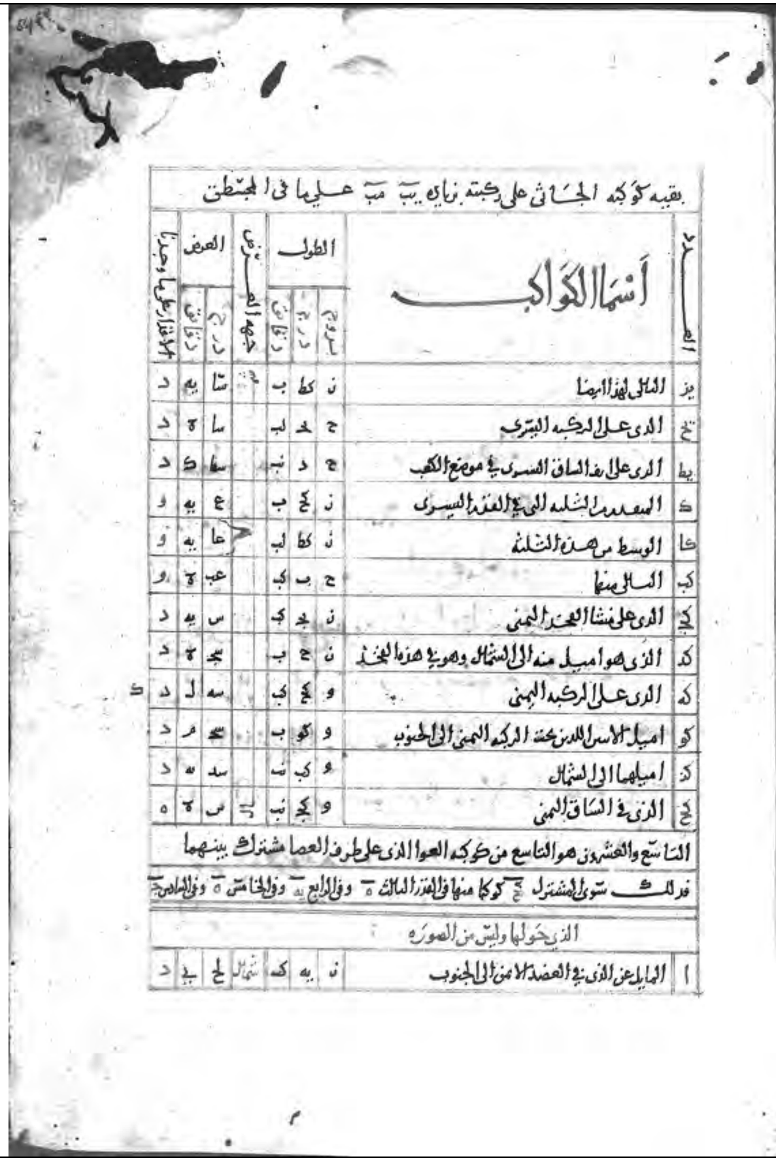
Folio 83

Table of the constellation Hercules (*al-Jāthī ‘ala Rukbateh*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star on the head	8(240)	0	22	N	37	30	3(s)
2	The star on the right shoulder by the armpit	7(210)	16	22	N	43	0	3
3	The star on the right upper arm	7(210)	54	22	N	40	10	3(s)
4	The star on the right elbow	7(210)	10	42	N	37	10	4(s)
5	The star on the left shoulder	7(210)	29	22	N	48	0	3
6	The star on the left upper arm	8(240)	4	42	N	49	30	5
7	The star on the left elbow	8(240)	10	22	N	52	0	4
8	The rearmost of the 3 stars in the left wrist	8(240)	18	12	N	52	50	4
9	The northernmost of the other 2	8(240)	54	22	N	54	0	4
10	The southernmost of them	8(240)	54	12	N	53	0	4
11	The star in the right side	7(210)	16	32	N	53	10	3
12	The star in the left side	7(210)	22	52	N	53	30	4
13	The one north of the latter on the left buttock	7(210)	22	42	N	56	10	5(s) or 6(m)
14	The one on the place where the thigh joins the same buttock	7(210)	28	52	N	38	30	5(s) or 6(m)
15	The most advanced of the 3 in the left thigh	7(210)	26	42	N	59	50	4(k)
16	The one to the rear of this	7(210)	28	2	N	60	20	5



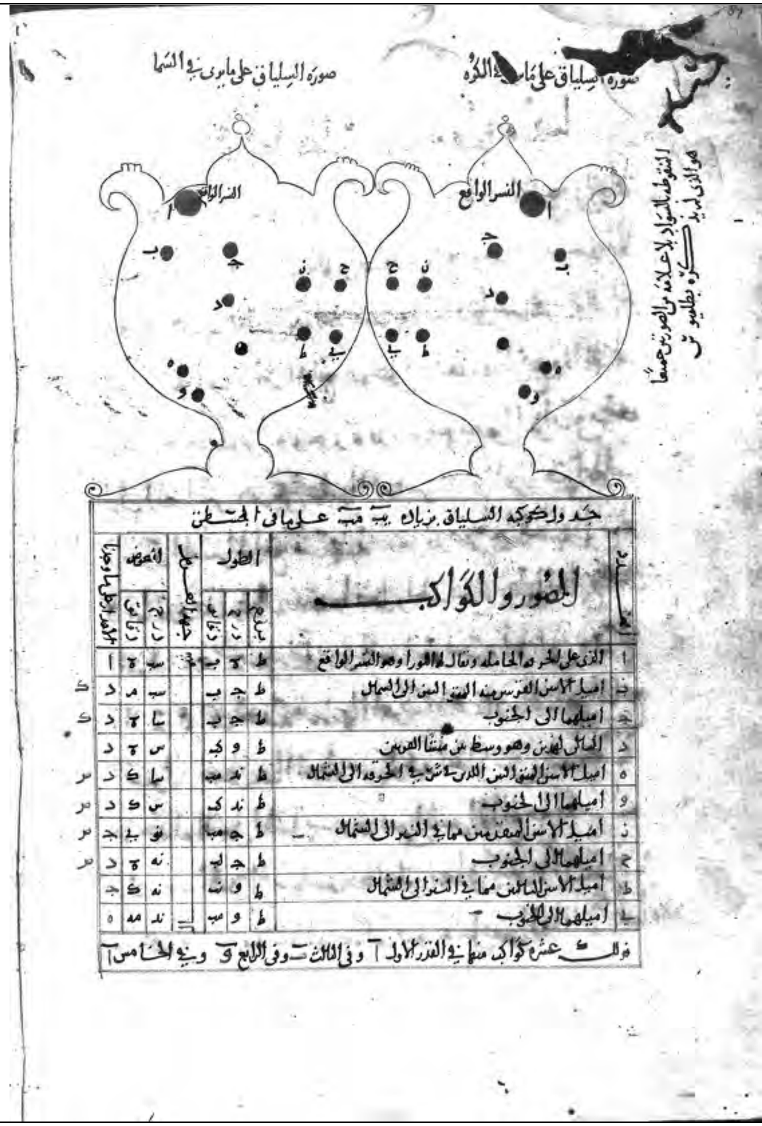
Folio 84

Number	Star Names	Longitude			Lat direction	Latitude		Magnitude as we found it
Remaining stars of the constellation Hercules with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
		zodiac	deg	min		deg	min	
17	The one still further to the rear of this	7(210)	29	2	N	61	15	4
18	The star on the left knee	8(240)	53	32	N	61	0	4
19	The star on the left shin	8(240)	4	52	N	69	20	4
20	The most advanced of the 3 stars in the left foot	7(210)	28	2	N	70	15	6
21	The middle one of the three	7(210)	29	32	N	71	15	6
22	The rearmost of them	8(240)	2	22	N	72	0	6
23	The star on the place where the right thigh joins the buttock	7(210)	53	22	N	60	15	4
24	The star north of it in the same thigh	7(210)	8	2	N	63	0	4
25	The star on the right knee	6(180)	28	22	N	65	30	4 or 4(m)
26	The southernmost of the 2 stars under the right knee	6(210)	26	2	N	63	40	4
27	The northernmost of them	6(180)	22	52	N	64	15	4
28	The star in the right lower leg	6(180)	23	52	N	60	0	5
	The twenty-ninth is the ninth star in the constellation Bootes which is common to both							
28 stars except the common one. 5 of the 3rd magnitude, 15 of the 4th magnitude, 5 of the 5th magnitude, 3 of the 6th magnitude.								
The ones surrounding the constellation but not in it.								
1	The star south of the one in the right upper arm	7(210)	15	22	N	38	10	4


بقية كوكبة الجاثي على ركبته زيادة يب مب على ما في المجسطي
أسماء الكواكب
الذي حولها وليس من الصورة

Folio 87

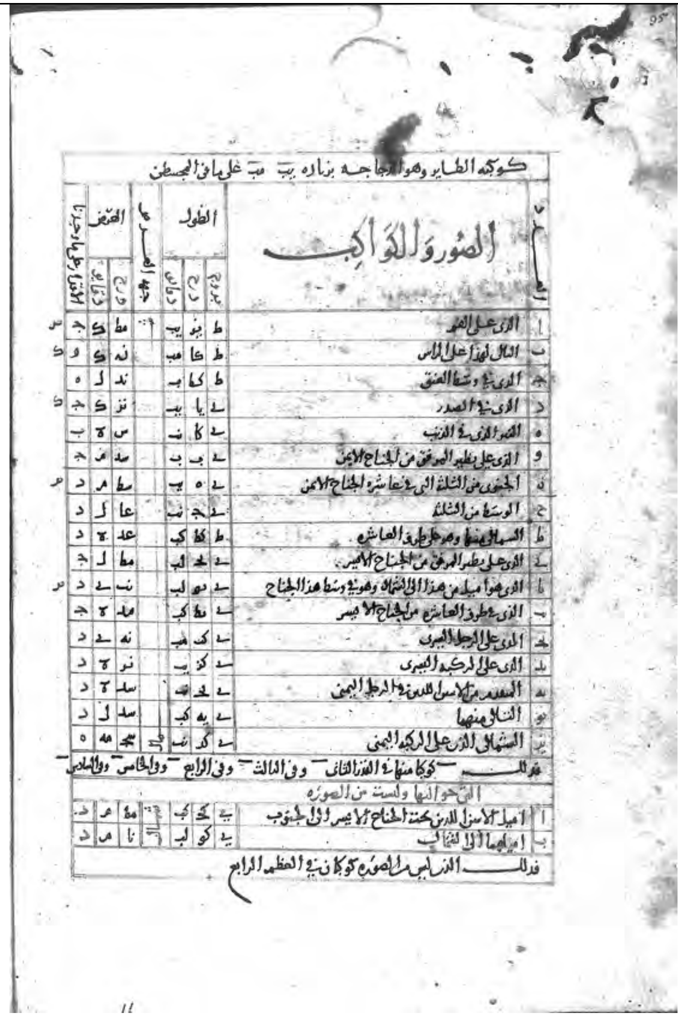
Table of the Constellation Lyra (*al-Silyāq*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The bright star on the shell called Lyra called *al-Nasr al-Wāqi‘*	9(270)	0	2	N	62	0	1
2	The northernmost of the 2 stars lying near the latter close together	9(270)	3	2	N	62	40	4(k)
3	The southernmost of them	9(270)	3	2	N	61	0	4(k)
4	The one to the rear of these in between the points where the horns of lyre are attached	9(270)	6	22	N	60	0	4
5	The northernmost of the 2 stars close together in the region to the east of the shell	9(270)	52	42	N	61	20	4(s)
6	The southernmost of them	9(270)	52	22	N	60	20	4(s)
7	The northernmost of the two advanced stars in the bridge	9(270)	3	42	N	56	10	3(s)
8	The southernmost of them	9(270)	3	32	N	55	0	4(s)
9	The northernmost of the two rear stars in the bridge	9(270)	6	52	N	55	20	3
10	The southernmost of them	9(270)	6	42	N	54	45	5 or 5(s)
10 stars, 1 is of the 1st magnitude, 2 of the 3rd magnitude, 6 of the 4th magnitude, 1of the 5th magnitude								



Folio 95

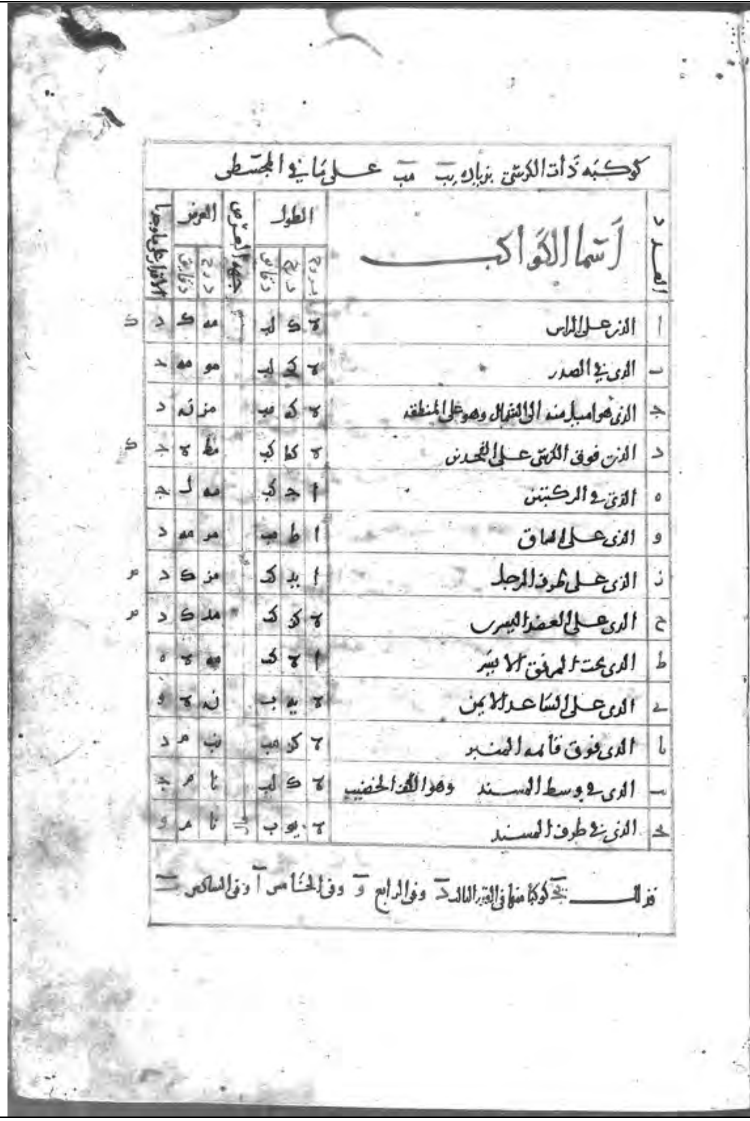
Constellation Cygnus (*al-Ṭā'er* also *al-Dajāja*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star on the beak	9(270)	19	12	N	49	20	3(s)
2	The one to the rear of this on the head	9(270)	21	42	N	50	20	6(m)
3	The star in the middle of the neck	9(270)	29	2	N	54	30	5
4	The star in the breast	10(300)	11	12	N	57	20	3(m)
5	The bright star in the tail	10(300)	21	52	N	60	0	2
6	The star in the bend of the right wing	10(300)	2	2	N	64	40	3
7	The southernmost of the 3 in the right wing feathers	10(300)	5	12	N	69	40	4(s)
8	The middle one of the 3	10(300)	3	52	N	71	30	4
9	The northernmost of them on the tip of the wing feathers	9(270)	29	22	N	74	0	4
10	The star on the bend of the left wing	10(300)	13	32	N	49	30	3
11	The star north of this in the middle of the same wing	10(300)	16	32	N	52	10	4(s)
12	The star in the tip of the feathers of the left wing	10(300)	19	22	N	44	0	3
13	The star on the left leg	10(300)	22	42	N	55	10	4
14	The star on the left knee	10(300)	27	12	N	57	0	4
15	The more advanced of the 2 stars in the right leg	10(300)	33	52	N	64	0	4
16	The one to the rear	10(300)	15	22	N	64	30	4
17	The nebulous star on the right knee	10(300)	24	52	N	63	45	5
17 stars, 1 is of the 2nd magnitude, 5 of the 3rd magnitude, 8 of the 4th magnitude, 2 of the 5th magnitude. and 1 of the 6th magnitude								
The ones surrounding the constellation but not in it.								
1	The southernmost of the 2 stars under the left wing	10(300)	23	22	N	49	40	4
2	The northernmost of them	10(300)	26	32	N	51	40	4
Those stars that are not part of the constellation are 2 stars of the 4th magnitude.								



Folio 104

Constellation Cassiopeia (*Dhāt al-Kursīy*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star on the head	0	20	32	N	45	20	4(k)
2	The star in the breast	0	23	32	N	46	45	3
3	The one north of that on the belt	0	25	42	N	47	50	4
4	The star over the throne just above the thighs	0	29	22	N	49	0	3(k)
5	The star in the knees	1(30)	3	22	N	45	30	3
6	The star on the lower leg	1(30)	9	42	N	47	20	4
7	The star on the end of the leg	1(30)	14	22	N	47	20	4(s)
8	The star on the left upper arm	0	27	22	N	44	20	4(s)
9	The star below the left elbow	1(30)	0	22	N	45	0	5
10	The star on the right fore arm	0	15	2	N	50	0	6
11	The star above the foot of the throne	0	27	42	N	52	40	4 or 4(s)
12	The star on the middle of the back of the throne called *al-Kaff al-Khaḍīb*	0	20	32	N	51	40	3
13	The star on the top of the throne back	0	16	2	N	51	40	6
13 stars, 4 of the 3rd magnitude, 6 of the 4th magnitude, 1of the 5th magnitude, 2 of the 6th magnitude								



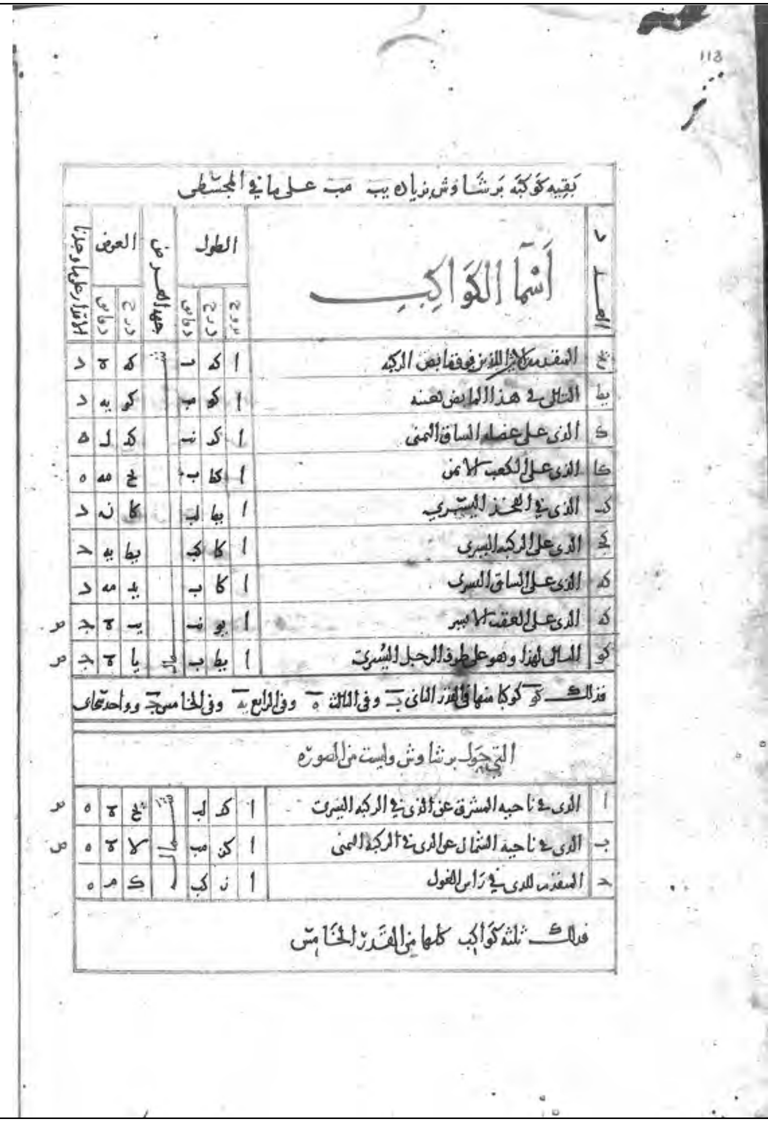
Folio 117

Constellation Perseus (*Barshāūsh*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The nebulous mass on the right hand	1(30)	9	22	N	40	30	nebulous
2	The star on the right elbow	1(30)	13	52	N	37	30	4
3	The star on the right shoulder	1(30)	15	22	N	34	30	3(s)
4	The star on the left shoulder	1(30)	10	12	N	32	20	4(s)
5	The star on the head	1(30)	13	22	N	34	30	5
6	The star located between the shoulders	1(30)	14	12	N	31	10	4
7	The bright star in the right side	1(30)	17	32	N	30	0	2
8	The most advanced of the 3 stars next to the one in the side	1(30)	18	2	N	27	50	4
9	The middle one of the three	1(30)	19	42	N	27	40	4
10	The rearmost of them	1(30)	20	22	N	27	20	3
11	The star on the left elbow	1(30)	13	12	N	27	0	4
12	The star in the gorgon's head the bright one	1(30)	12	22	N	23	0	2(s)
13	The star in the gorgon's head the one to the rear of this	1(30)	11	52	N	21	0	4(s)
14	The star in the gorgon's head the one in advance of the bright star	1(30)	10	22	N	21	0	4(m)
15	The star in the gorgon's head the remaining one yet again in advance of this	1(30)	9	32	N	22	15	4
16	The star in the right knee	1(30)	27	32	N	28	15	4
17	The one in advance of this over the knee	1(30)	25	42	N	28	10	4

Folio 118

Remaining stars of the constellation Perseus with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
18	The more advanced of the 2 stars above the bend in the knee	1(30)	25	2	N	25	0	4
19	The rearmost of them just over the bend in the knee	1(30)	26	42	N	26	15	4
20	The star on the right calf	1(30)	24	52	N	24	30	5
21	The star on the right ankle	1(30)	29	2	N	18	45	5
22	The star in the left thigh	1(30)	19	32	N	21	50	4
23	The star on the left knee	1(30)	21	22	N	19	15	3
24	The star on the left lower leg	1(30)	21	2	N	14	45	4
25	The star on the left heel	1(30)	16	52	N	12	0	3(s)
26	The one to the rear of this on the left foot	1(30)	19	2	N	11	0	3(s)
26 stars, 2 are of the 2nd magnitude, 5 of the 3rd magnitude, 15 of the 4th magnitude, 3 of the 5th magnitude and 1 nebula.								
The ones surrounding the constellation but not in it.								
1	The star to the east of the one on the left knee	1(30)	24	32	N	18	0	5(s)
2	The star to the north of the one in the right knee	1(30)	27	42	N	31	0	5(s)
3	The star in advance of those in the gorgon's head	1(30)	7	22	N	20	40	5
3 stars, all of the 5th magnitude.								



Folio 121

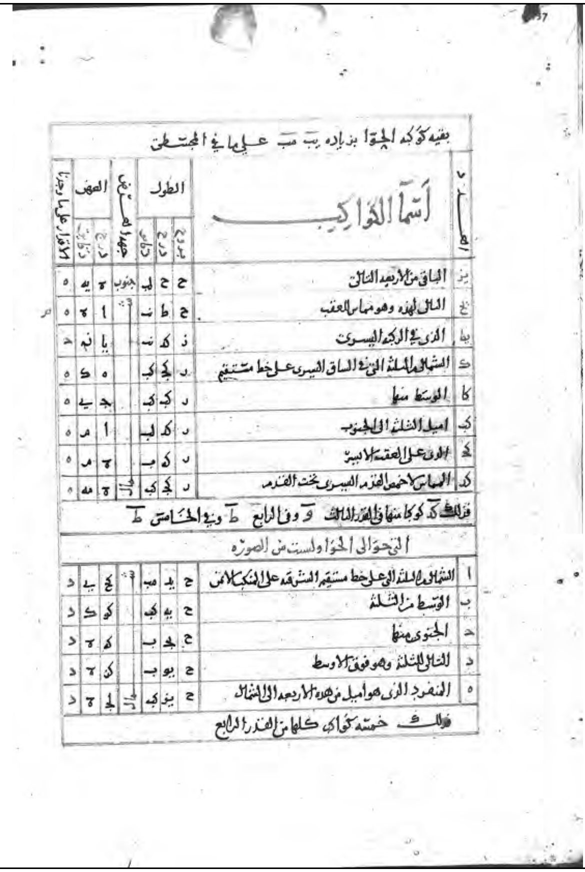
Constellation Auriga (*Mumsek al-A‘ina*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The southernmost of the two on the head	2(60)	15	12	N	30	0	4
2	The northernmost of these above the head	2(60)	15	2	N	30	50	5
3	The star on the left shoulder called *al-‘Ayyūq* (Capella)	2(60)	7	42	N	22	30	1
4	The star on the right shoulder	2(60)	15	32	N	20	0	2
5	The star on the right elbow	2(60)	13	52	N	15	15	5
6	The star on the right wrist	2(60)	15	32	N	13	20	3
7	The star on the left elbow	2(60)	4	42	N	20	40	4
8	The rearmost of the two stars on the left wrist which are called *al-Jadayain*	2(60)	4	52	N	18	0	4
9	The more advanced of these	2(60)	4	42	N	18	0	4
10	The star on the left ankle	2(60)	2	32	N	10	10	3(s)
11	The star on the right ankle which is applied in common to the horn of Taurus	2(60)	8	22	N	5	0	2
12	The one to the north of the latter in the lower hem of the garment	2(60)	8	42	N	8	30	6
13	The one north again of this on the buttock	2(60)	9	2	N	12	20	6
13 stars, 1 is of the 1st magnitude, 2 of the 2nd magnitude, 2 of the 3rd magnitude, 4 of the 4th magnitude, 2 of the 5th magnitude, 2 of the 6th magnitude.								

Folio 136

Constellation Ophiuchus (*al-Ḥawwā’*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*									
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star on the head	8(240)	7	32	N	36	0	3
2	The more advanced of the 2 stars on the right shoulder	8(240)	10	42	N	27	15	3(s)
3	The rearmost of them	8(240)	11	42	N	26	45	4
4	The more advanced of the 2 stars on the left shoulder	7(210)	26	2	N	33	0	4
5	The rearmost of them	7(210)	27	22	N	31	50	3(s) or 4(m)
6	The star on the left elbow	7(210)	21	2	N	24	30	4
7	The more advanced of the 2 stars in the left hand	7(210)	17	42	N	17	0	3
8	The rearmost of them	7(210)	18	42	N	16	30	3(s)
9	The star on the right elbow	8(240)	9	22	N	15	0	5(m)
10	The more advanced of the 2 stars in the right hand	8(210)	15	2	N	13	40	4(m)
11	The rearmost of them	8(240)	16	2	N	14	20	5
12	The star on the right knee	8(240)	3	52	N	7	30	3
13	The star on the right lower leg	8(210)	6	22	N	2	15	5(m) or 4(s)
14	The most advanced of the 4 stars on the right foot	8(240)	5	42	S	2	15	5(k) or 4(s)
15	The one to the rear of this	8(240)	7	2	S	1	1	4(k)
16	The one to the rear again of that	8(240)	7	42	S	0	20	4(s)

Folio 137

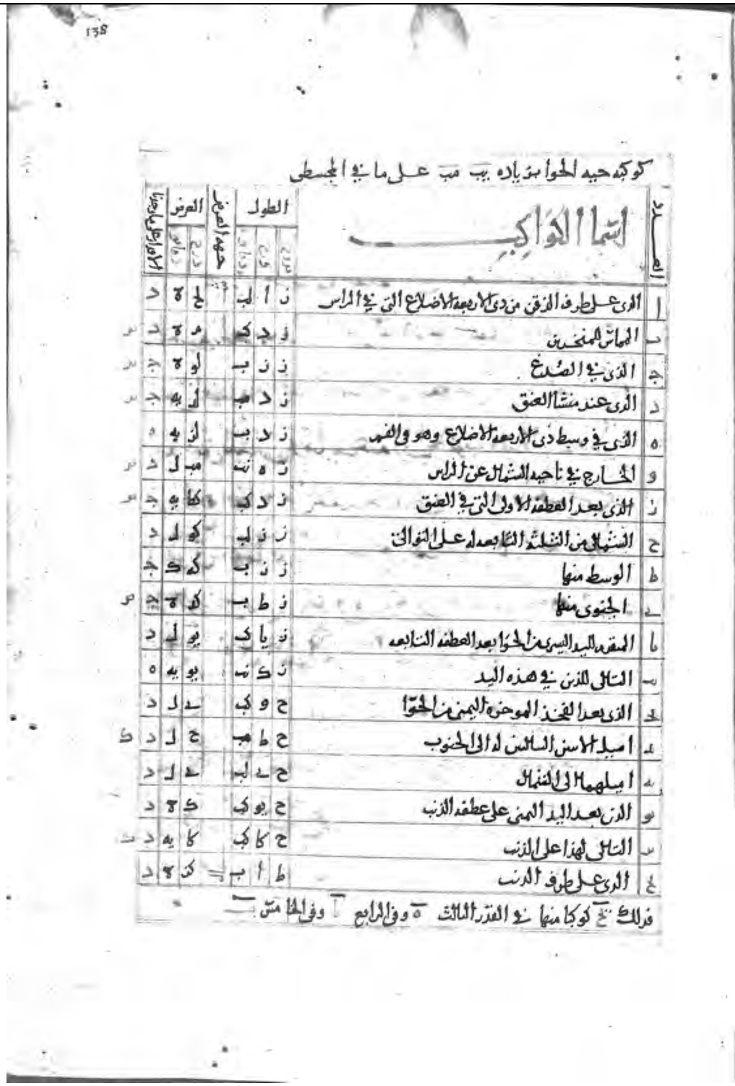
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
Remaining stars of the constellation Ophiuchus with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
17	The last and rearmost of the 4	8(240)	8	32	S	0	15	5
18	The star to the rear of these which touches the heel	8(240)	9	52	N	1	0	5(s)
19	The star in the left knee	7(210)	24	52	N	11	50	3
20	The northernmost of the 3 stars in a straight line in the left lower leg	7(210)	23	22	N	5	20	5
21	The middle one of these	7(210)	22	22	N	3	10	5
22	The southernmost of the three	7(210)	24	32	N	1	40	5
23	The star on the left heel	7(210)	25	2	N	0	40	5
24	The star touching the hollow of the left foot	7(210)	23	22	N	0	45	5
24 stars. 6 of the 3rd magnitude, 9 of the 4th magnitude, 9 of the 5th magnitude								
The ones surrounding the constellation but not in it.								
1	The northernmost of the 3 to the east of the right shoulder	8(240)	14	42	N	28	10	4
2	The middle one of three	8(240)	15	22	N	26	20	4
3	The southernmost of them	8(240)	13	2	N	25	0	4
4	The star to the rear of these over the middle one	8(240)	16	2	N	27	0	4
5	The lone star north of these 4	8(240)	17	22	N	33	0	4
5 stars, all of the 4th magnitude.								



Folio 138

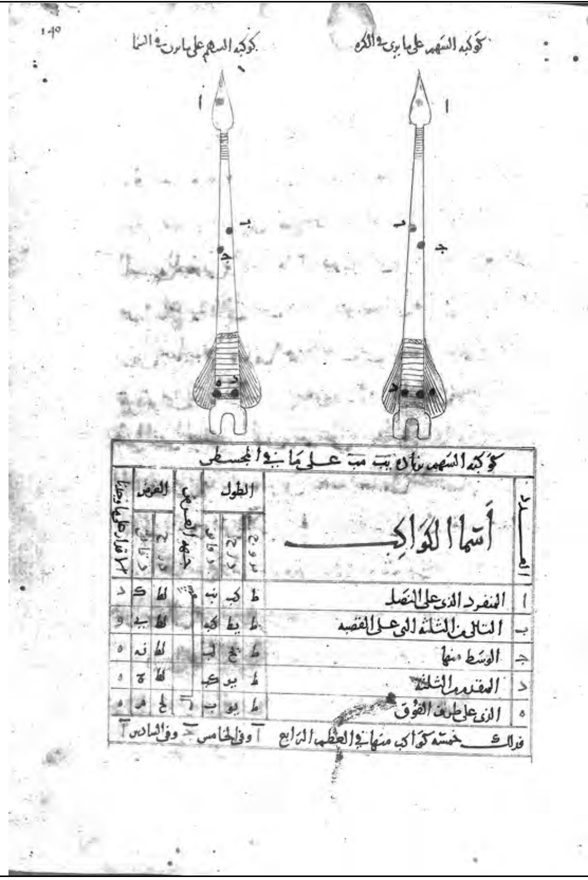
Constellation Serpens (*al-Ḥayya*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The stars on the quadrilateral in the head, the one on the end of the jaw	7(210)	1	32	N	38	0	4
2	The stars on the quadrilateral in the head, the one touching the nostrils	7(210)	4	22	N	40	0	4(s)
3	The stars on the quadrilateral in the head, the one in the temple	7(210)	7	2	N	36	0	3(s)
4	The stars on the quadrilateral in the head, the one where the neck joins the head	7(210)	4	42	N	34	15	3(s)
5	The stars on the quadrilateral in the head, the one in the middle of the quadrilateral in the mouth	7(210)	4	2	N	37	15	5
6	The star outside the head to the north of it	7(210)	5	52	N	42	30	4(s)
7	The one after the first bend in the neck	7(210)	4	22	N	29	15	3(s)
8	The northernmost of the 3 following this	7(210)	7	32	N	26	30	4
9	The middle one of the three	7(210)	7	2	N	25	20	3
10	The southernmost of them	7(210)	9	2	N	24	0	3(s)
11	The star after the next bend which is in advance of the left hand of Ophiuchus	7(210)	11	22	N	16	30	4
12	The star to the rear of those in the hand of Ophiuchus	7(210)	20	52	N	16	15	5
13	The one after the back of the right thigh of Ophiuchus	8(240)	6	22	N	10	30	4
14	The southernmost of the 2 to the rear of the latter	8(240)	9	42	N	8	30	4(m)
15	The northernmost of them	8(240)	10	32	N	10	30	4
16	The one after the right hand of Ophiuchus on the bend in the tail	8(240)	16	22	N	20	0	4
17	The one to the rear of this likewise on the tail	8(240)	21	22	N	21	15	4(m)
18	The star on the tip of the tail	9(270)	1	2	N	27	0	4
18 stars, 5 is of the 3rd magnitude, 11 of the 4th magnitude, 2 of the 5th magnitude.								



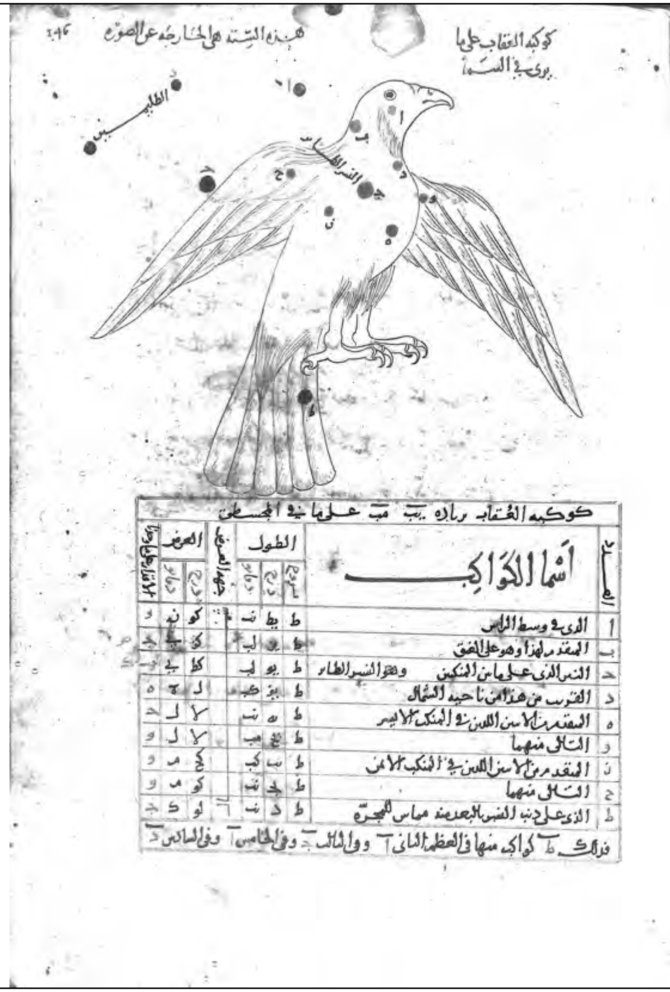
Folio 140

Constellation Sagitta (*al-Sahem*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*									
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The lone star on the arrow head	9(270)	22	52	N	39	20	4
2	The rearmost of the three stars in the shaft	9(270)	19	22	N	39	10	6
3	The middle one	9(270)	18	32	N	39	50	5
4	The most advanced of the three	9(270)	16	22	N	39	0	5
5	The star on the end of the notch	9(270)	16	2	N	38	40	5
5 stars, 1 is of the 4th magnitude, 3 of the 5th magnitude, 1 of the 6th magnitude								



Folio 146

Constellation Aquila (*al-‘Uqāb*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star in the middle of the head	9(270)	19	52	N	26	50	6
2	The one in advance of this on the neck	9(270)	17	32	N	27	10	3(s)
3	The bright star on the place between the shoulders called al-*Nasr al-Ṭā’er* (Aquila)	9(270)	16	32	N	29	10	2(m)
4	The one close to this towards the north	9(270)	17	22	N	30	0	5
5	The more advanced of the 2 in the left shoulder	9(270)	15	52	N	31	30	3
6	The rearmost of them	9(270)	18	42	N	31	30	6
7	The more advanced of the two in the right shoulder	9(270)	12	22	N	28	40	6
8	The rearmost of them	9(270)	13	52	N	26	40	6
9	The star some distance under the tail of Aquila touching the Milky Way	9(270)	4	52	N	36	20	3
9 stars 1 of the 2nd magnitude, 3 of the 3rd magnitude, 1 of the 5th magnitude, 4 of the 6th magnitude.								



Folio 147

The ones surrounding the constellation Aquila but not in it with the addition of 12 (degrees) 42 (minutes) to what is found in the Almagest								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	the more advanced of the 2 stars south of the head of Aquila	9(270)	16	52	N	21	40	3(s)
2	the rearmost of them	9(270)	21	22	N	19	10	3
3	the star to the south and west of the right shoulder of Aquila	9(270)	8	42	N	25	0	3(s)
4	the one to the south of this	9(270)	10	52	N	20	0	4(s)
5	the one to the south again of the latter	9(270)	12	22	N	15	30	5
6	the star most in advance of all	9(270)	3	52	N	18	10	3(s)
6 stars, 4 of the 3rd magnitude, 1 of the 4th magnitude, 1 of the 5th magnitude								

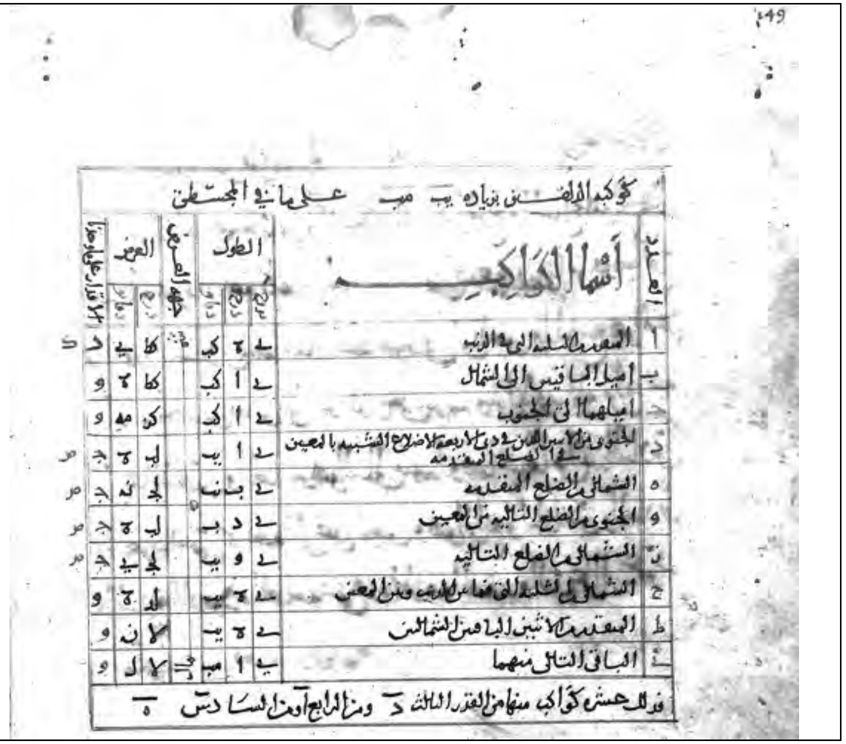

التي حول النسر وليست من الصورة بزيادة يب مب على ما في المجسطي

العدد	اسماء الكواكب	الطول برج	درج	دقائق	جهة العرض	العرض درج	دقائق	العظم
ا	المتقدم من الاثنين اللذين من ناحية الجنوب عن راس النسر	ط	يو	نب		كا	م	ج صر
ب	التالي منهما	ط	كا	كب		يط	ي	ج
ج	الذي من ناحية الجنوب والمغرب عن المنكب الايمن للنسر	ط	ح	مب		كه		ج صر
د	الذي من ناحية الجنوب عن هذا	ط	ي	نب		ك		د صر
ه	الذي هو ابعد عن هذا ايضا الى الجنوب	ط	يب	كب		يه	ل	ه
و	المتقدم لجميعها	ط	ج	نب		يح	ي	ج صر

فذلك ستة كواكب منها من القدر الثالث د ومن الرابع ا ومن الخامس ا

Folio 149

Constellation Delphinus (*al-Dalfīn*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The most advanced of the 3 stars in the tail	10(300)	0	22	N	29	10	4(m)
2	The northernmost of the other 2	10(300)	1	22	N	29	0	6
3	The southernmost of them	10(300)	1	22	N	27	45	6
4	The southernmost star on the advanced side of the rhombus	10(300)	1	12	N	32	0	3(s)
5	The northernmost star on the advanced side of the rhombus	10(300)	2	52	N	33	50	3(s)
6	The southernmost star on the rear side of the rhombus	10(300)	4	2	N	32	0	3(s)
7	The northernmost star on the rear side of the rhombus	10(300)	6	12	N	33	10	3(s)
8	The southernmost of the 3 stars between the tail and the rhombus	10(300)	0	12	N	34	0	6
9	The more advanced of the other 2 to the north	10(300)	0	12	N	31	50	6
10	The remaining rearmost one	10(300)	1	42	N	31	30	6
10 stars, 4 is of the 3rd magnitude, 1 of the 4th magnitude, 5 of the 6th magnitude								



Folio 150

Constellation Equuleus (*Quṭ‘at al-Faras*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The more advanced of the 2 stars in the head	10(300)	9	2	N	20	30	4
2	The rearmost of them	10(300)	10	42	N	20	40	6
3	The more advanced of the two stars in the mouth	10(300)	9	2	N	25	20	5(s)
4	The rearmost of them	10(300)	10	22	N	25	0	5(s)

4 stars, 1 of the 4th magnitude, 2 of the 5th magnitude, 1 of the 6th magnitude

Folio 157

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
Constellation Pegasus (*al-Faras al-A'ẓam*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
		zodiac	deg	min		deg	min	
1	The star on the navel which is applied in common to the head of Andromeda	0	0	32	N	26	0	2(s)
2	The star on the rump and the wing tip	11(330)	24	52	N	12	30	2(s)
3	The star on the right shoulder and the place where the leg joins it	11(330)	14	52	N	31	0	2(s)
4	The star on the place between the shoulders and shoulder part of the wing	11(330)	9	22	N	19	40	2(s)
5	The northernmost of the two stars in the body under the wing	11(330)	17	12	N	25	30	4
6	The southernmost of them	11(330)	17	42	N	25	0	4
7	The northernmost of the two stars in the right knee	11(330)	11	42	N	35	0	5 or 3
8	The southernmost of them	11(330)	11	12	N	34	30	5
9	The more advanced of the two stars close together in the chest	11(330)	8	52	N	29	0	4(k)
10	The rearmost of them	11(330)	9	42	N	29	30	4(k)
11	The more advanced of the 2 stars close together in the neck	11(330)	1	32	N	18	0	3(s)
12	The rearmost of them	11(330)	3	12	N	19	0	4(s)
13	The southernmost of the two stars on the mane	11(330)	4	2	N	15	0	6 or 5(s)
14	The northernmost of them	11(330)	3	12	N	16	0	6 or 5(s)
15	The northernmost of the two stars close together on the head	10(300)	22	2	N	16	50	3(s)
16	The southernmost of them	10(300)	20	42	N	16	0	5(s)
17	The star in the muzzle	10(300)	18	2	N	22	30	3
18	The star in the right hock	11(330)	6	22	N	41	10	4
19	The star on the left knee	11(330)	5	22	N	34	15	4
20	The star in the left hock	10(300)	25	2	N	36	50	4
20 stars, 4 is of the 2nd magnitude, 3 of the 3rd magnitude, 8 of the 4th magnitude, 5 of the 5th magnitude.								

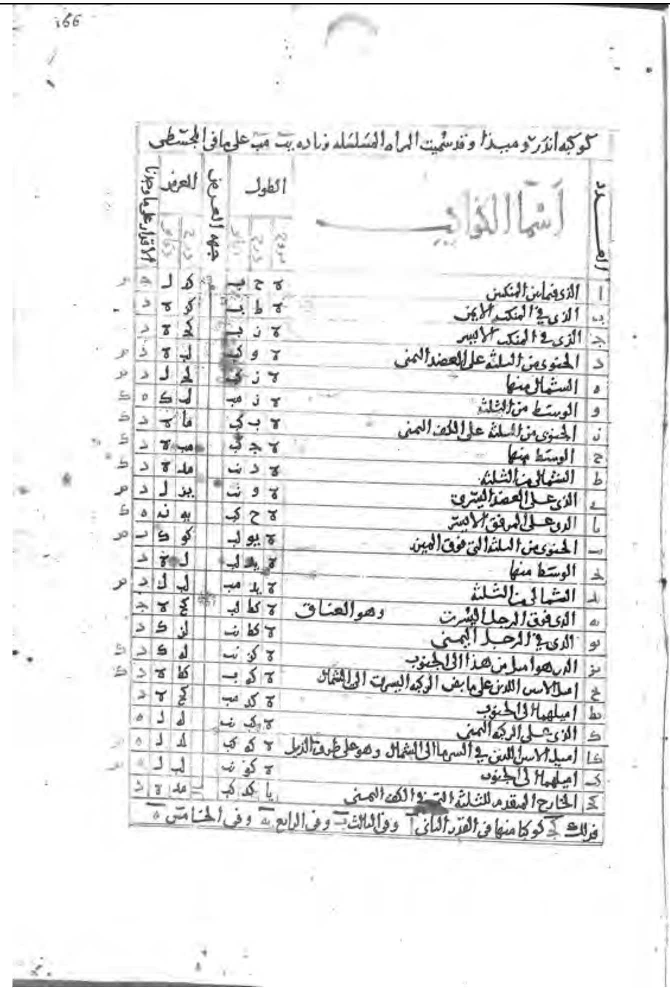

كوكبة الفرس الاعظم تزاد يب مب على ما في المجسطي

Folio 166

Constellation Andromeda (*al-Mara’ Al-Musalsala*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*

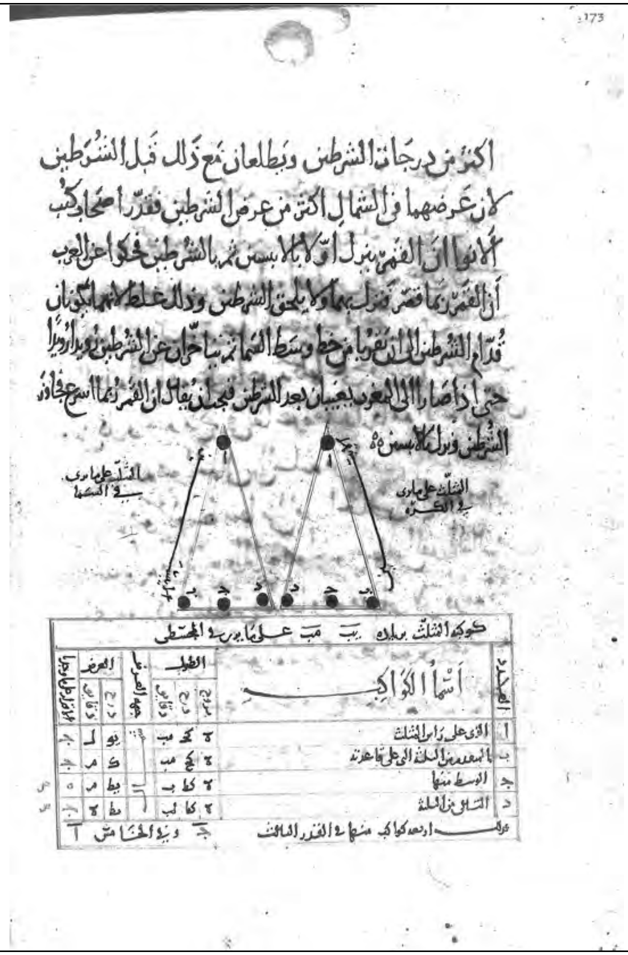
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star in the place between the shoulders	0	8	2	N	24	30	3(s)
2	The star in the right shoulder	0	9	2	N	27	0	4
3	The star in the left shoulder	0	7	2	N	23	0	4
4	The southernmost of the 3 stars on the right upper arm	0	6	22	N	32	0	4(s)
5	The northernmost of them	0	7	22	N	33	30	4(s)
6	The middle one of the three	0	7	42	N	32	20	5(m) or 5(s)
7	The southernmost of the 3 stars on the right hand	0	2	22	N	41	0	4(m)
8	The middle one of these	0	3	22	N	42	0	4(m)
9	The northernmost of the three	0	4	52	N	44	0	4(m)
10	The star on the left upper arm	0	6	52	N	17	30	4(s)
11	The star on the left elbow	0	8	22	N	15	50	5(m)
12	The southernmost of the 3 stars over the griddle	0	16	32	N	26	20	2(s)
13	The middle one of these	0	14	32	N	30	0	4
14	The northernmost of the three	0	14	42	N	32	30	4(s)
15	The star over the left foot called *al-‘Anāq*	0	29	32	N	28	0	3
16	The star in the right foot	0	29	52	N	37	20	4
17	The one south of the latter	0	27	52	N	35	20	4(m)
18	The northernmost of the 2 stars on the left knee bend	0	25	2	N	29	0	4(m)
19	The southernmost of them	0	24	42	N	28	0	4
20	The star on the right knee	0	22	52	N	35	30	5
21	The northernmost of the 2 stars in the lower hem of the garment	0	25	22	N	34	30	5(s) or 6
22	The southernmost of them	0	26	52	N	32	30	5(s) or 6
23	The star in advance of the three in the right hand outside of it	11(330)	24	22	N	44	0	4(m) or 4

23 stars, 1 is of the 2nd magnitude, 2 of the 3rd magnitude, 15 of the 4th magnitude, 5 of the 5th magnitude.



Folio 173

Constellation Triangulum (*al-Muthallath*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star in the apex of the triangle	0	23	42	N	16	30	3
2	The most advanced of the 3 on the base	0	28	42	N	20	40	3
3	The middle one of these	0	29	2	N	19	40	5(s)
4	The rearmost of the three	0	29	32	N	19	0	3(s)
4 stars, 3 of the 3rd magnitude, 1 of the 5th magnitude								



Folio 182

Table for the Constellation Aries (*al-Ḥamal*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The more advanced of the 2 stars on the horn	0	19	22	N	7	20	3(s)
2	The rearmost of them	0	20	22	N	8	20	3
3	The northernmost of the 2 stars on the muzzle	0	23	42	N	7	40	5(s)
4	The southernmost of them	0	24	12	N	6	0	4(s)
5	The star on the neck	0	19	12	N	5	30	5
6	The star on the rump	1(30)	0	22	N	6	0	6
7	The star on the place where the tail joins [the body]	1(30)	4	2	N	4	50	5
8	The most advanced of the 3 stars in the tail	1(30)	6	32	N	1	40	4
9	The middle one of the three	1(30)	8	2	N	2	30	4
10	The rearmost of them	1(30)	9	42	N	1	50	4
11	The star in the back of the thigh	1(30)	2	22	N	1	10	5
12	The star under the knee-bend	1(30)	0	42	N	1	30	5
13	The star on the hind hoof	0	27	42	N	5	15	4
13 stars, 2 is of the 3rd magnitude, 5 of the 4th magnitude,5 of the 5th magnitude, 1of the 6th magnitude								
The ones surrounding the constellation Aries but not in it.								
1	The star over the head, which Hipparchus [calls] 'the one on the muzzle'	0	23	22	N	10	0	3(k)
2	The 4 stars over the rump: the rearmost, which is brighter [than the others]	1(30)	4	22	N	10	10	4
3	The northernmost of the other 3, fainter stars	1(30)	4	2	N	12	40	5
4	The middle one of these three	1(30)	2	22	N	11	10	5
5	The southernmost of them	1(30)	1	52	N	10	40	5(s)
5 stars, 1 is of the 3rd magnitude, 1 of the 4th magnitude, 3 of the 5th magnitude.								

Folio 183 (Manuscript Marsh144)

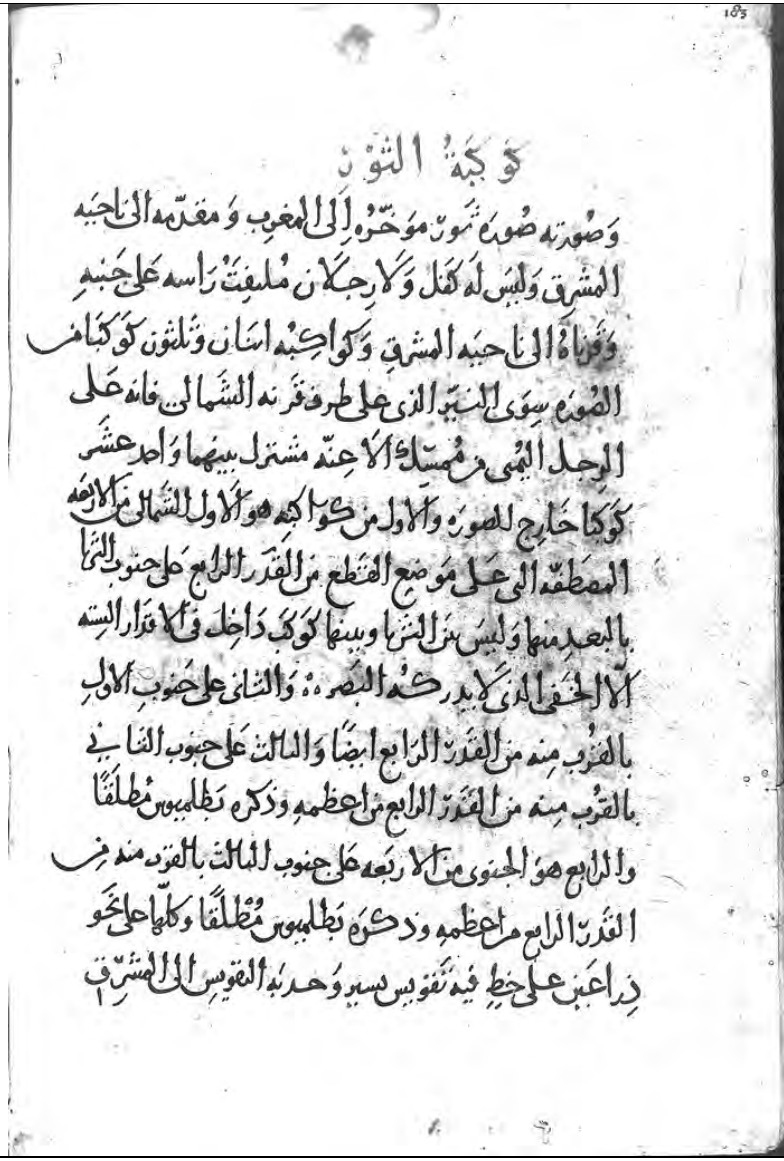
The constellation Taurus (*al-Thawr)*

Its image looks like a bull with its end (pointed) to the west and its front towards the east. It does not have a rump or legs. Its head is turned towards its side and its horns point towards the east.

Its stars are thirty-two stars in the main picture, except the bright (star) on the tip of its northern horn which is part of the right leg of *Mumsek al-A'ina* (constellation Auriga) and is common to both (constellations). There are eleven stars outside the picture (of the constellation).

The first of its stars is the northernmost (star) of the four aligned on the cut-off position (where figure of bull is cut short) and is of the 4th magnitude. It is far south of the Pleiades, and there are no stars between the Pleiades and this star which are as bright as the 6th magnitude except the faint stars which are hardly seen.

The second (star) is south of the first, close to it, and is also of the 4th magnitude.
The third is south of the second, close to it, and is much greater than 4th magnitude, but it was mentioned by Ptolemy as 4th magnitude exactly.
The fourth is the southernmost star of the four, south and close to the third, and is much greater then 4th magnitude, but it was mentioned by Ptolemy as 4th magnitude exactly.
(The four stars) all form a slightly curved line the size of two *dhirā'* (1 *dhirā'* = 2 deg 20 min, 2 *dhirā'* = 4 deg 40 min) with its curve pointed towards the east.

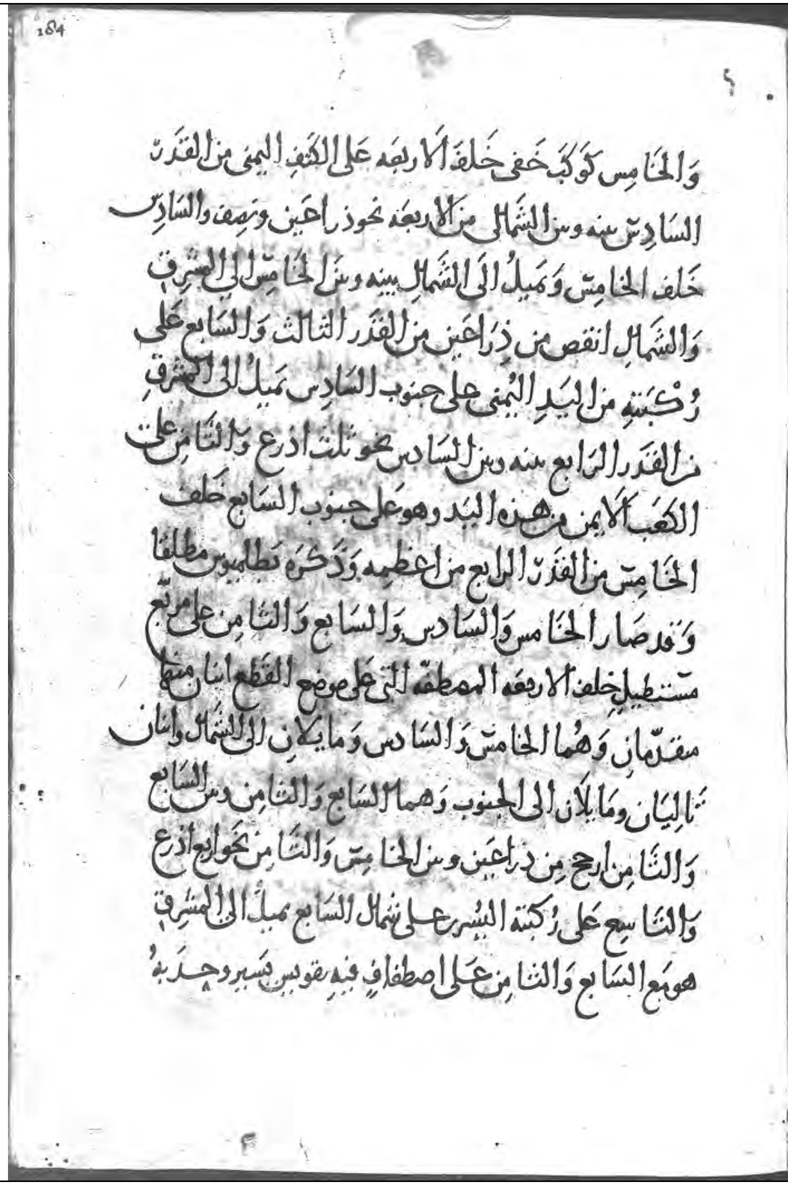

183

كوكبة الثور

وصورته صورة ثور مؤخره إلى المغرب ومقدمه إلى ناحية
المشرق وليس له كفل ولا رجلان ملتفت رأسه على جنبه
وقرناه إلى ناحية المشرق وكواكبه اثنان وثلثون كوكبا في
الصورة سوى النير الذي على طرف قرنه الشمالي فإنه على
الرجل اليمنى من ممسك الأعنة مشترك بينهما وأحد عشر
كوكبا خارج الصورة والأول من كواكبه هو الأول الشمالي من الأربعة
المصطفة التي على موضع القطع من القدر الرابع على جنوب الثريا
بالبعد منها وليس بين الثريا وبينها كوكب داخل في الأقدار الستة
إلا الخفي الذي لا يدركه البصر. والثاني على جنوب الأول
بالقرب منه من القدر الرابع أيضا والثالث على جنوب الثاني
بالقرب منه من القدر الرابع من أعظمه وذكره بطلميوس مطلقا
والرابع هو الجنوبي من الأربعة على جنوب الثالث بالقرب منه من
القدر الرابع من أعظمه وذكره بطلميوس مطلقا وكلها على نحو
ذراعين على خط فيه تقويس يسير وحدبة التقويس إلى المشرق

Folio 184

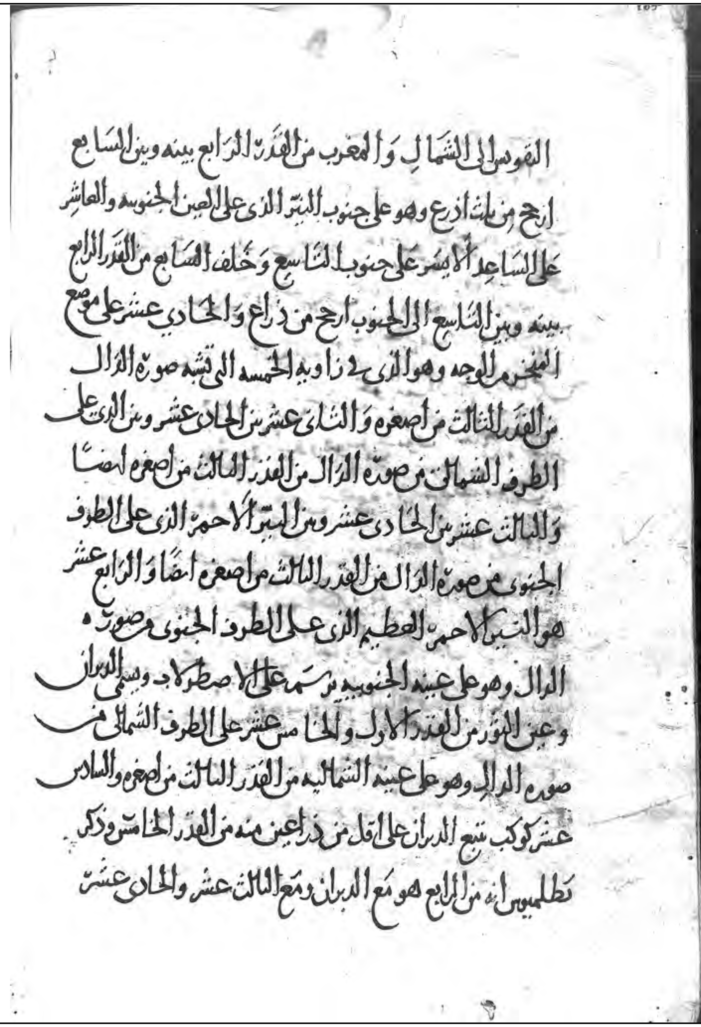
The fifth is a dim star behind the four (stars) on the right shoulder and is of the 6th magnitude. The distance between it and the southern of the four is two *dhirā’* and a half.
The sixth is behind the fifth towards the north. The south easterly distance between it and the fifth is less then two *dhirā’* and it is of the 3rd magnitude.
The seventh is on the left knee south of the sixth (star) towards the east and is of the 4th magnitude. The distance between it and the sixth (star) is around three *dhirā’*.
The eighth is on the right hock of this hand and it is south of the seventh behind the fifth, and is much more than 4th magnitude while Ptolemy mentioned it to be exactly (4th magnitude).
The fifth, sixth, seventh and eighth form a *Murabba’ Mustaṭīl* (quadrilateral) behind the four (stars) which are aligned on the cut-off position. Two stars are in front, those are the fifth and the sixth (and) oriented towards the north, and the other two are oriented towards the south and these are the seventh and the eighth. The distance between the seventh and the eight is slightly more than two *dhirā’*. The distance between the fifth and the eighth is around four *dhirā’*.
The ninth is on the left knee north of the seventh and is oriented towards the east. (The ninth) together with the seventh and the eighth (stars) form a line with a slight curve with its curve pointed towards the north-west.


184

والخامس كوكب خفي خلف الاربعة على الكتف اليمنى من القدر
السادس بينه وبين الشمالي من الاربعة نحو ذراعين ونصف والسادس
خلف الخامس ويميل الى الشمال بينه وبين الخامس الى الشرق
والشمال انقص من ذراعين من القدر الثالث والسابع على
ركبته من اليد اليمنى على جنوب السادس يميل الى المشرق
من القدر الرابع بينه وبين السادس نحو ثلث اذرع والثامن على
الكعب الايمن من هذه اليد وهو على جنوب السابع خلف
الخامس من القدر الرابع من اعظمه وذكره بطلميوس مطلقا
وقد صار الخامس والسادس والسابع والثامن على مربع
مستطيل خلف الاربعة المصطفة التي على موضع القطع اثنان منها
مقدمان وهما الخامس والسادس ومايلان الى الشمال واثنان
تاليان ومايلان الى الجنوب وهما السابع والثامن وبين السابع
والثامن ارجح من ذراعين وبين الخامس والثامن نحو اربع اذرع
والتاسع على ركبته اليسرى على شمال السابع يميل الى المشرق
هو مع السابع والثامن على اصطفاف فيه تقويس يسير وحدبته

Folio 185

It (the ninth star) is of the 4th magnitude. The distance between it (the ninth) and the seventh (star) is slightly more than three *dhirā'*. It is south of the bright (star) which is on the southern eye.
The tenth is on the left leg south of the ninth and behind the seventh, and is of the 4th magnitude. The distance between it and the ninth to the south is around one *dhirā'*.
The eleventh is on the nose of the face and it is on the corner of the five (stars) which resemble *al-Dāl* (the Greek letter Δ), and it is less than 3rd magnitude.
The twelfth is between the eleventh and (the star) on the north edge of the stars that resemble *al-Dāl* and it is also less than 3rd magnitude.
The thirteenth is between the eleventh and the bright red (star) which is on the south edge of the stars that resemble *al-Dāl* and it is also less than 3rd magnitude.
The fourteenth is the large bright red (star) on the south edge of the stars that resemble *al-Dāl.* It is located on the south eye and is drawn on al-Isṭerlāb (the Astrolabe). It is called *al-Dabarān* (Aldebaran) and *Ain al-Thawr* (the eye of Taurus) and is of the 1st magnitude.
The fifteenth is on the north edge of the stars that resemble *al-Dāl*. It is located on the north eye and is less then 3rd magnitude.
The sixteenth star is distant from Aldebaran by less than two *dhirā'* and is of the 5th magnitude. Ptolemy mentioned that it is of the 4th magnitude. (The sixteenth) together with Aldebaran and the thirteenth and eleventh (stars) which are close to Aldebaran form a line with a slight curve with its curve pointed towards the south.


القوس الى الشمال والمغرب من القدر الرابع بينه وبين السابع
ارجح من ثلث اذرع وهو على جنوب النير الذي على العين الجنوبية والعاشر
على الساعد الايسر على جنوب التاسع وخلف السابع من القدر الرابع
بينه وبين التاسع الى الجنوب ارجح من ذراع والحادي عشر على موضع
المنخر من الوجه وهو الذي في زاوية الخمسة التي تشبه صورة الدال
من القدر الثالث من اصغره والثاني عشر بين الحادي عشر وبين الذي على
الطرف الشمالي من صورة الدال من القدر الثالث من اصغره ايضا
والثالث عشر بين الحادي عشر وبين النير الاحمر الذي على الطرف
الجنوبي من صورة الدال من القدر الثالث من اصغره ايضا والرابع عشر
هو النير الاحمر العظيم الذي على الطرف الجنوبي من صورة
الدال وهو على عينه الجنوبية مرسوم على الاصطرلاب ويسمى الدبران
وعين الثور من القدر الاول والخامس عشر على الطرف الشمالي من
صورة الدال وهو على عينه الشمالية من القدر الثالث من اصغره والسادس
عشر كوكب يتبع الدبران على اقل من ذراعين منه من القدر الخامس وذكر
بطلميوس انه من الرابع وهو مع الدبران ومع الثالث عشر والحادي عشر

Folio 186

The seventeenth is the southern of three stars which form a line with a slight curve with its curve pointed towards the east. It follows the sixteenth and is of the 5th magnitude.

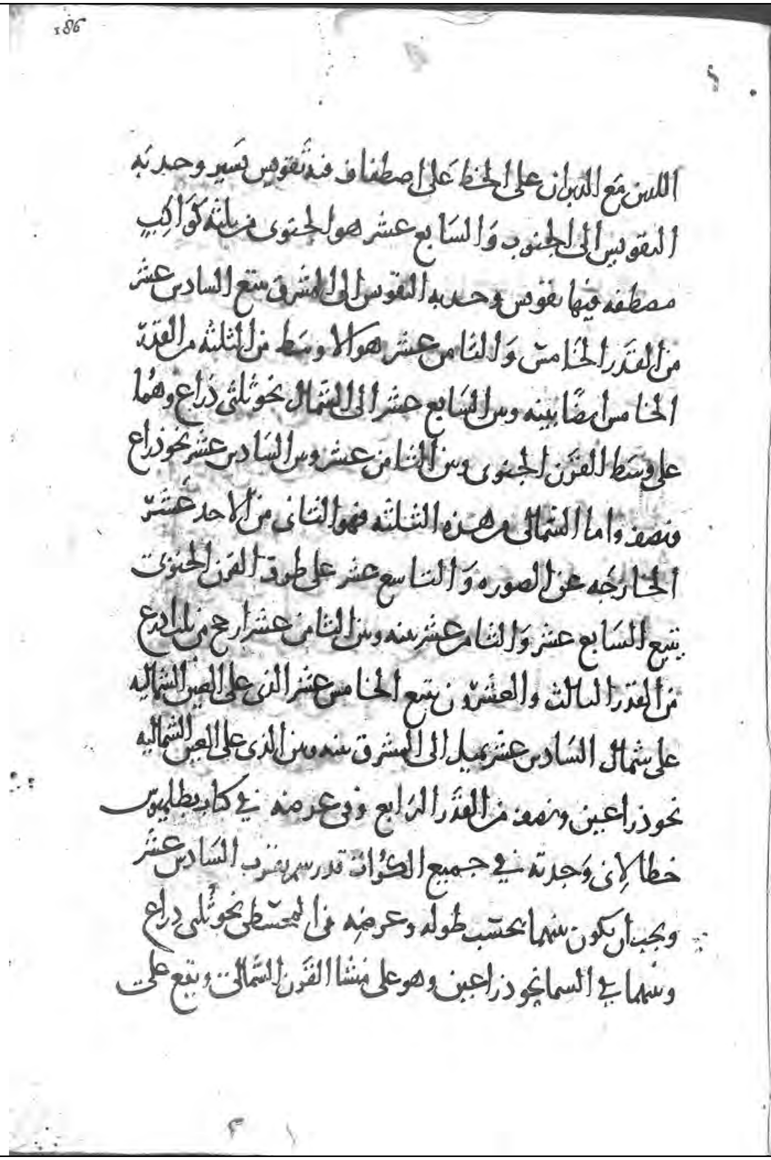
The eighteenth is the middle (star) of the three and is of the 5th magnitude also. The distance between it and the seventeenth towards the north is around a third of a *dhirā’*. Both are located in the middle of the southern horn.

The distance between the eighteenth and the sixteenth is around one *dhirā’ and* a half. As for the northern star of these three it is the second star from the eleven stars which are outside of the constellation.

The nineteenth is on the tip of the southern horn following the seventeenth and the eighteenth. The distance between it and the seventeenth and the eighteenth. The distance between it and the eighteenth is more than three *dhirā’ and* it is of the 3rd magnitude.

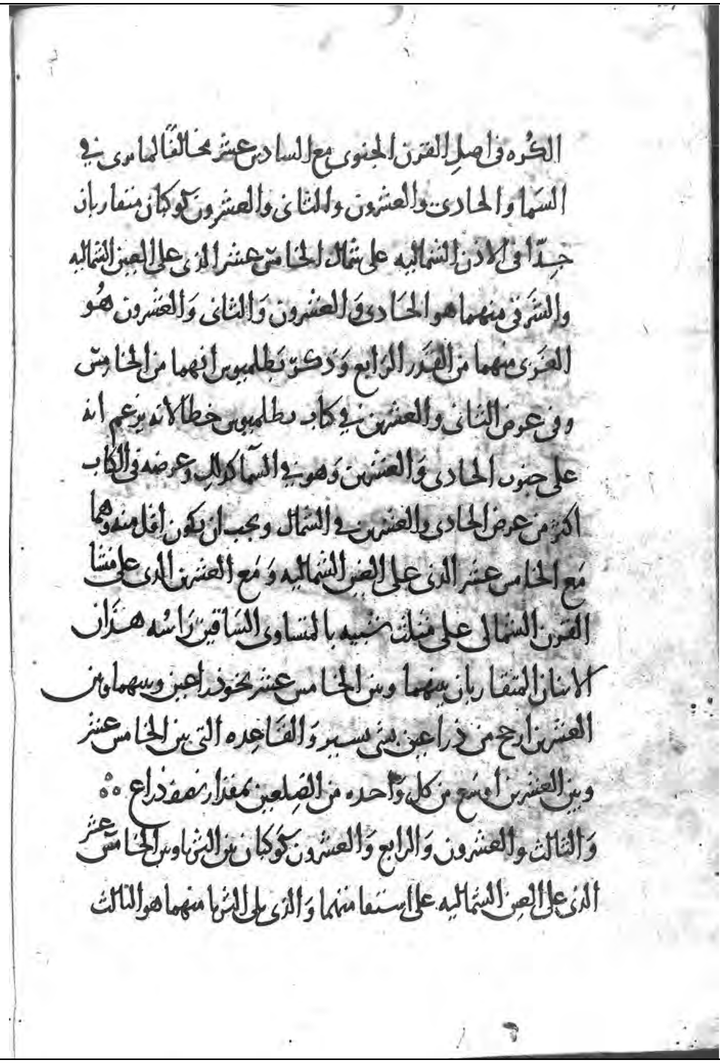
The twentieth follows the fifteenth which is on the northern eye. It is north of the sixteenth towards the east. The distance between it and the star on northern eye is around two and a half *dhirā’*, and it is of the 4th magnitude.

Its latitude in the book of Ptolemy is wrong because I found that it has been drawn on all globes next to the sixteenth star. For according to the longitude and latitude in *Almagest* the distance between them should be around a third of *dhirā’*, while the distance between them in the sky is around two *dhirā’*.



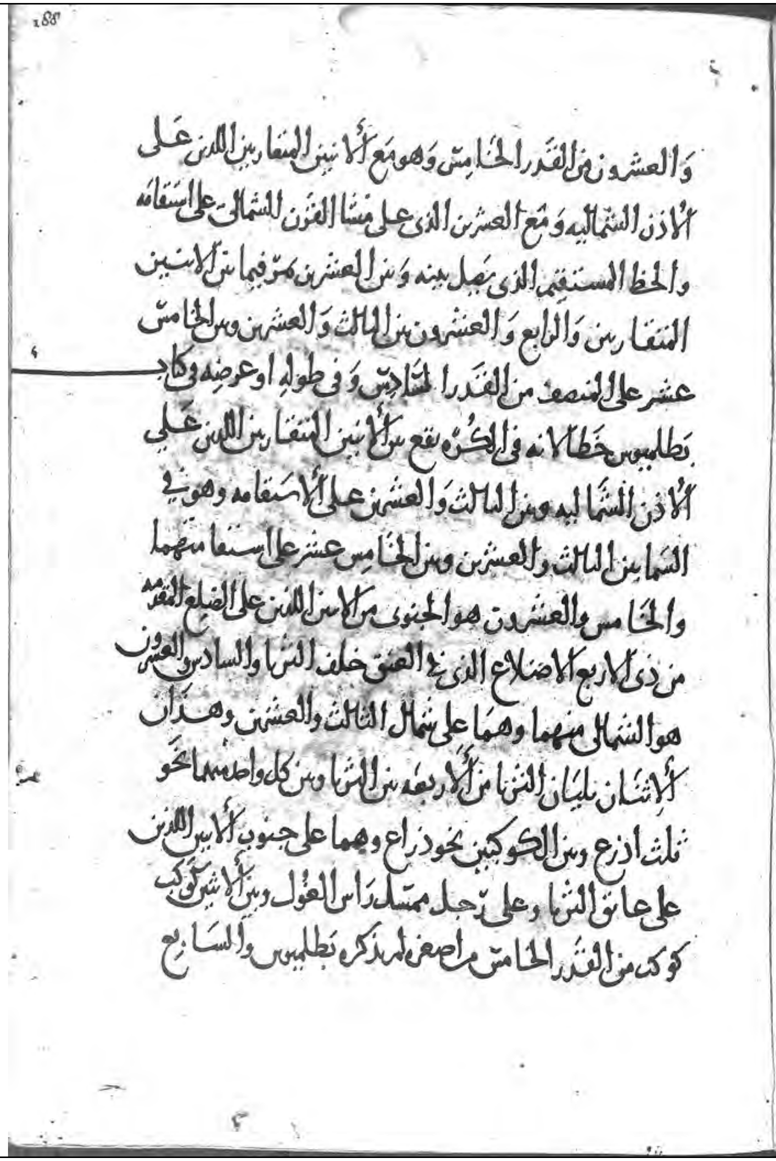
Folio 187

It (the twentieth star) is located on the tip of the northern horn, while on the globes it is located on the southern horn together with the sixteenth (star) contrary to what is seen in the sky.
The twenty-first and twenty-second are two very close stars located on the northern ear, north of the fifteenth star which is on the northern eye. The eastern of these two stars is the twenty first and the twenty second is the southern of the two, (and both) are of the 4th magnitude. Ptolemy mentioned that they are of the 5th (magnitude). The latitude of the twenty-second in Ptolemy's book is wrong because as he claims that it is south of the twenty-first, as it really is in the sky, however its latitude towards the north in (Ptolemy's) book is more than that of the twenty-first and it should be less.
Both (stars) together with the fifteenth star, which is located on the northern eye, and the twentieth star, which is located on the beginning of the northern horn, (all) form a *Muthallath* (triangle) similar to a *Mutasāwi al-Saqain* (Isosceles triangle) with these two close stars on its head.
The distance between (the two stars) and the fifteenth is around two *dhirā' and* between the twentieth is slightly more than two *dhirā'*.
The base between the fifteenth and the twentieth is wider then the two sides by half a *dhirā'*.
The twenty-third and the twenty-fourth are two stars located between *al-Thurayyā* (the Pleiades) and the fifteenth, which is on the northern eye on the same line.



Folio 188

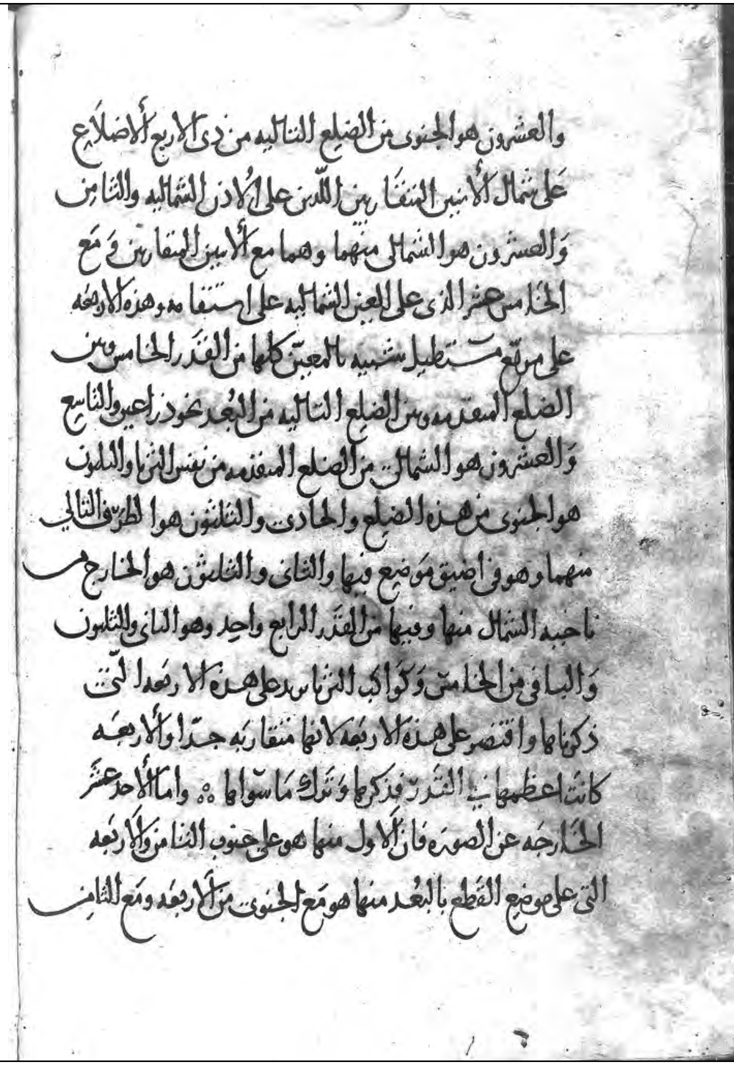
The one closer to *al-Thurayyā* (the Pleiades) is the twenty-third which is of the 5th magnitude and this star together with the two close stars on the northern ear and with the twentieth on the beginning of the northern horn are on a straight line.
The straight line that connects it with the twentieth passes between the two close stars.
The twenty-fourth is located in the middle of the distance between the twenty-third and the fifteenth and it is of the 6th magnitude.
Its longitude or latitude in the book of Ptolemy is wrong because (as per Ptolemy if it is to be drawn) on a globe it forms a straight line between the two close stars on the northern ear and the twenty-third while in the sky it is located on a straight line between the twenty-third and the fifteenth.
The twenty-fifth is the southern of the two stars located on the front side of the four sided (quadrilateral). It is located on the neck behind *al-Thurayyā* (the Pleiades).
The twenty-sixth is the northern of the two. Both are north of the twenty-third and are the closer of the four to *al-Thurayyā*. The distance between *al-Thurayyā* and every one of them is around one third of a *dhirā’* . The distance between these two stars is around one *dhirā’*.
They are located south of the two stars that are close to *al-Thurayyā* and the leg of *Mumsek Ra’s al-Ghūl* (the Man holding the head of the monster which is the Constellation Perseus).
Between these two stars is a star less than the 5th magnitude which was not mentioned by Ptolemy.


188

والعشرون من القدر الخامس وهو مع الاثنين المتقاربين اللذين على
الأذن الشمالية ومع العشرين الذي على مبدأ القرن الشمالي على استقامة
والخط المستقيم الذي يصل بينه وبين العشرين يمر فيما بين الاثنين
المتقاربين والرابع والعشرون بين الثالث والعشرين وبين الخامس
عشر على المنتصف من القدر السادس وفي طوله او عرضه في كتاب
بطلميوس خطأ لأنه في الكرة يقع بين الاثنين المتقاربين اللذين على
الأذن الشمالية وبين الثالث والعشرين على الاستقامة وهو في
السماء بين الثالث والعشرين وبين الخامس عشر على استقامة بينهما
والخامس والعشرون هو الجنوبي من الاثنين اللذين على الضلع المقدم
من ذي الأربع الأضلاع الذي في العنق خلف الثريا والسادس والعشرون
هو الشمالي منهما وهما على شمال الثالث والعشرين وهذان
الاثنان يليان الثريا من الأربعة بين الثريا وبين كل واحد منهما نحو
ثلث ذراع وبين الكوكبين نحو ذراع وهما على جنوب الاثنين اللذين
على عاتق الثريا وعلى رجل ممسك رأس الغول وبين الاثنين كوكب
من القدر الخامس أصغر لم يذكره بطلميوس والسابع

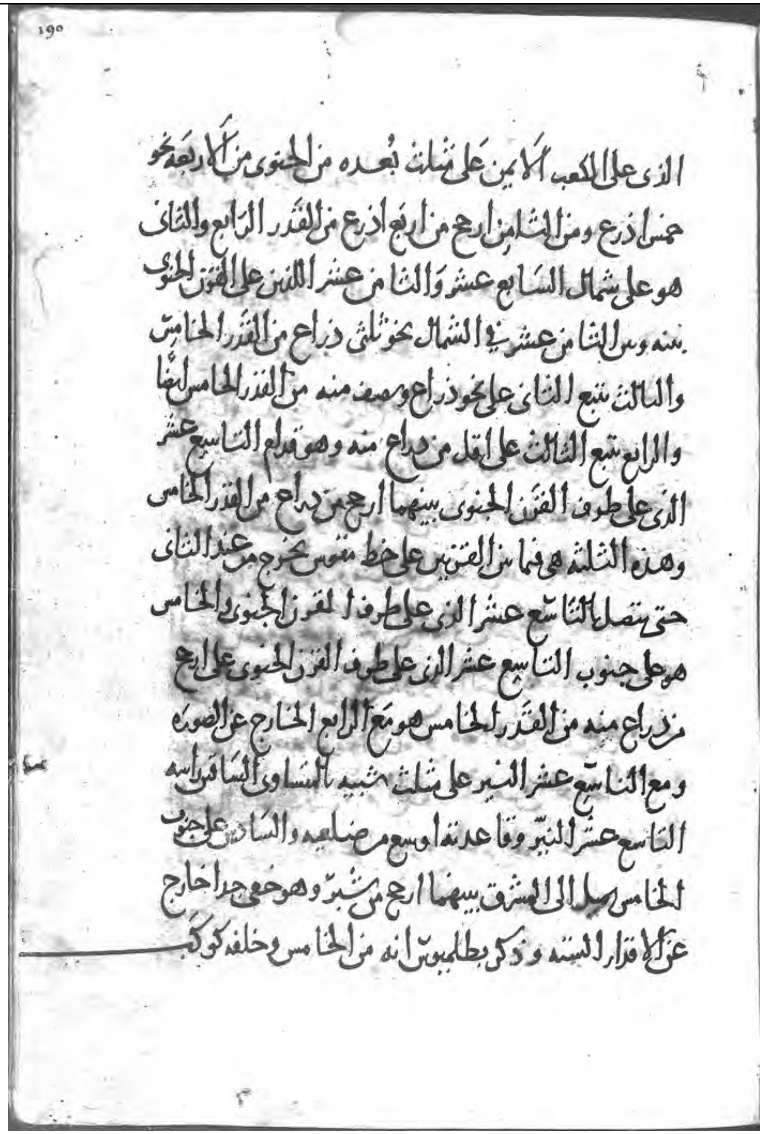
Folio 189

The twenty-seventh is the southernmost star of the other side of the four sided (quadrilateral), and is north of the two close stars which are located on the northern ear.
The twenty-eighth is the northernmost of the two. Together with the two close stars and with the fifteenth which is on the northern eye it forms a straight line. These four (stars) form a quadrilateral which resembles a *Mu'en* (rhombus) and they are all of the 5th magnitude. The distance between the front side and the other side is around two *dhirā'*.
The twenty-ninth is the northern (star) of the sides of *al-Thurayyā* (the Pleiades) and the thirtieth is the southern of these sides. The thirty-first is on the other side and is located in the narrowest position in it. The thirty-second is the (star) outside (of the main image of *al-Thurayyā*) towards the north.
Al-Thurayyā has one star of the 4th magnitude which is the thirty-second and the rest are of the 5th magnitude.
The stars of *al-Thurayyā* are more (in number) than these four which we mentioned; (however) I will only mention these four because they are very close together. These four were the brightest in magnitude therefore (Ptolemy) (only) mentioned them and left the others.
As for the eleven (stars) which are outside the constellation, the first of these is the (star) located south of the eighth (star) and (south) of the four (stars) on the cut-off position.


والعشرون هو الجنوبي من الضلع التالية من ذي الاربع الاضلاع
على شمال الاثنين المتقاربين اللذين على الاذن الشمالية والثامن
والعشرون هو الشمالي منهما وهما مع الاثنين المتقاربين ومع
الخامس عشر الذي على العين الشمالية على استقامة وهذه الاربعة
على مربع مستطيل شبيه بالمعين كلها من القدر الخامس وبين
الضلع المتقدمة وبين الضلع التالية من البعد نحو ذراعين والتاسع
والعشرون هو الشمالي من الضلع المتقدمة من نفس الثريا والثلاثون
هو الجنوبي من هذه الضلع والحادي والثلاثون هو الطرف التالي
منهما وهو في اضيق موضع فيها والثاني والثلاثون هو الخارج
ناحية الشمال منها وفيها من القدر الرابع واحد وهو الثاني والثلاثون
والباقي من الخامس وكواكب الثريا تزيد على هذه الاربعة التي
ذكرناها واقتصر على هذه الاربعة لانها متقاربة جدا والاربعة
كانت اعظمها في القدر فذكرها وترك ما سواها ∴ واما الاحد عشر
الخارجة عن الصورة فان الاول منها هو على جنوب الثامن والاربعة
التي على موضع القطع بالبعد منها هو مع الجنوبي من الاربعة ومع الثامن

Folio 190

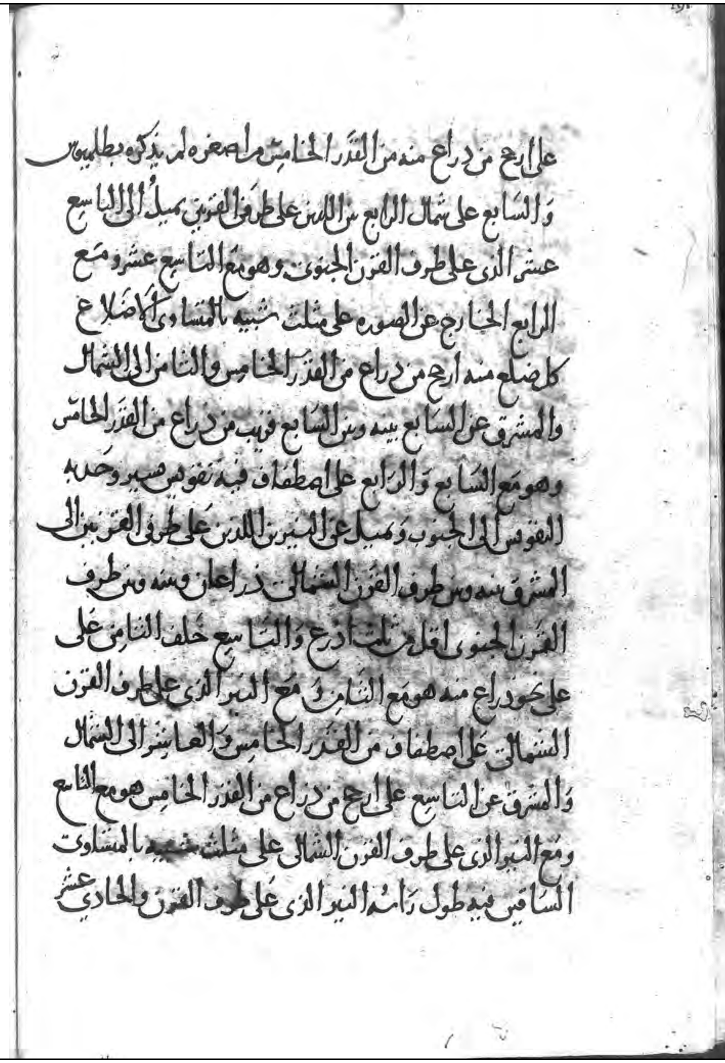
It forms a triangle together with the southern (star) of the four and with the eighth (star) on the right hock.
The distance between it (the first star) and the southern (star) of the four is around five *dhirā’*, and between it and the eighth is a little more than four *dhirā’*. It is of the 4th magnitude.
The second (star) is located north of the seventeenth and the eighteenth which are on the southern horn.
The distance between it and the eighteenth (star) towards the north is close to two third of *dhirā’*, and it is of the 5th magnitude.
The third is close to the second by around one and a half *dhirā’*, and is also of the 5th magnitude.
The fourth is close to the third by less than one *dhirā’*, and it is in-front of the nineteenth (star) which is on the southern horn. The distance between them is a little more than one *dhirā’*. It is of the 5th magnitude.
These three (stars) are located between the two horns and form a curved line which starts from the second (star) and reaches the nineteenth (star) which is on the southern horn.
The fifth (star) is south of the nineteenth (star) which is on the southern horn. It is more than one *dhirā’ away* from it and is of the 5th magnitude. It forms together with the fourth (star) that is outside the constellation and the bright nineteenth (star) a *Muthallath* (triangle) similar to a *Mutasawi al-Saqain* (Isosceles triangle) whereby its head is the bright nineteenth (star) and its base is wider than its sides.
The sixth (star) is south of the fifth, towards the east. The distance between them is slightly more than one *Shibr* (1 *Shibr* = 1/3 dhirā’). It is very dim; outside of the sixth magnitude, (however) Ptolemy mentioned that it is of the 5th magnitude.


190

الذي على الكعب الايمن على مثلث بعده من الجنوبي من الاربعة نحو
خمس اذرع ومن الثامن اربع من ربع اذرع من القدر الرابع والثاني
هو على شمال السابع عشر والثامن عشر اللذين على القرن الجنوبي
بينه وبين الثامن عشر في الشمال نحو ثلثي ذراع من القدر الخامس
والثالث يتبع الثاني على نحو ذراع ونصف منه من القدر الخامس ايضا
والرابع يتبع الثالث على اقل من ذراع منه وهو قدام التاسع عشر
الذي على طرف القرن الجنوبي بينهما ارجح من ذراع من القدر الخامس
وهذه الثلثة هي فيما بين القرنين على خط مقوس يخرج من عند الثاني
حتى يتصل بالتاسع عشر الذي على طرف القرن الجنوبي والخامس
هو على جنوب التاسع عشر الذي على طرف القرن الجنوبي على ارجح
من ذراع منه من القدر الخامس وهو مع الرابع الخارج عن الصورة
ومع التاسع عشر النير على مثلث شبيه بالمتساوي الساقين راسه
التاسع عشر النير وقاعدته اوسع من ضلعيه والسادس على جنوب
الخامس مايل الى المشرق بينهما ارجح من شبر وهو خفي جدا خارج
عن الاقدار الستة وذكر بطلميوس انه من الخامس وخلفه كوكب

Folio 191

Behind it is a star that is slightly more than one *dhirā'* away which is less than 5th magnitude (and) which was not mentioned by Ptolemy.
The seventh (star) is north of the fourth between the two sides of the horns towards the nineteenth (star) which is on the southern horn. It forms an equilateral triangle together with the nineteenth and the fourth (star) that is outside the constellation where every side is slightly more than one *dhirā' in* length. It is of the 5th magnitude.
The eighth (star) is north east of the seventh. The distance between it and the seventh is close to (one) *dhirā'*. It is of the 5th magnitude. (The eighth) together with the seventh and the fourth form a line with a slight curve with its curve facing towards the south.
It is located towards the east between the two bright stars on the horn. The distance between it and the tip of the northern horn is two *dhirā'* and between it and the southern horn less than a third of a *dhirā'*.
The ninth (star) is behind the eight (star) close to one *dhirā' in* distance away from it. It forms a straight line together with the eight (star) and the bright (star) on northern horn. It is of the 5th magnitude.
The tenth (star) is north east of the ninth more than one *dhirā'* away and is of the 5th magnitude.
It forms together with the ninth (star) and the bright (star) on the northern horn a *Muthallath* (triangle) similar to a *Mutasawi al-Saqain* (Isosceles triangle), whereby its head is the bright (star) on the tip of the horn.



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The eleventh (star) is close to the ninth and the tenth. The distance between it and the ninth is more than one *dhirā'* and between it and the tenth less one *dhirā'*. It is of the 5^{th} magnitude. The latitudes and longitudes of these five (stars) from the seventh up to the eleventh is wrong. For if they are to be drawn on a globe they will be different from how they would appear in the sky.

South of the four stars on the cut off position and the eight star of the constellation are two aligned stars of the 6^{th} magnitude which have not been mentioned by Ptolemy. South of the eighth star and on the same line there is a star of the 6^{th} magnitude which has not been mentioned also.

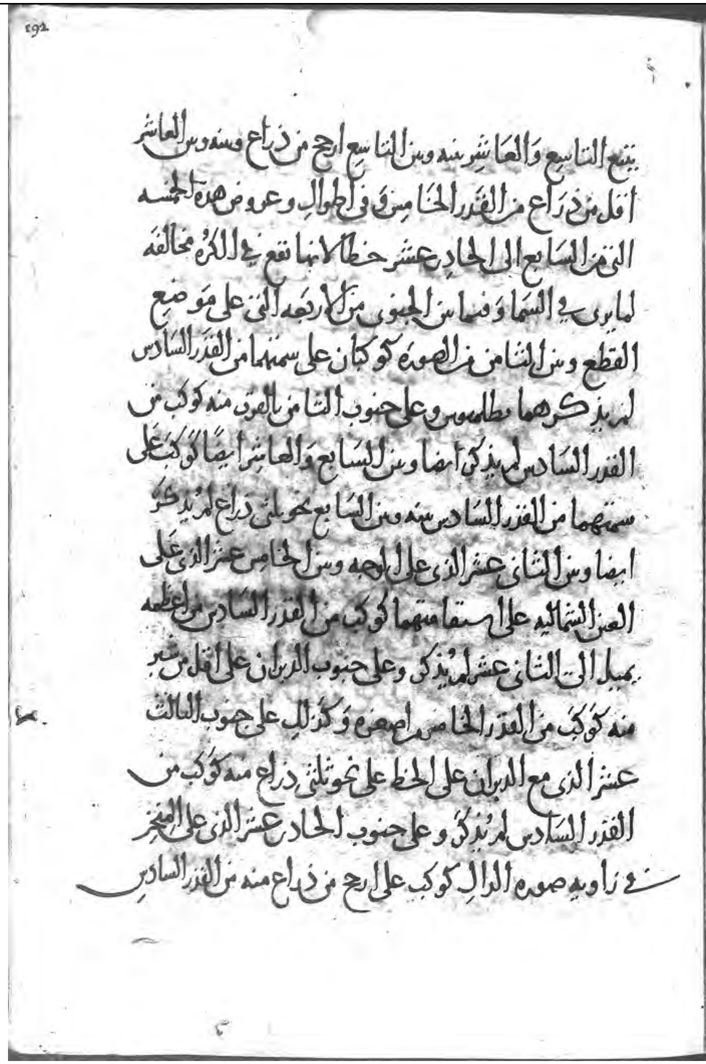
Between the seventh and the tenth (stars) there is also a star on the same line which is of the 6^{th} magnitude. It is two thirds of a *dhirā'* away from the seventh star and was also not mentioned (by Ptolemy).

Between the twelfth, which is on the face, and the fifteenth which is on the northern eye, is a star on the same line. It is much greater than a 6^{th} magnitude but closer to the twelfth star and was (also) not mentioned.

South of Aldebaran and a little less than one *Shibr* away from it, is a star that is less than a 5^{th} magnitude.

Also south of the thirteenth star which forms a line with Aldebaran and is two-thirds of a *dhirā'* away from it, is a star of the 6^{th} magnitude that was not mentioned.

South of the eleventh star which is on the nose and on the corner of the (stars) that resemble *al-Dāl* (the Greek letter Δ), is a star that is more than one *dhirā'* away. It is of the 6^{th} magnitude and was not mentioned (by Ptolemy).



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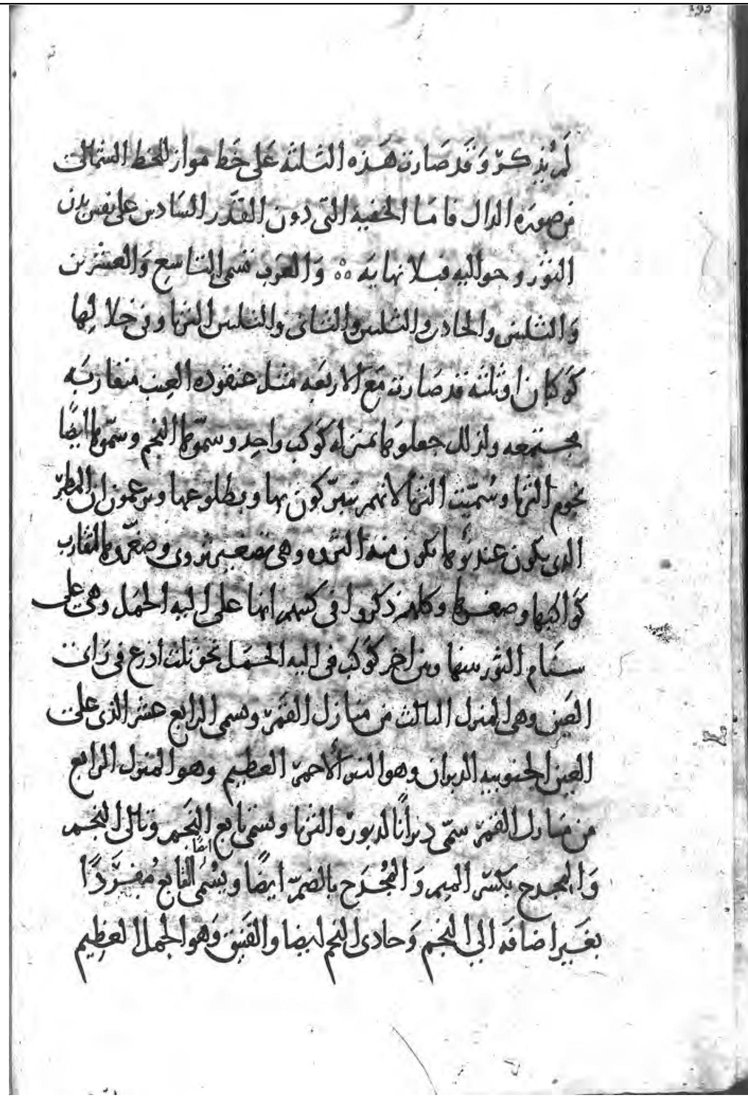
All these three stars form a parallel line to the northern line of (stars) that resemble *al-Dāl* (the Greek letter Δ).
As for the dim stars on the body and around Taurus which are fainter than the 6th magnitude, they are endless.
The Arabs called the twenty-ninth, the thirtieth, the thirty-first and the thirty-second, *al-Thurayyā* (the Pleiades). Inside (the Pleiades) are two stars or three together with the other four looking like a bunch of grapes that are close together. Therefore they considered them as one star and named it *al-Najm* (The Star) par excellence. They also named it *Nujūm al-Thurayyā* (the stars of the Pleiades). It was called *al-Thurayyā* because they were blessed by it and by its rising, and they claimed that the rain which falls when it *Naw'* (sets) brings fortune. (*al-Thurayyā)* means a small fortune (the diminutive noun for fortune). They (the Arabs) diminutised it because its stars are close and small. They mentioned in their books that it is located on the *Aliyet* (the buttocks or the fat tail of a sheep) of (the constellation) Aries, (however) it is located on the *Sinām* (hump) of Taurus.
The distance between it and the last star on the buttocks of Aries is three *dhirā'* as is seen by the eye. It is the third of *Manāzil al-Qamar* (the lunar mansions).
The fourteenth star which is on the southern eye is called *Al-Dabarān*. It is a great bright red star. It is the fourth of the lunar mansions. It was called *Al-Dabarān* because it follows *al-Thurayyā*. It is (also) called *Tab' al-Najm* (the follower star) and *Tālī al-Najm* (the rear star) and *al-Mijdaḥ* where the letter M is accented, as well as *al-Mujdaḥ*. It is just called *al-Tab'* (follower) by itself without adding the word *al-Najm* (star). It is also called *Ḥadī al-Najm* (star follower – follower of the Pleiades) and *al-Fanīq*, which means the great Camel.


لم يذكره وقد صارت هذه الثلثة على خط موازٍ للخط الشمالي
من صورة الدال فاما الخفية التي دون القدر السادس على نفس بدن
الثور وحواليه فلا نهاية ٥٥ والعرب تسمي التاسع والعشرين
والثلثين والحادي والثلثين والثاني والثلثين الثريا ومن خلالها
كوكبان او ثلثة قد صارت مع الاربعة مثل عنقود العنب متقاربة
مجتمعة ولذلك جعلوها بمنزلة كوكب واحد وسموها النجم وسموها ايضا
نجوم الثريا وسميت الثريا لانهم يتبركون بها وبطلوعها ويزعمون ان المطر
الذي يكون عند نوءها يكون منه الثروة وهي تصغير ثروى وصغروها لتقارب
كواكبها وصغرها وكلهم ذكروا في كتبهم انها على الية الحمل وهي على
سنام الثور بينها وبين اخر كوكب في الية الحمل نحو ثلث اذرع في رأي
العين وهي المنزل الثالث من منازل القمر ويسمى الرابع عشر الذي على
العين الجنوبية الدبران وهو النير الاحمر العظيم وهو المنزل الرابع
من منازل القمر سمي دبرانا لدبوره الثريا ويسمى تابع النجم وتالي النجم
والمجدح بكسر الميم والمجدح بالضم ايضا ويسمى التابع مفردا
بغير اضافة الى النجم وحادي النجم ايضا والفنيق وهو الجمل العظيم

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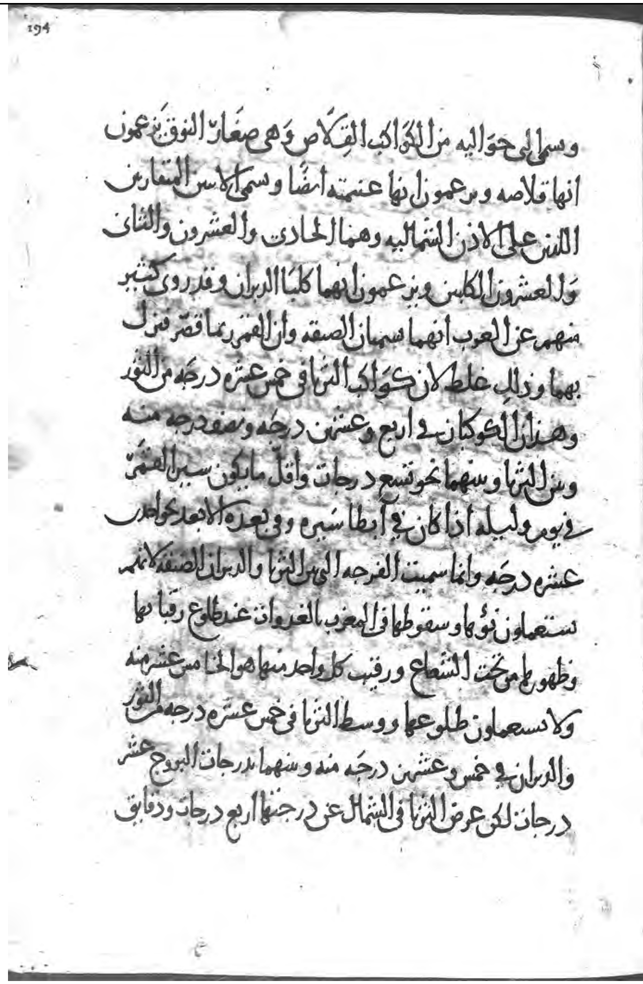
The stars around (*Aldebaran)* are called *al-Qilāṣ* which are the small Camels. (The Arabs) claim that (these stars) are named *Qilāṣa* and also (named) *Ghunaīma*.
The two close stars on the northern ear, which are the twenty-first and the twenty-second are called *al-Kalbain* (the two dogs). (The Arabs) claim they are the dogs of Aldebaran.
Many (scholars) narrate from the Arabs that (these two stars) are called *al-Ḍayīqa* (the small gap) and that the Moon perhaps slowed down and stopped there. This is wrong because the stars of al-*Thurayyā* are fifteen degrees in (the sign of) Taurus and these two stars are twenty-four and a half degrees in it. The distance between them and al-*Thurayyā* is nine degrees and the least amount the Moon travels in one day and one night when it is (moving) slowest and at its greatest distance (from the Earth), is eleven degrees.
The gap between the *al-Thurayyā* and *Aldebaran* was called *al-Ḍayīqa* because they (the Arabs) use its *Naw'* (setting) and its setting in the west at dawn when its *Raqīb* (companion star) rises from under the light (of the Sun). The *Raqīb* (companion star) of each one is the fifteenth star (of the lunar mansions). They (the Arabs) do not use its rising.
The middle of *al-Thurayyā* is on the fifteenth degrees of Taurus and Aldebaran is at twenty five degree in it. The distance on the degrees of the zodiac between them is ten degrees. However the latitude of *al-Thurayyā* in the north from its (zodiac) degree is four degrees and a few minutes.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وسمي ما حواليه من الكواكب القلاص وهي صغار النوق يزعمون
انها قلاصه ويزعمون انها غنيمته ايضا وسمي الاثنين المتقاربين
اللذين على الاذن الشمالية وهما الحادي والعشرون والثاني
والعشرون الكلبين ويزعمون انهما كلبا الدبران وقد روى كثير
منهم عن العرب انهما سميا الضيقة وان القمر ربما اقصر فنزل
بهما وذلك غلط لان كواكب الثريا في خمس عشرة درجة من الثور
وهذان الكوكبان في اربع وعشرين درجة ونصف درجة منه
وبين الثريا وبينهما نحو تسع درجات واقل ما يكون سير القمر
في يوم وليلة اذا كان في ابطا سيره وفي بعده الابعد نحو احدى
عشرة درجة وانما سميت الفرجة التي بين الثريا والدبران الضيقة لانهم
يستعملون نوءها وسقوطها في المغرب بالغدوات عند طلوع رقيبها
وظهوره من تحت الشعاع ورقيب كل واحد منها هو الخامس عشر منه
ولا يستعملون طلوعها ووسط الثريا في خمس عشرة درجة من الثور
والدبران في خمس وعشرين درجة منه وبينهما بدرجات البروج عشر
درجات لكن عرض الثريا في الشمال عن درجتها اربع درجات ودقائق

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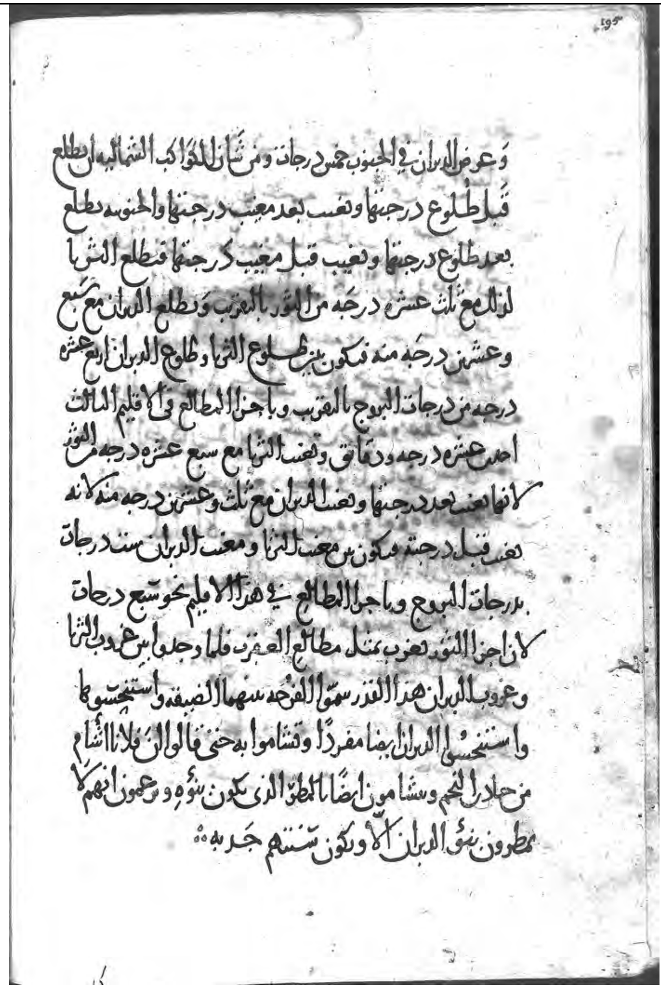
And the latitude of Aldebaran in the south is five degrees. And it is in the nature of the northern stars to rise before their (zodiac) degree rises and to set after their (zodiac) degree sets, and the southern (stars) rise after their (zodiac) degree rises and to set before their (zodiac) degrees sets.
Therefore *al-Thurayyā* rises approximately at thirteen degrees of Taurus and Aldebaran rises at twenty seven of it. Thereby the degrees between the rise of *al-Thurayyā* and Aldebaran are approximately fourteen degrees of the degrees of the zodiac and eleven degrees and a few minutes from the horizon in the third *Iqlīm* zone (one of the seven climatic zones which the Earth is divided into).
And *al-Thurayyā* sets at seventeen degrees of Taurus because it sets after its zodiac degree. And Aldebaran sets at twenty three degrees of it because it sets before its zodiac degrees. Thereby the degrees between the setting of *al-Thurayyā* and Aldebaran are six degrees of the degrees of the zodiac and seven degrees from the horizon in this zone. The degrees of Taurus sets at the same time as the degrees of Scorpio rise. When they found this difference between the setting of *al-Thurayyā* and Aldebaran they called this gap between them *al-Ḍayīqa* (the small gap). They considered it (*al-Ḍayīqa)* to be unlucky, as well as Aldebaran by itself, and they (believed) it to be a bad omen. They say that someone is more unlucky than (the star) *Ḥadī al-Najm*. They are also ill-omened from the rain that falls when it *Naw'* (sets) and they claim that whenever rain falls when Aldebaran *Naw'* (sets) then that year will be dry.



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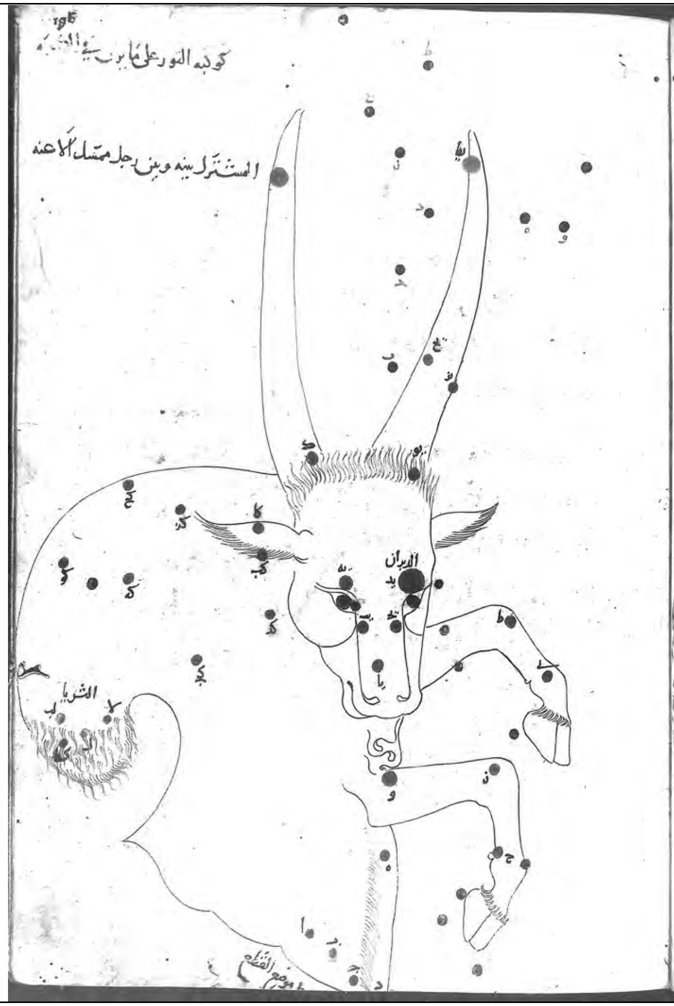
The constellation Taurus as seen on the globe.



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The constellation Taurus as seen in the sky.

The stars drawn in red and labeled in black, in both images, are part of the constellation. The stars drawn in black and labeled in red are outside the constellation. The stars drawn in black and not labeled are those not mentioned by Ptolemy.

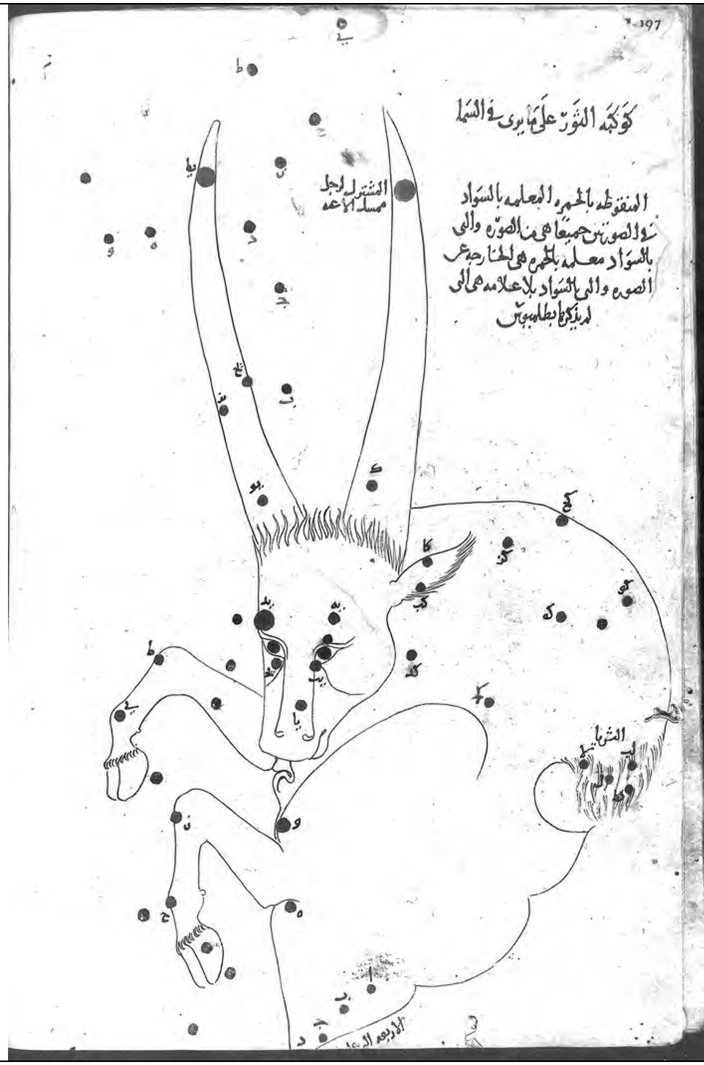

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Table of the constellation Taurus with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Asterism and stars	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The northernmost of the 4 stars in the cut-off position.	1(30)	09	02	S	06	00	4
2	The one after.	1(30)	08	42	S	07	15	4
3	The one after this also.	1(30)	07	22	S	08	30	4(m)
4	The southernmost of the 4.	1(30)	07	02	S	09	15	4(m)
5	The one on the rear of these, on the right shoulder blade.	1(30)	12	22	S	09	30	6
6	The star in the chest.	1(30)	16	22	S	03	00	3
7	The star in the right knee.	1(30)	59	22	S	12	40	4
8	The star on the right hock.	1(30)	15	42	S	14	50	4(m)
9	The star on the left knee.	1(30)	24	52	S	10	00	4
10	The star on the left lower leg.	1(30)	15	42	S	13	00	4
11	The star on the nostrils in the face looks like the letter (Δ) al-*Dāl* from the books of the Greeks.	1(30)	21	42	S	05	45	3(s)
12	The one between this and the northern eye.	1(30)	23	02	S	04	15	3(s)
13	The one between it and the southern eye.	1(30)	23	32	S	05	50	3(s)
14	The bright star the reddish one of the letter (Δ) al-*Dāl* on the southern eye and it is al-Dabarān	1(30)	25	22	S	05	10	1
15	The remaining one on the northern eye	1(30)	24	32	S	03	00	3(s)
16	The star on the place where the southern horn and the ear join the head	1(30)	29	52	S	04	00	5
17	The southernmost of the 2 stars in the southern horn	2(60)	03	02	S	05	00	5
18	The northernmost of these	2(60)	02	42	S	03	30	5
19	The star on the tip of the southern horn	2(60)	10	22	S	04	30	3
20	The star on the northern horn triangle. "The star on the tip of the northern horn is the same star as the one on right leg of the constellation Auriga"	1(30)	28	22	S	04	00	4
21	The northernmost of the 2 stars close together in the northern ear	1(30)	24	42	N	00	30	4
22	The southern of them. The latitude as seen in the sky should be 00 00.	1(30)	24	22	N	04	00	4
23	The more advanced of the 2 small stars in the neck	1(30)	19	42	N	00	40	5

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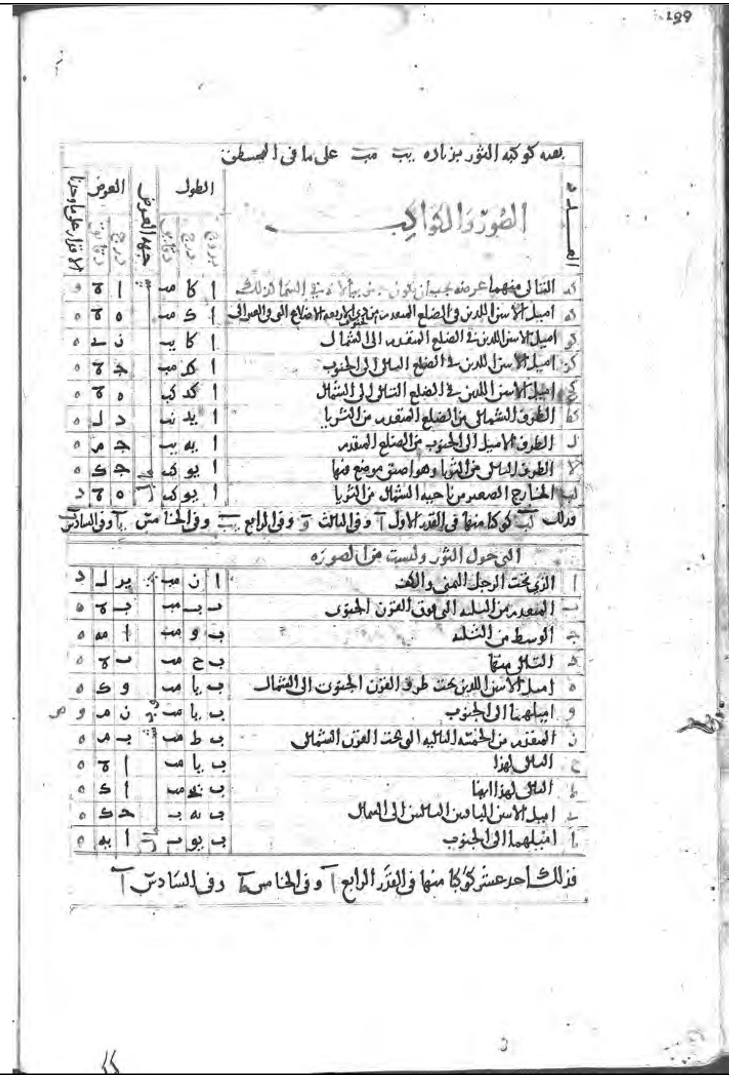
Remaining of the constellation Taurus with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
number	Asterism and stars	longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
24	The rearmost of them. Its latitude should be southerly because in the sky it is so.	1(30)	21	42	N	01	00	6
25	The quadrilateral in the neck, the southernmost star on the advanced side	1(30)	20	42	N	05	00	5
26	The northernmost star on the advanced side	1(30)	21	12	N	50	10	5
27	The southernmost star on the rear side	1(30)	24	42	N	03	00	5
28	The northernmost one on the rear side	1(30)	24	24	N	05	00	5
29	The Pleiades the northern end of the advanced side	1(30)	14	52	N	04	30	5
30	the southern end of the advanced side	1(30)	15	12	N	03	40	5
31	The rearmost and narrowest end of the Pleiades	1(30)	16	22	N	03	20	5
32	The small star outside the Pleiades towards the north	1(30)	16	22	N	05	00	4
32 stars, 1 of the 1st magnitude, 6 of the 3rd, 12 of the 4th, 11of the 5th, 2 of the 6th								
The stars around the constellation and not part of the constellation								
1	The star under the right foot and the shoulder blade	1(30)	50	42	S	14	30	4
2	The most advanced of the 3 stars over the southern horn	2(60)	02	42	S	02	00	5
3	The middle one of the three	2(60)	06	42	S	01	45	5
4	The rearmost of them	2(60)	08	42	S	02	00	5
5	The northernmost of the 2 stars under the southern tip of the southern horn	2(60)	11	42	S	06	20	5
6	The southernmost of them	2(60)	11	42	S	50	40	6(s)
7	The most advanced of the 5 stars under the northern horn.	2(60)	09	42	N	02	40	5
8	The one to the rear of this	2(60)	11	42	N	01	00	5
9	The one to the rear again of the latter	2(60)	13	42	N	01	20	5
10	The northernmost of the remaining rearmost 2	2(60)	15	02	N	03	20	5
11	The southernmost of these two	2(60)	16	02	N	01	15	5
11 stars, 1 of the 4th magnitude, 10 of the 5th, 1 of the 6th magnitude								



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Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
Table for the Constellation Gemini (*al-Tawāmān*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
1	The star on the head of the forward twin	3(90)	6	2	N	9	40	2
2	The reddish star on the head of the rear twin	3(90)	9	22	N	6	15	2
3	The star in the left forearm of the forward twin	2(60)	29	22	N	10	0	4(m)
4	The star in the same [left] upper arm	3(90)	1	22	N	50	20	4
5	The one to the rear of that, just over the place between the shoulders	3(90)	4	42	N	5	30	4
6	The one to the rear of this, on the right shoulder of the same [forward] twin	3(90)	6	42	N	4	50	4
7	The star on the rear shoulder of the rear twin	3(90)	9	22	N	2	40	4(k)
8	The star on the right side of the forward twin	3(90)	4	22	N	2	40	5(s)
9	The star on the left side of the rear twin	3(90)	5	52	N	3	0	5
10	The star on the left knee of the forward twin	2(60)	25	42	N	1	30	3(s)
11	The star under the left knee of the rear twin	3(90)	4	22	S	0	30	3
12	The star in the left groin of the rear twin	3(90)	0	57	S	2	30	4(m)
13	The star over the bend in the right knee of the same [rear] twin	3(90)	4	2	S	6	0	3(s)
14	The star on the forward foot of the forward twin	2(60)	19	12	S	1	30	4(k)
15	The one to the rear of this on the same foot	2(60)	20	52	S	1	15	4(k)
16	The star on the right foot of the forward twin	2(60)	22	52	S	3	30	3(s)
17	The star on the left foot of the rear twin	2(60)	24	42	S	50	30	3
18	The star on the right foot of the rear twin	2(60)	27	22	S	10	30	4
18 stars, 2 is of the 2nd magnitude, 5 of the 3rd magnitude, 9 of the 4th magnitude, 2 of the 5th magnitude								

The ones surrounding the constellation Gemini but not in it.								
1	The star in advance of the forward foot of the forward twin	2(60)	16	52	S	0	40	4(s)
2	The bright star in advance of the forward knee	2(60)	19	12	N	5	50	4(s)
3	The star in advance of the left knee of the rear twin	2(60)	17	52	S	2	15	5(s)
4	The northernmost of the three stars in a straight line to the rear of the right arm of the rear twin	3(90)	11	2	S	1	20	5(s)
5	The middle one of the three	3(90)	9	2	S	3	20	5(s)
6	The southernmost of them, near the forearm of the [right] arm	3(90)	8	42	S	4	30	5(s)
7	The bright star to the rear of the above-mentioned 3	3(90)	13	22	S	2	40	4(s)
7 stars, 3 of the 4th magnitude, 4 of the 5th magnitude.								

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Table for the constellation Cancer (*al-Saraṭān*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The middle of the nebulous mass in the chest, called *al-Mi'laf* (Praesepe)	3(90)	23	12	N	0	40	nebula
2	The quadrilateral containing the nebula [no. 1]: the northernmost of the two foremost stars	3(90)	20	22	N	1	15	4(s)
3	The southernmost of the two foremost stars	3(90)	20	42	S	1	10	4(s)
4	The northernmost of the rear 2 stars on the quadrilateral, which are called *al-Ḥimārain* (Aselli)	3(90)	23	2	N	2	40	4
5	The southernmost of these two	3(90)	24	2	S	0	10	4
6	The star on the southern claw	3(90)	29	12	S	5	30	4
7	The star on the northern claw	3(90)	21	2	N	11	50	4
8	The star on the northern rear leg	3(90)	14	22	N	1	0	5(s)
9	The star on the southern rear leg	3(90)	20	12	S	7	30	4
9 stars, 7 of the 4th magnitude, 1 of the 5th magnitude and 1 nebula.								

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The ones surrounding the constellation Cancer but not in it with the addition of 12 (degrees) 42 (minutes) to what is found in the Almagest								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star over the joint in the southern claw	4(120)	2	22	S	2	20	4(s)
2	The star to the rear of the tip of the southern claw	4(120)	4	22	S	5	40	4(s)
3	The more advanced of the two stars over the nebula and to the rear of it	3(90)	26	42	N	7	50	5
4	The rearmost of these [two]	3(90)	29	42	N	5	15	5
4 stars, 2 of the 4th magnitude, 2 of the 5th magnitude								

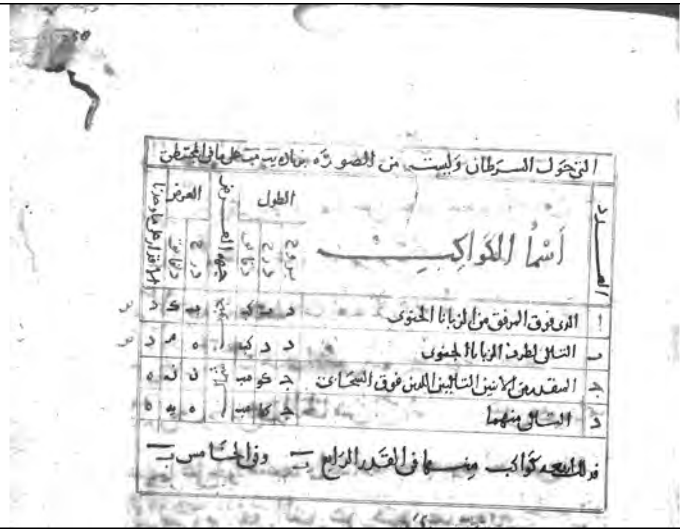

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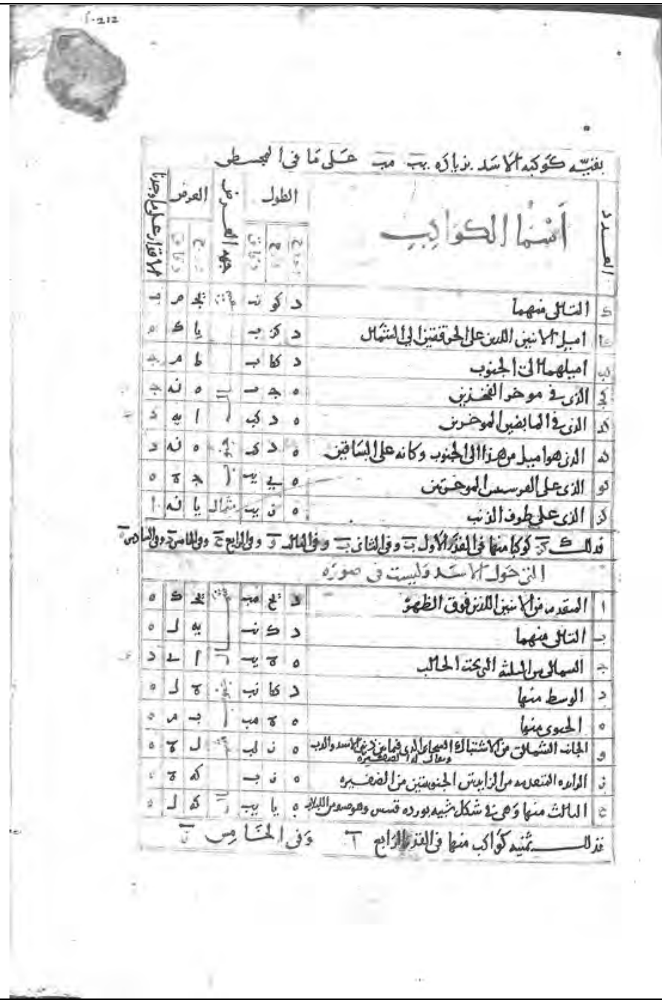
Table of the constellation Leo (*al-Asad*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star on the tip of the nostrils	4(120)	1	2	N	10	0	4
2	The star in the gaping jaws	4(120)	3	52	N	7	30	4
3	The northernmost of the two stars in the head	4(120)	7	2	N	12	0	3(s)
4	The southernmost of these	4(120)	6	52	N	9	30	3(k)
5	The northernmost of the 3 stars in the neck	4(120)	12	52	N	11	0	3
6	The one close to this, the middle one of the three	4(120)	14	52	N	8	30	2
7	The southernmost of them	4(120)	13	22	N	4	30	3
8	The star on the heart, called *al-Malikī* and *Qalb al-Asad* (Regulus)	4(120)	15	12	N	0	10	1
9	The one south of this, approximately on the chest	4(120)	16	12	S	1	50	4
10	The star a little in advance of the star on the heart [no. 8]	4(120)	12	42	S	0	15	5
11	The star on the right knee	4(120)	10	2	0	0	0	6
12	The star on the right front paw	4(120)	6	52	S	3	40	6
13	The star on the left front paw	4(120)	10	2	S	4	10	4(k)
14	The star on the left [front] knee	4(120)	15	12	S	4	15	4
15	The star on the left armpit	4(120)	21	52	S	0	10	4
16	The most advanced of the three stars in the belly	4(120)	19	42	N	4	0	6
17	The northernmost of the other, rearmost 2	4(120)	25	42	N	5	20	6
18	The southernmost of these [two]	4(120)	25	2	N	2	20	6
19	The foremost of the two stars on the rump	4(120)	24	2	N	12	15	5(m)


جدول كواكب الأسد بزيادة يب مب على ما في المجسطي
أسماء الكواكب

Folio 212

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
Remaining stars of the constellation Leo with the addition of 12 (degrees) 42 (minutes) to what is found in the Almagest								
		zodiac	deg	min		deg	min	
20	The rearmost of them	4(120)	26	52	N	13	40	2
21	The northernmost of the 2 stars in the buttocks	4(120)	27	2	N	11	20	5
22	The southernmost of them	4(120)	29	2	N	9	40	3
23	The star in the hind thighs	5(150)	3	2	N	5	50	3(s)
24	The star in the hind leg-bends	5(150)	4	22	N	1	15	4(k)
25	The one south of this, approximately in the lower legs	5(150)	4	22	S	5	50	4
26	The star on the hind paws	5(150)	10	12	S	3	0	5
27	The star on the end of the tail	5(150)	7	12	N	11	50	1
27 stars, 2 of the 1st magnitude, 2 of the 2nd magnitude, 6 of the 3rd magnitude, 8 of the 4th magnitude, 4 of the 5th magnitude, 5 of the 6th magnitude.								
The ones surrounding the constellation but not in it.								
1	The foremost of the two above the back	4(120)	18	42	N	13	20	5
2	The rearmost of them	4(120)	20	52	N	15	30	5
3	The northernmost of the 3 under the flank	5(150)	0	12	N	1	10	4(s)
4	The middle one of these	4(120)	29	52	S	0	30	5
5	The southernmost of them	5(150)	0	42	S	2	40	5
6	The northernmost part of the nebulous mass between the edges of Leo and Ursa [Major], called *al-Ḍafira* (Coma Berenices)	5(150)	7	32	N	30	0	5
7	The foremost of those on the southern edge of Coma	5(150)	7	2	N	25	0	5
8	The rearmost of them. They (three stars) are shaped like an ivy leaf	5(150)	11	12	N	25	30	5
8 stars, 1 of the 4th magnitude, 7 of the 5th magnitude.								

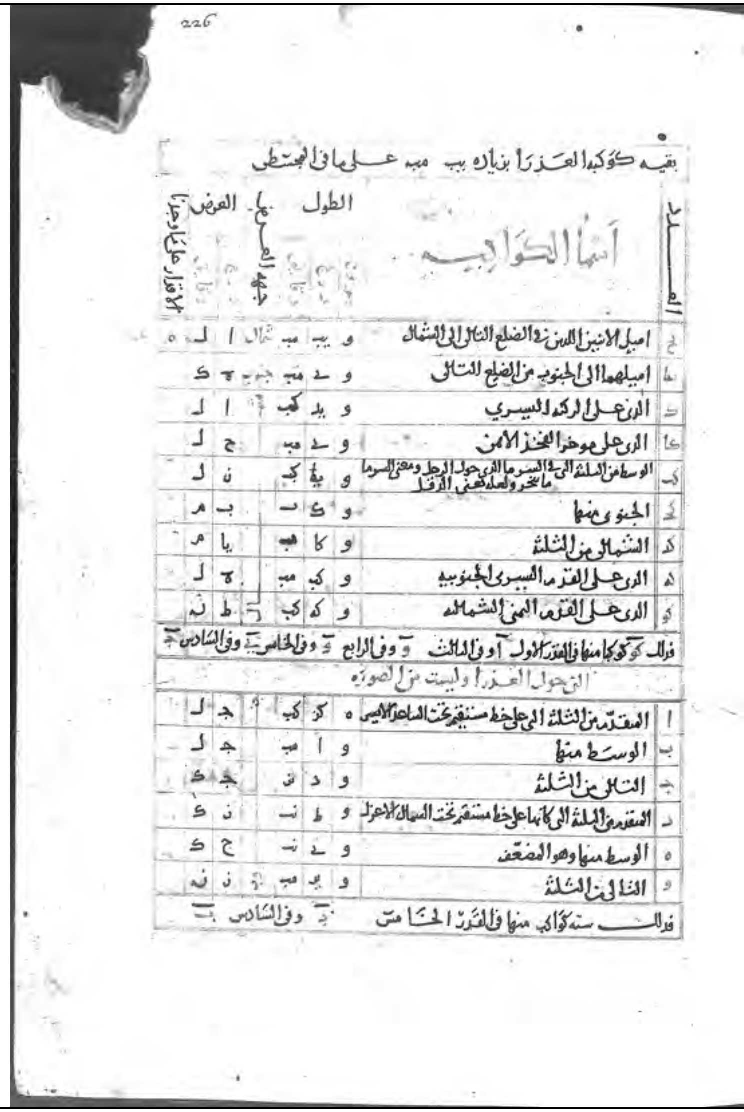


Folio 225

Table of the constellation Virgo (*al-'Adhrā'*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The southernmost of the 2 stars in the top of the skull	5(150)	9	2	N	4	15	5
2	The northernmost of them	5(150)	9	42	N	5	40	5
3	The northernmost of the 2 stars to the rear of these, in the face	5(150)	13	22	N	8	0	5
4	The southernmost of them	5(150)	12	52	N	5	30	5
5	The star on the tip of the southern left wing	5(150)	11	42	N	0	10	3
6	The foremost of the 4 stars in the left wing	5(150)	20	57	N	1	10	3
7	The one to the rear of this	5(150)	25	52	N	2	50	3
8	the one farther to the rear of this	5(150)	29	52	N	2	50	6
9	The last and rearmost of the 4	6(180)	3	42	N	1	40	4
10	The star in the right side under the girdle	5(150)	27	2	N	8	30	3
11	the foremost of the 3 stars on the right northern wing	5(150)	20	52	N	13	50	5(s)
12	The southernmost of the other 2	5(150)	22	52	N	11	40	6
13	The northernmost of these, called *al-'Iṭāf*	5(150)	24	52	N	15	10	3
14	The star on the left hand, called *al-Sunbula* and *al-Simāk al-A'zal.*	6(180)	9	22	S	2	0	1(s)
15	The star under the apron just about over the right buttock	6(180)	7	32	N	8	40	3(s)
16	The quadrilateral in the left thigh: the northern star on the foremost side	6(180)	9	2	N	3	20	5(s)
17	The southern star on the foremost side	6(180)	9	42	N	0	10	6

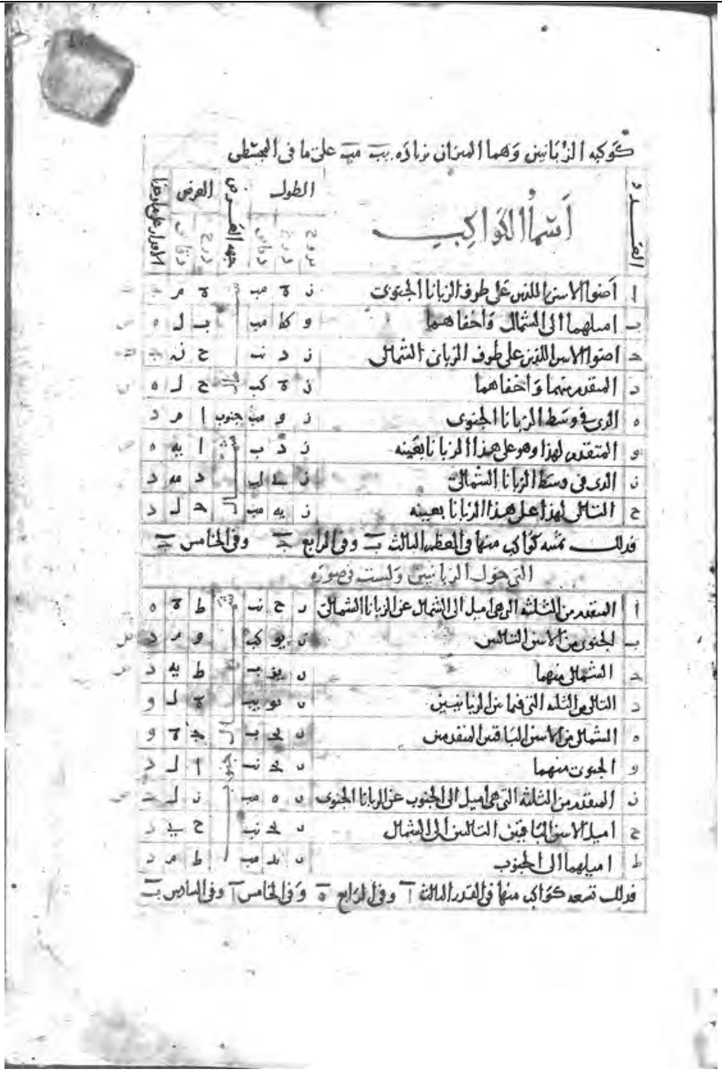
Folio 226

Remaining stars of the constellation Virgo with the addition of 12 (degrees) 42 (minutes) to what is found in the Almagest								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
18	The northernmost of the 2 stars on the rear side	6(180)	12	42	N	1	30	5(s)
19	The southernmost star on the rear side	6(180)	10	42	S	0	20	5(s)
20	The star on the left knee	6(180)	14	22	N	1	30	5(s)
21	The star in the back of the right thigh	6(180)	10	42	N	8	30	5
22	The middle star of the 3 in the garment-hem round the feet	6(180)	19	22	N	7	30	4
23	The southernmost of them	6(180)	20	2	N	2	40	4
24	The northernmost of the three	6(180)	21	2	N	11	40	4(s)
25	The star on the left, southern foot	6(180)	22	42	N	0	30	4
26	The star on the right, northern foot	6(180)	25	22	N	9	50	4(m)
26 stars, 1 of the 1st magnitude, 6 of the 3rd magnitude, 6 of the 4th magnitude, 10 of the 5th magnitude, 3 of the 6th magnitude.								
The ones surrounding the constellation but not in it.								
1	The foremost of the three in a straight line under the left forearm	5(150)	27	22	S	3	30	5
2	The middle one of these	6(180)	1	42	S	3	30	5
3	The rearmost of the 3	6(180)	4	57	S	3	20	5
4	The foremost of the 3 stars almost on a straight line under *al-Simāk al-A'zal*	6(180)	9	52	S	7	20	6
5	The middle one of these, which is a double star	6(180)	10	52	S	8	20	5
6	The rearmost of the three	6(180)	17	52	S	7	50	6
6 stars, 4 of the 5th magnitude, 2 of the 6th magnitude.								



Folio 236

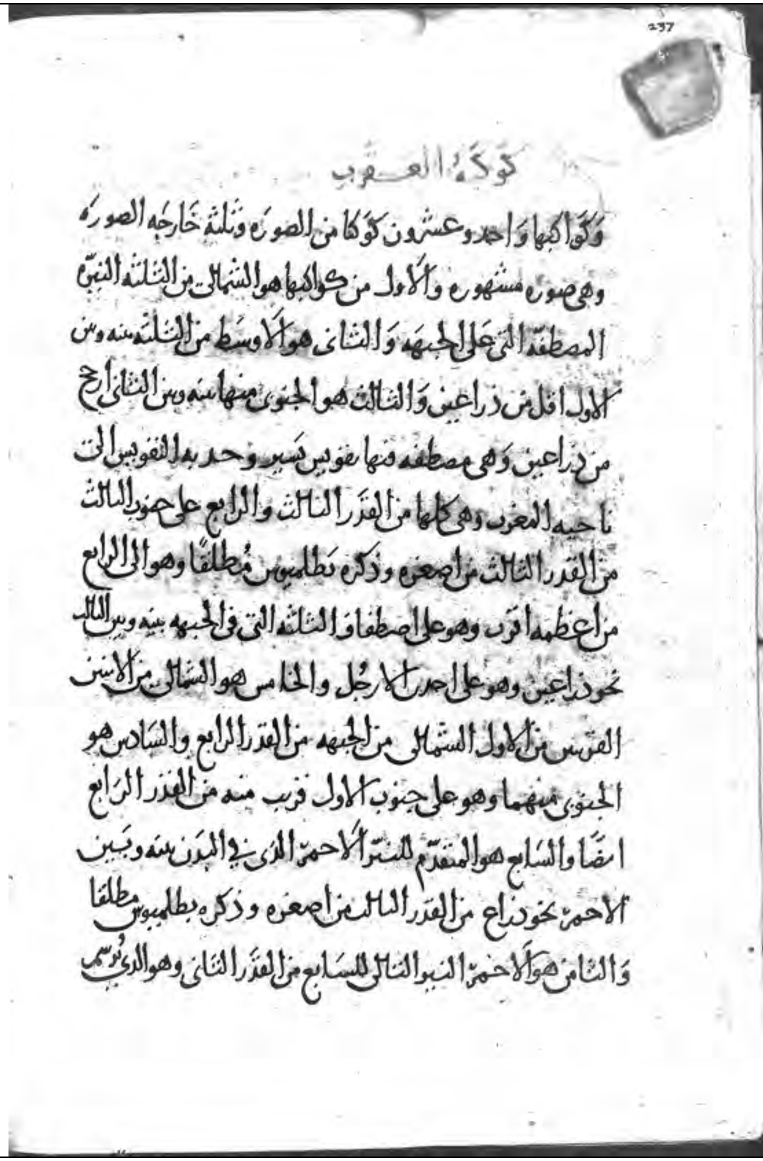
Constellation Libra (*al-Zubānayn* and also *al-Mīzān*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star on the tip of *al-Zubānā al-Janūbī* (the southern claw): the bright one	7(210)	0	42	N	0	40	3(k)
2	The star to the north of this and fainter than it	6(180)	29	42	N	2	30	5(s)
3	The star on the tip of *al-Zubānā al-Shamālī* (the northern claw): the bright one	7(210)	4	52	N	8	50	3(m)
4	The faint star in advance of this	7(210)	0	22	N	8	30	5(s)
5	The star in the middle of the southern claw	7(210)	6	42	S	1	40	4
6	The one in advance of this on the same claw	7(210)	4	2	N	1	15	5(s)
7	The star in the middle of the northern claw	7(210)	10	32	N	4	45	4
8	The one to the rear of this on the same claw	7(210)	15	42	N	3	30	4
8 stars, 2 are of the 3rd magnitude, 3 of the 4th magnitude, 3 of the 5th magnitude.								
The ones surrounding the constellation Libra but not in it.								
1	The most advanced of the 3 stars north of the northern claw	7(210)	8	52	N	9	0	5
2	The southernmost of the rearmost 2 [of these]	7(210)	16	22	N	6	40	4(s)
3	The northernmost of them	7(210)	17	2	N	9	15	4(s)
4	The rearmost of the 3 stars between the claws	7(210)	16	12	N	0	30	6
5	The northernmost of the other 2 in advance [of the latter]	7(210)	13	2	N	3	0	6
6	The southernmost of them	7(210)	13	52	S	1	30	4
7	The most advanced of the 3 stars south of the southern claw	7(210)	5	42	S	7	30	3(s)
8	The northernmost of the other 2 towards the rear	7(210)	13	52	S	8	10	4
9	The southernmost of them	7(210)	14	42	S	9	40	4
9 stars, 1 is of the 3rd magnitude, 5 of the 4th magnitude, 1 of the 5th magnitude, 2 of the 6th magnitude.								



Folio 237 (Manuscript Marsh144)

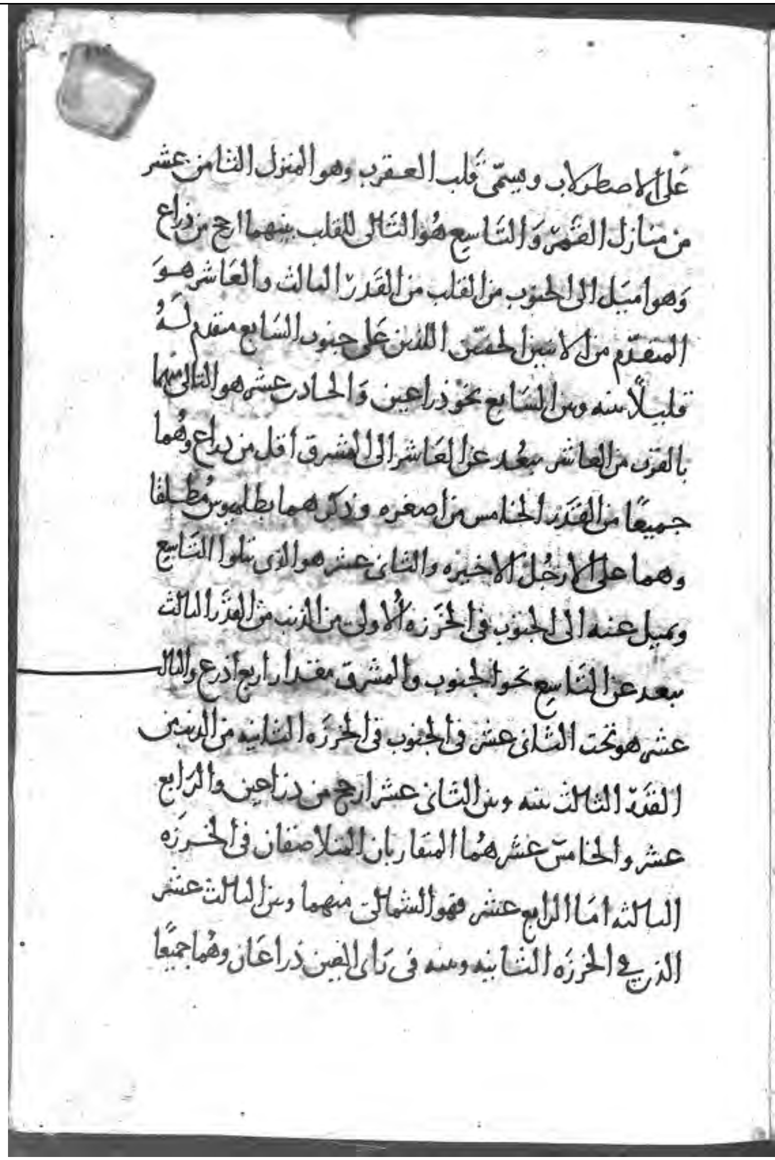
The constellation Scorpio (*al-'Aqrab)*

Its stars are twenty-one stars in the constellation and three outside the constellation. It is a well known constellation.
The first of its stars is the northern of the three aligned bright (stars) on the forehead. The second is the middle of the three. The distance between it and the first is less than two *dhirā'*. The third is the southern of them. The distance between it and the second is a little more than two *dhirā'*. They all form a slightly curved line with its curve pointed towards the west. They are all of the 3rd magnitude.
The fourth is south of the third. It is less than 3rd magnitude. Ptolemy mentioned that it is exactly 3rd magnitude. However its magnitude can be considered as much greater than 4th magnitude. It is aligned with the three (stars) on the forehead. The distance between it and the third is close to two *dhirā'*. It is located on one of the legs (of the constellation).
The fifth is the northern of the two stars which are close to the first northern (star) on the forehead. It is of the 4th magnitude.
The sixth is the southern of these (two). It is south of the first (star) and close by it. It is also of the 4th magnitude.
The seventh is closer to the bright red (star) on the body. The distance between it and the red (star) is close to one *dhirā'*. It is less than 3rd magnitude. Ptolemy mentioned that it is exactly 3rd magnitude.
The eighth is the bright red (star) that is close to the seventh. It is of the 2nd magnitude. It is (one of the stars that are) drawn on an astrolabe.



Folio 238

It is called *Qalb al-‘Aqrab* (the heart of Scorpio). It is the eighteenth of the lunar mansions.
The ninth is to the rear of *al-Qalb* (the heart). The distance between them is a little more then one *dhirā’*. It is closer to the south than *al-Qalb* (the heart). It is of the 3rd magnitude.
The tenth is the more advanced of the two dim stars which are south of the seventh (but) is a little in front of it. The distance between it and the seventh is close to two *dhirā’*.
The eleventh is the rearmost of the two close to the tenth. The distance between it and the tenth towards the south is less than one *dhirā’*.
They are all less than 5th magnitude. Ptolemy mentioned that they are exactly 5th magnitude. They are on the last leg (of the constellation).
The twelfth is to the rear of the ninth towards the south. It is located on the first *Kharaza* (joint) of the tail. It is of the 3rd magnitude. The distance between it and ninth towards the south-east is about four *dhirā’*.
The thirteenth is under the twelfth, towards the south in the second *Kharaza* (joint) of the tail. It is of the 3rd magnitude. The distance between it and the twelfth is close to two *dhirā’*.
The fourteenth and the fifteenth are two close and nearby (stars) located on the third *Kharaza* (joint). As for the fourteenth it is north of the two. The distance between it and the thirteenth (star) which is located on the second *Kharaza* (joint) is a distance of two *dhirā’*, as can be seen by the eye.
They are all of the 4th magnitude.


علي الاصطرلاب ويسمى قلب العقرب وهو المنزل الثامن عشر
من منازل القمر والتاسع هو التالي للقلب بينهما ازيد من ذراع
وهو اميل الى الجنوب من القلب من القدر الثالث والعاشر هو
المتقدم من الاثنين الخفيين اللذين على جنوب السابع متقدم له
قليلا منه وبين السابع نحو ذراعين والحادي عشر هو التالي منهما
بالقرب من العاشر بعده عن العاشر الى المشرق اقل من ذراع وهما
جميعا من القدر الخامس من اصغره وذكرهما بطليموس مطلقا
وهما على الرجل الاخيرة والثاني عشر هو الذي يتلو التاسع
ويميل عنه الى الجنوب في الخرزة الاولى من الذنب من القدر الثالث
بعده عن التاسع نحو الجنوب والمشرق مقدار اربع اذرع والثالث
عشر هو تحت الثاني عشر في الجنوب في الخرزة الثانية من الذنب
القدر الثالث بينه وبين الثاني عشر ازيد من ذراعين والرابع
عشر والخامس عشر هما المتقاربان المتلاصقان في الخرزه
الثالثة اما الرابع عشر فهو الشمالي منهما وبين الثالث عشر
الذي في الخرزه الثانية بينه وبينه في راي العين ذراعان وهما جميعا

Folio 239

The sixteenth follows the fifteenth and is located on the fourth *Kharaza* (joint) of the tail. It is less than 3rd magnitude. However its magnitude can be considered as much greater than 4th magnitude. Ptolemy mentioned that it is exactly 3rd magnitude. The distance between it and the fifteenth towards the east is a distance of one and a half *dhirā'* as can be seen by the eye.
The seventeenth follows the sixteenth but is a little further from it towards the north. It is located on the fifth *Kharaza* (joint) of the tail. It is of the 3rd magnitude. The distance between it and the sixteenth towards the east is close to two and a half *dhirā'*.
The eighteenth follows the seventeenth but is a little further from it towards the north. It is located on the sixth *Kharaza* (joint). It is less than 3rd magnitude. Ptolemy mentioned that it is exactly 3rd magnitude. The distance between it and the seventeenth towards the north east is close to two *dhirā'*.
The nineteenth is north of the eighteenth but is a little further from it towards the west. It is located on the seventh *Kharaza* (joint). The distance between it and the eighteenth which is in the sixth *Kharaza* (joint) towards the north-west is distance of one *dhirā'*. It is of the 3rd magnitude.
The twentieth is to the rear of the two bright stars which are located on *al-Ḥumma* (the sting). It is also of the 3rd magnitude. It is closer to the nineteenth (star) towards the north. The distance between it and the nineteenth is close to one and a half *dhirā'*.
The twenty-first is the more advanced of the two (stars) which are close together.


من القدر الرابع والسادس عشر يتلو الخامس عشر وفي الخرزة الرابعة
من الذنب من القدر الثالث من اصغره وهو الى الرابع من اعظمه
اقرب وذكره بطلميوس مطلقا بينه وبين الخامس عشر الى المشرق
ذراع ونصف في رأي العين والسابع عشر يتلو السادس عشر
ويميل عنه الى الشمال ميلا يسيرا وهو في الخرزة الخامسة
من الذنب من القدر الثالث بينه وبين السادس عشر الى المشرق نحو
ذراعين ونصف والثامن عشر يتلو السابع عشر ويميل الى الشمال
ميلا يسيرا في الخرزة السادسة من القدر الثالث من اصغره وذكره
بطلميوس مطلقا بينه وبين السابع عشر الى المشرق والشمال مقدار
ذراعين والتاسع عشر على شمال الثامن عشر متقدما عنه قليلا الى المغرب
في الخرزة السابعة بينه وبين الثامن عشر الذي في الخرزة السادسة
نحو الشمال والمغرب مقدار ذراع من القدر الثالث والعشرون هو
التالي من الاثنين النيرين اللذين في الحمة من القدر الثالث
ايضا متقدم للتاسع عشر ومائل عنه الى الشمال بينه وبين التاسع
عشر نحو ذراع ونصف والحادي والعشرون هو المتقدم منهما بالقرب

Folio 240

It is less than 3rd magnitude. Ptolemy mentioned that it is of the 4th magnitude. (However) its (magnitude) is not less then (the star located) on the fourth joint, for (Ptolemy) mentioned that that was of the 3rd (magnitude). The distance between it and the twentieth (star) that is located in the sting is a distance of about one *Shibr*.

The Arabs call the three (stars) on the forehead *al-Iklīl* (crown). We explained about this when we mentioned the constellation Libra and that the story from the Arabs about this is wrong.

The bright red eighth star on the body is called *al-Qalb* (the heart).

The seventh star in front of *al-Qalb* and the ninth star behind it are called *al-Nīyāṭ*.

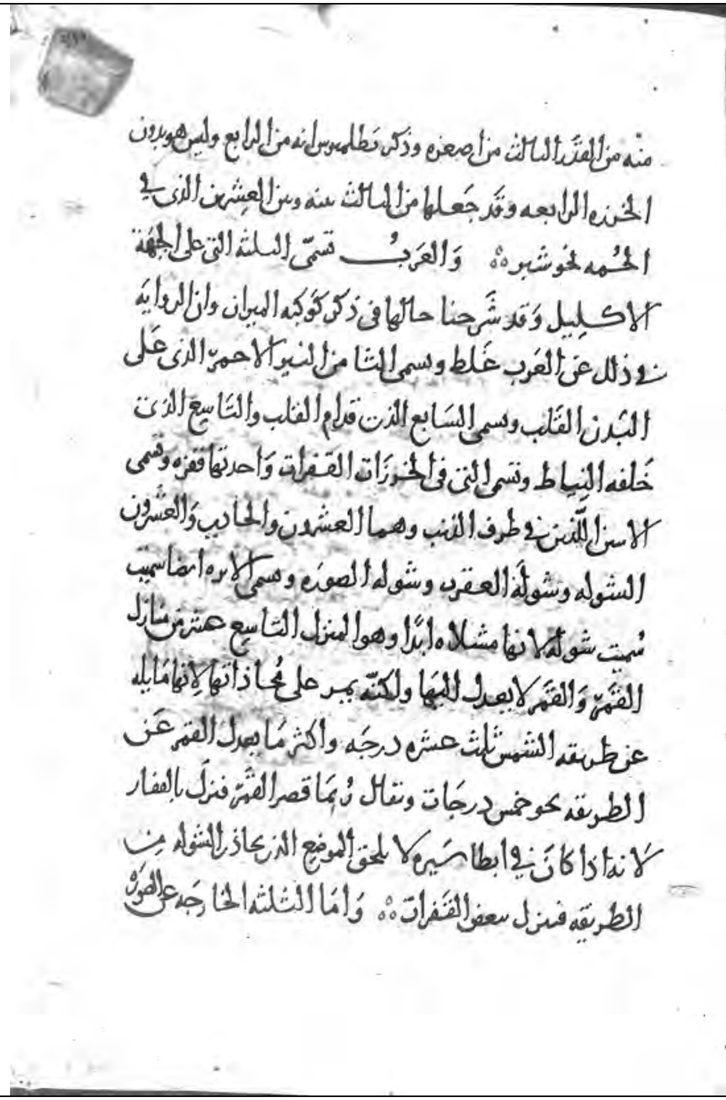
The stars on the *Kharazāt* (plural of joint) are called *al-Fiqarāt* (spinal vertebrae) and singularly *Fiqra*.

The two stars, on the tip of the tail, which are the twentieth and the twenty-first are called *al-Shawla* (the sting) or *Shawlat al-ʻAqrab* (the sting of Scorpio) or *Shawlat al-Sura* (the sting of the constellation) and are also called *al-Ibra* (the needle). They were called *al-Shawla* because they always rise vertically. They are the nineteenth of the lunar mansions.

(However the Moon) does not approach them but passes close by because they are thirteen degrees further away than the orbit of the Sun.

The furthest distance the Moon drifts from its orbit is five degrees.

They (the Arabs) say that when the Moon slows down it might stay in the joints. Because if the Moon is in its slowest pace it does not reach the location of *al-Shawla* but stays in some of the joints.


منه من القدر الثالث من اصغره وذكر بطلميوس انه من الرابع وليس هو بدون
الخرز الرابعه وقد جعلها من الثالث منه وبين العشرين الذي في
الحمه نحو شبر ٥٥ والعرب تسمي الثلثة التي على الجبهة
الاكليل وقد شرحنا حالها في ذكر كوكبة الميزان وان الرواية
في ذلك عن العرب غلط وسمي الثامن النير الاحمر الذي على
البدن القلب وسمي السابع الذي قدام القلب والتاسع الذي
خلفه النياط وتسمى التي في الخرزات الفقرات واحدتها فقرة وتسمى
الاثنان اللذان في طرف الذنب وهما العشرون والحادي والعشرون
الشوله وشولة العقرب وشولة الصورة وتسمى الابره وانما
سميت شولة لانها مشالة ابدا وهو المنزل التاسع عشر من منازل
القمر والقمر لا يصل اليها ولكنه يمر على محاذاتها لانها مايلة
عن طريقة الشمس ثلث عشرة درجة واكثر ما يميل القمر عن
الطريقة نحو خمس درجات وتقول ربما قصر القمر فنزل بالفقار
لانه اذا كان في ابطا سيره لا يلحق الموضع الذي يحاذي الشولة من
الطريقة فنزل بعض الفقرات ٥٥ واما الثلثة الخارجة على الصورة

Folio 241

As for the three stars outside the constellation, the first is a star to the rear of *al-Shawla* and behind the nineteenth star which is on the seventh joint. It is less than 4th magnitude. Ptolemy mentioned that it is a nebulous object. The distance between it and the nineteenth star which is on the seventh *Kharaza* (joint) is a distance that is a little more than one *dhirā'*. And the distance between it and *al-Shawla* is close to one and a half *dhirā'*.

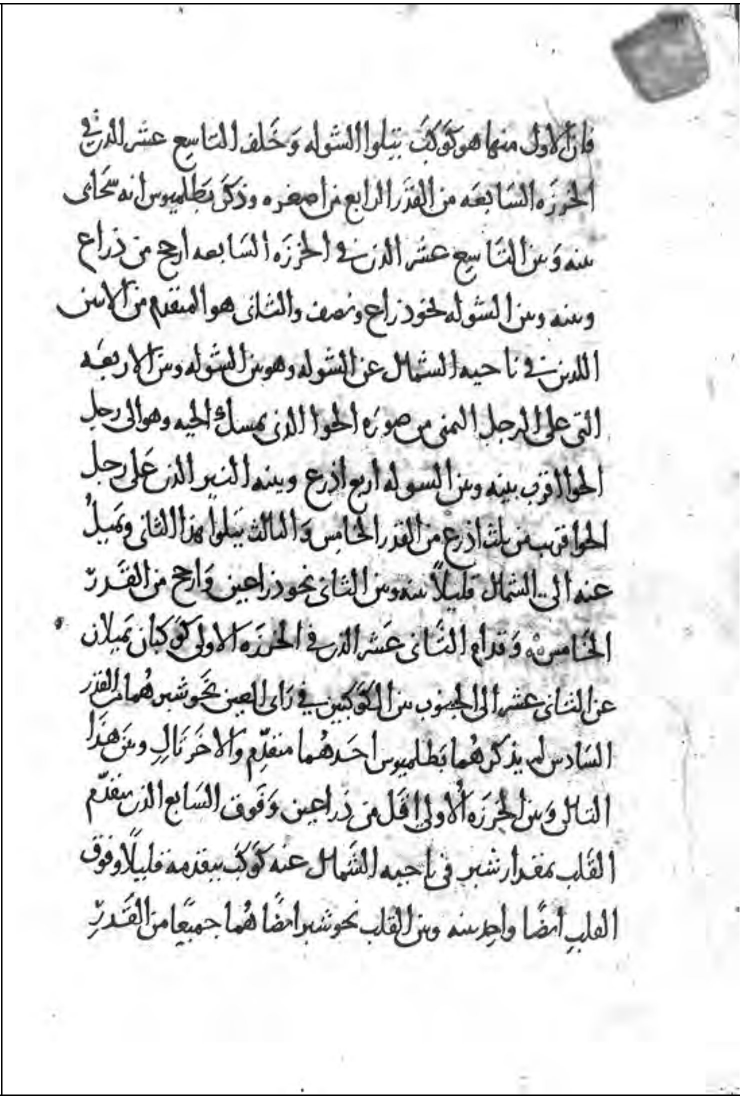
The second star is the most advanced of the two stars towards the north from *al-Shawla*. It is located between *al-Shawla* and the four stars which are on the right leg of the constellation *al-Ḥawwā* (Ophiuchus) holding *al-Ḥayya* (the constellation Serpens or the snake). It is closer to the leg of the constellation *al-Ḥawwā*. The distance between it and *al-Shawla* is four *dhirā'* while the distance between it and the bright star on the leg of *al-Ḥawwā* is less than three *dhirā'*. It is of the 5th magnitude.

The third is to the rear of the second and a little towards the north. The distance between it and the second is close to two *dhirā'*. It is of the 5th magnitude.

In front of the twelfth star which is on the first joint are two stars towards the south. The distance between these two stars as can be seen by the eye is a distance of one *Shibr*. They are of the 6th magnitude. They were not mentioned by Ptolemy. One is in front and the second is to the rear. The distance between the one to the rear and between the first joint is a distance that is less than two *dhirā'*.

Above the seventh star that is in advance to *al-Qalb* by one *Shibr* towards the north is a star that is a little further away.

Above *al-Qalb* also is another star that is one *Shibr* away.


فأما الأول منها هو كوكب يتلو الشولة وخلف التاسع عشر الذي في
الخرزة السابعة من القدر الرابع من أصغره وذكر بطلميوس أنه سحابي
بينه وبين التاسع عشر الذي في الخرزة السابعة أرجح من ذراع
وبينه وبين الشولة نحو ذراع ونصف والثاني هو المتقدم من الاثنين
اللذين في ناحية الشمال عن الشولة وهو بين الشولة وبين الأربعة
التي على الرجل اليمنى من صورة الحوا الذي يمسك الحية وهو إلى رجل
الحوا أقرب بينه وبين الشولة أربع أذرع وبينه وبين النير الذي على رجل
الحوا قريب من ثلث أذرع من القدر الخامس والثالث يتلو هذا الثاني ويميل
عنه إلى الشمال قليلاً بينه وبين الثاني نحو ذراعين وأرجح من القدر
الخامس وقدام الثاني عشر الذي في الخرزة الأولى كوكبان يميلان
عن الثاني عشر إلى الجنوب بين الكوكبين في رأي العين نحو شبر هما من القدر
السادس لم يذكرهما بطلميوس أحدهما متقدم والآخر تال وبين هذا
التالي وبين الخرزة الأولى أقل من ذراعين وفوق السابع الذي يتقدم
القلب بمقدار شبر في ناحية الشمال عنه كوكب يتقدمه قليلاً وفوق
القلب أيضاً واحد بينه وبين القلب نحو شبر أيضاً هما جميعاً من القدر

Folio 242

These are all less than 5th magnitude and were not mentioned by Ptolemy. In front of the southernmost of the three stars on the forehead are two nearby stars which are of the 6th magnitude and which were also not mentioned by Ptolemy.

The constellation Scorpio as seen on the globe.

Folio 243

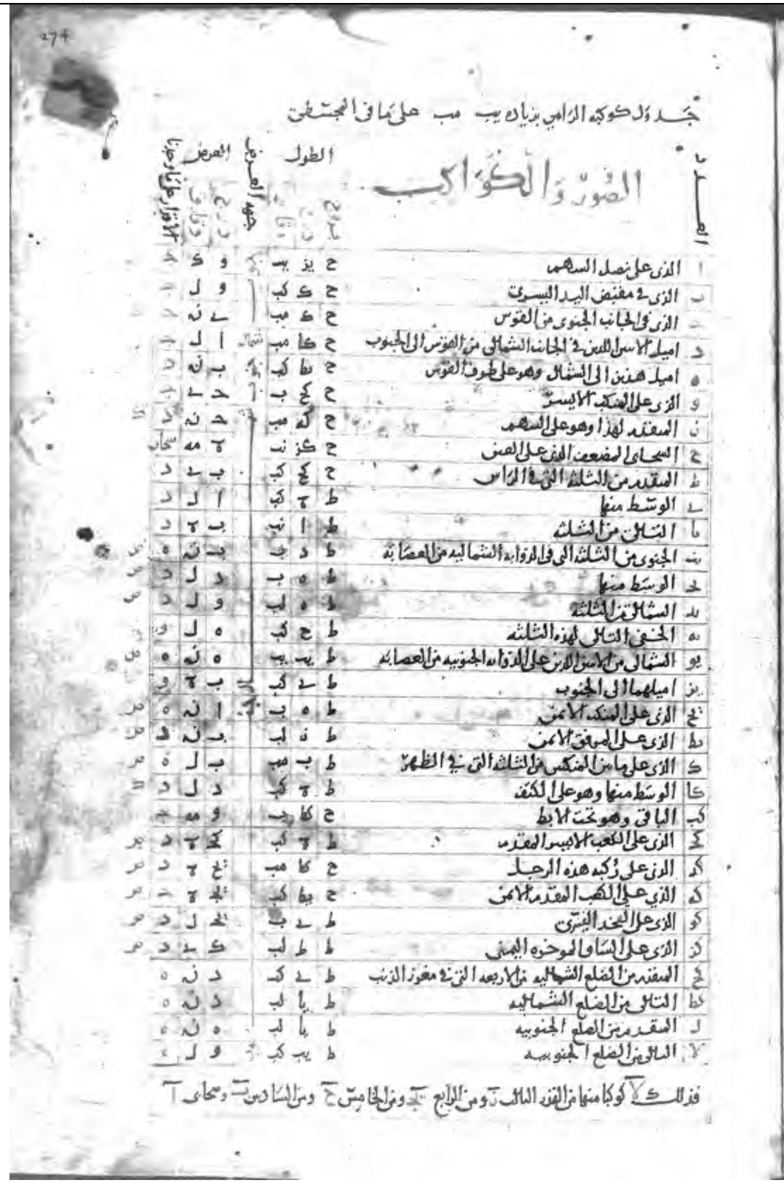
The constellation Scorpio as seen in the sky.

Folio 244

Number	Names of the stars	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
Table of the constellation Scorpio with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
1	The northernmost of the 3 bright stars on the forehead.	7(210)	19	02	N	01	20	3
2	The middle one of these.	7(210)	18	22	S	01	40	3
3	The southernmost of the three	7(210)	18	22	S	05	00	3
4	The star south again of this on one of the legs	7(210)	18	42	S	50	50	3(s)
5	The southernmost of the 2 stars adjacent to the northernmost of the three bright ones	7(210)	19	42	N	01	40	4
6	The southernmost of these	7(210)	19	02	N	00	30	4
7	The most advanced of the 3 bright stars in the body	7(210)	23	22	S	03	45	3(s)
8	The middle one of these which is reddish and called *Qalb al-'Aqrab* (Antares)	7(210)	25	22	S	04	00	2
9	The rearmost of the 3	7(210)	17	12	S	05	30	3
10	The advanced star of the 2 under these approximately on the last leg	7(210)	22	10	S	06	10	5(s)
11	The rearmost of these	7(210)	23	22	S	06	40	5(s)
12	The star in the first tail joint from the body	8(240)	01	12	S	11	00	3
13	The one after this in the 2nd joint	8(240)	01	32	S	15	00	3
14	The northern star of *al-Muḍ'af* (the double star) in the 3rd joint	8(240)	02	42	S	18	40	4
15	The southern star of the double star	8(240)	02	52	S	19	30	4
16	The one following in the 4th joint	8(240)	05	52	S	19	30	3(s)
17	The one after that in the 5th joint	8(240)	10	52	S	18	50	3
18	The next one again in the 6th joint	8(240)	12	12	S	16	40	3(s)
19	The star in the 7th joint the joint next to the sting	8(240)	11	42	S	15	20	3
20	The rearmost of the 2 stars in the sting	8(240)	10	12	S	13	20	3
21	The more advanced of these	8(240)	09	42	S	13	30	3
21 stars, 1 of the 2nd magnitude, 14 of the 3rd, 4 of the 4th, 2 of the 5th								
The stars around the constellation Scorpio and not part of the constellation								
1	The nebulous star to the rear of the sting	8(240)	13	52	S	13	15	4(s)
2	The most advanced of the 2 stars to the north of the sting.	8(240)	08	12	S	06	10	5
3	The rearmost of them.	8(240)	12	12	S	04	10	5
3 stars, 1 of the 4th magnitude, 2 of the 5th magnitude								

Folio 274

Table of the constellation Sagittarius (*al-Rāmi*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star on the point of the arrow	8(240)	17	12	S	6	20	3(s)
2	The star in the [bow-] grip held by the left hand	8(240)	20	22	S	6	30	3
3	The star in the southern portion of the bow	8(240)	20	42	S	10	50	3(m)
4	The southernmost of the [2] stars in the northern portion of the bow	8(240)	21	42	N	1	30	3
5	The northernmost of these, on the tip of the bow	8(240)	19	2	S	2	50	4
6	The star on the left shoulder	8(240)	28	2	S	3	10	3
7	The one in advance of this, just over the arrow	8(240)	25	42	N	3	50	4(k)
8	The star on the eye, which is nebulous and double	8(240)	27	52	N	0	45	nebula
9	The most advanced of the 3 stars in the head	8(240)	28	22	N	2	10	4
10	The middle one of these	9(270)	0	22	N	1	30	4
11	The rearmost of the three	9(270)	1	52	N	2	0	4
12	The southernmost of the 3 stars in the northern cloak-attachment	9(270)	4	2	N	2	50	5(s)
13	The middle one of these	9(270)	5	2	N	4	30	4(s)
14	The northernmost of the three	9(270)	5	32	N	6	30	4(s)
15	The faint star to the rear of these three	9(270)	8	22	N	5	30	6
16	The northernmost of the 2 stars on the southern cloak-attachment	9(270)	12	12	N	5	50	5(s)
17	The southernmost of them	9(270)	10	22	N	2	0	6
18	The star on the right shoulder	9(270)	5	2	S	1	50	5(s)
19	The star on the right elbow	9(270)	7	32	S	2	50	4(s)
20	The three stars in the back: the one just above the place between the shoulders	9(270)	2	42	S	2	30	5(s)
21	The middle one, just above the shoulder-blade	9(270)	0	22	S	4	30	4(k)
22	The other one, under the armpit	8(240)	29	2	S	6	45	3
23	The star on the front left hock	9(270)	0	22	S	23	0	4(s)
24	The one on the knee of the same leg	8(240)	29	42	S	18	0	4(s)



25	The star on the front right hock	8(240)	19	22	S	13	0	3(s)
26	The star on the left thigh	9(270)	10	2	S	13	30	4(s)
27	The star on the right hind lower leg	9(270)	9	32	S	20	10	4(s)
28	The four stars [forming a quadrilateral] in the place where the tail joins [the body]: the advance star on the northern side	9(270)	10	22	S	4	50	5
29	The rear star on the northern side	9(270)	11	32	S	4	50	5
30	The advance star on the southern side	9(270)	11	32	S	5	50	5
31	The rear star on the southern side	9(270)	12	22	S	6	30	5
31stars, 7 is of the 3rd magnitude, 13 the 4th magnitude, 8 of the 5th magnitude, 2 of the 6th magnitude and 1 nebula.								

Folio 281

Constellation Capricorns (*al-Jadī*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*

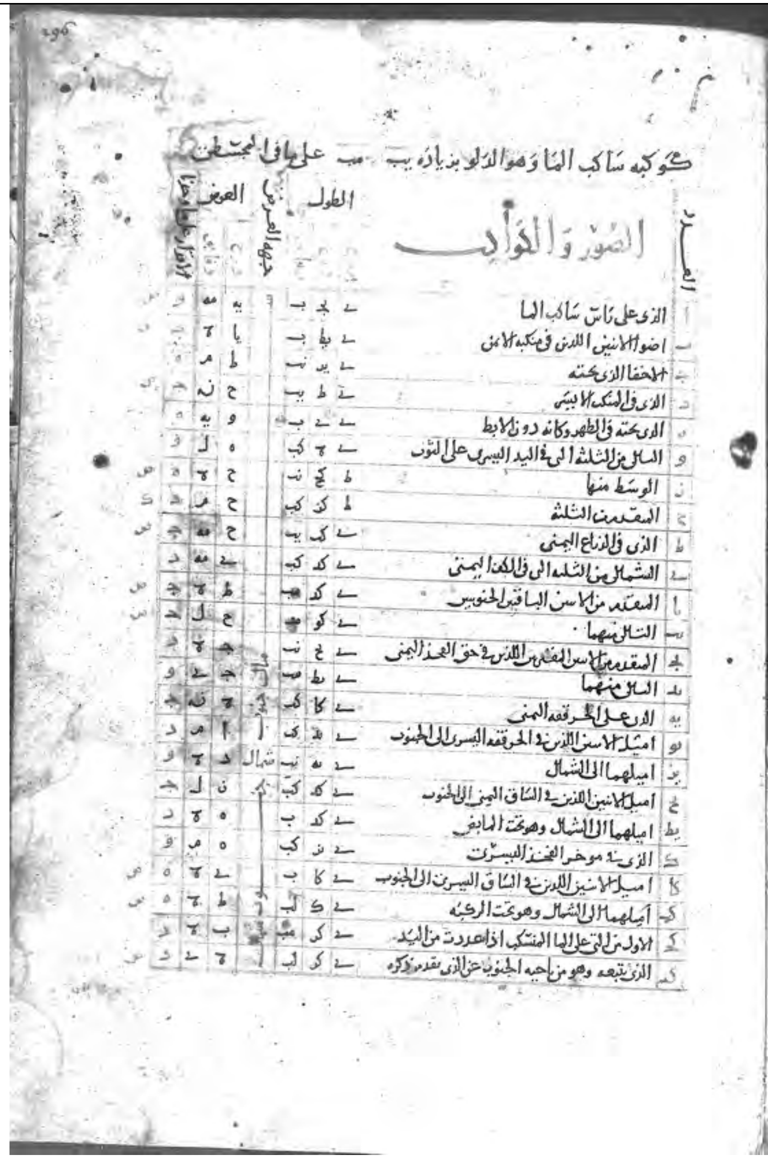
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The northernmost of the 3 stars in the rear horn	9(270)	20	2	N	7	20	3(s)
2	The middle one of these	9(270)	20	22	N	6	40	5(s)
3	The southernmost of the three	9(270)	20	2	N	5	0	3(s)
4	The star on the tip of the advanced horn	9(270)	17	42	N	8	0	6(s)
5	The southernmost of the 3 stars in the muzzle	9(270)	21	42	N	0	45	6
6	The more advanced of the other two	9(270)	21	22	N	1	45	6
7	The rearmost of these	9(270)	21	32	N	1	30	6
8	The star in advance of the [above] 3, under the right eye	9(270)	18	52	N	0	40	6
9	The northernmost of the 2 stars in the neck	9(270)	24	22	N	3	50	6
10	The southernmost of them	9(270)	24	32	N	0	50	6
11	The star on the left, doubled-up knee	9(270)	23	32	S	6	30	4
12	The star under the right knee	9(270)	24	22	S	8	40	4
13	The star on the left shoulder	9(270)	29	22	S	7	40	4(s)
14	The more advanced of the 2 stars close together under the belly	10(300)	2	52	S	6	50	4(s)
15	The rearmost of these	10(300)	3	2	S	6	0	5(m)
16	The rearmost of the 3 stars in the middle of the body	10(300)	1	22	S	4	15	6
17	The southernmost of the other, advanced 2	9(270)	29	22	S	4	0	6
18	The northernmost of them	9(270)	29	22	S	2	50	5(s)
19	The more advanced of the 2 stars in the back	9(270)	29	22	0	0	0	4
20	The rearmost of them	10(300)	3	42	S	0	50	4
21	The more advanced of the 2 stars in the southern spine	10(300)	6	2	S	4	45	4
22	The rearmost of them	10(300)	7	42	S	4	30	4(s)
23	The more advanced of the 2 stars in the section [of the body] next to the tail	10(300)	7	32	S	2	10	3(s)
24	The rearmost of them	10(300)	9	2	S	2	0	3


كوكبة الجدي بزيادة يب مب على ما في المجسطي

25	The most advanced of the 4 stars on the northern portion of the tail	10(300)	9	32	N	0	20	5(s)
26	The southernmost of the other 3	10(300)	11	22	0	0	0	5
27	The middle one of these	10(300)	10	22	N	2	50	5
28	The northernmost of them, on the end of the tail-fin	10(300)	11	22	N	4	20	5
28stars, 4 is of the 3rd magnitude, 8 the 4th magnitude, 7 of the 5th magnitude, 9 of the 6th magnitude.								

Folio 296

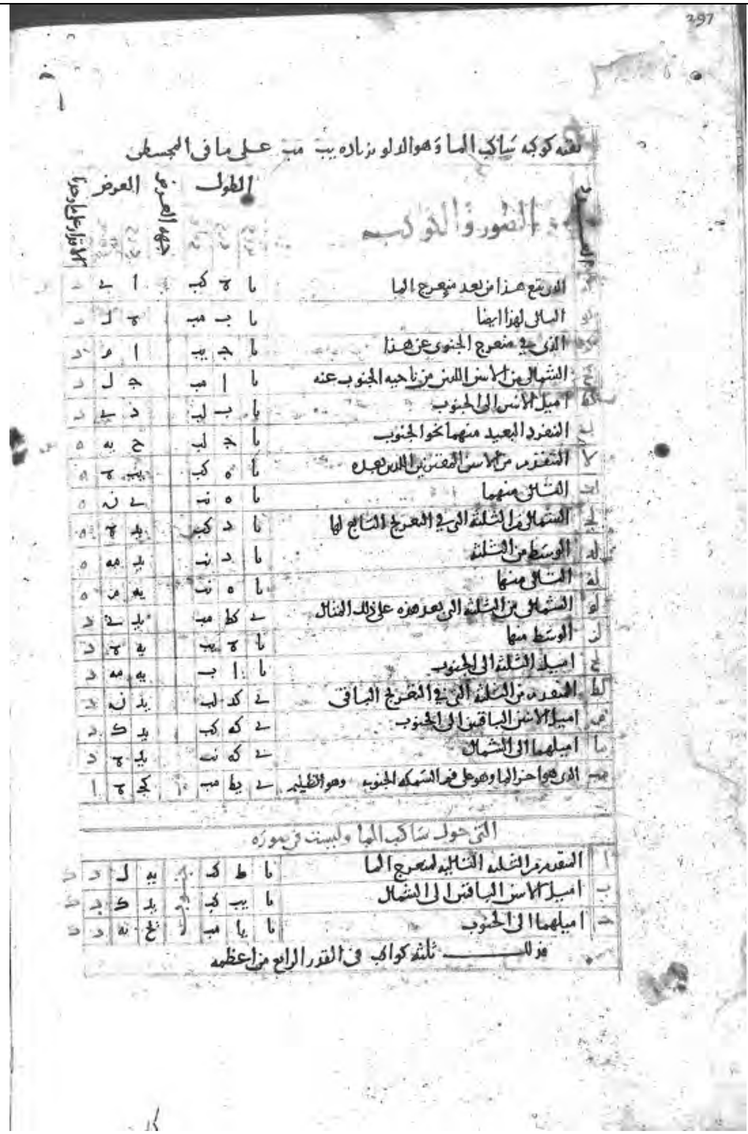
Constellation Aquarius (*Sākib al-Mā'*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star on the head of Aquarius	10(300)	13	2	N	15	45	6(s)
2	The brighter of the 2 stars in the right shoulder	10(300)	19	2	N	11	0	3(s)
3	The fainter one, under it	10(300)	17	52	N	9	40	5
4	The star in the left shoulder	10(300)	9	12	N	8	50	3(s)
5	The one under that, in the back, approximately under the armpit	10(300)	10	2	N	6	15	5
6	The rearmost of the three stars in the left arm, on the coat	10(300)	0	22	N	5	30	6
7	The middle one of these	9(270)	28	52	N	8	0	5(s)
8	The most advanced of the three	9(270)	27	22	N	8	40	4(m)
9	The star in the right forearm	10(300)	22	12	N	8	45	3(s)
10	The northernmost of the 3 stars on the right hand	10(300)	24	22	N	10	45	4(k)
11	The more advanced of the other 2 to the south	10(300)	24	42	N	9	0	3(s)
12	The rearmost of them	10(300)	26	42	N	8	30	3(s)
13	The more advanced of the 2 stars close together in the hollow of the right [hip]	10(300)	18	52	N	3	0	4
14	The rearmost of them	10(300)	19	42	N	3	10	5(s)
15	The star on the right buttock	10(300)	21	22	S	0	50	4(s)
16	The southernmost of the 2 stars in the left buttock	10(300)	14	22	S	1	40	4(s)
17	The northernmost of them	10(300)	15	52	N	4	0	6
18	The southernmost of the 2 stars in the right lower leg	10(300)	24	22	S	7	30	3
19	The northernmost of them, under the knee-bend	10(300)	24	2	S	5	0	4
20	The star in the back of the left thigh	10(300)	17	22	S	5	40	6
21	The southernmost of the 2 stars in the left lower leg	10(300)	21	2	S	10	0	5(s)
22	The northernmost of these, under the knee	10(300)	20	32	S	9	0	5(s)
23	The stars on the flow of water: the most advanced [in the section] beginning at the hand	10(300)	27	42	N	2	0	4
24	The one next to the latter towards the south	10(300)	27	32	N	0	10	4(s)



Folio 297

Remaining stars of the constellation Aquarius with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*

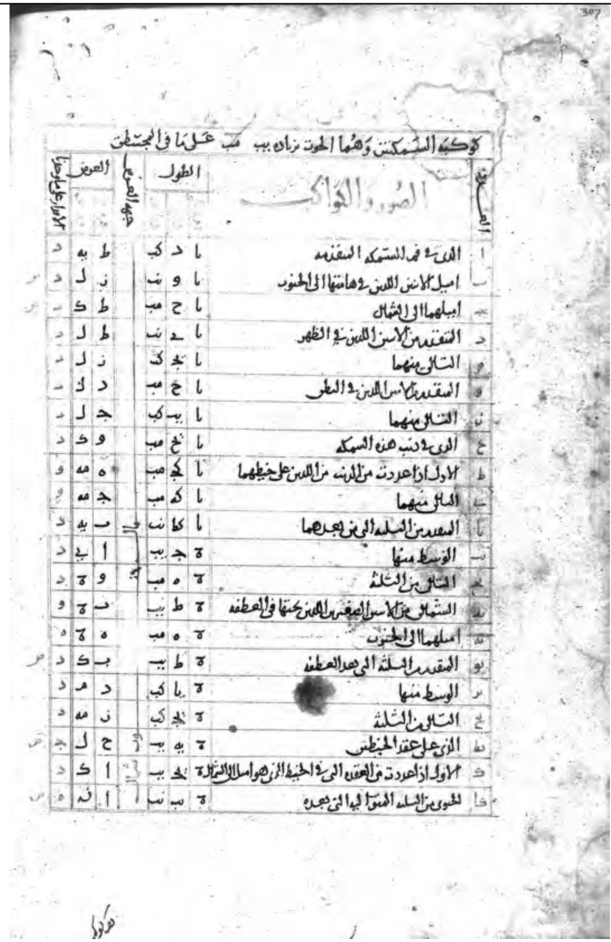
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
25	The one next to this, after [the beginning of] the bend	11(330)	0	22	S	1	10	4(s)
26	The one to the rear again of this	11(330)	2	42	S	0	30	4(s)
27	The one in the bend to the south of this	11(330)	3	12	S	1	40	4
28	The northernmost of the 2 stars to the south of this	11(330)	1	42	S	3	30	4
29	The southernmost of the two	11(330)	2	32	S	4	10	4
30	The lone star at some distance from these [two] towards the south	11(330)	3	32	S	8	15	5(s)
31	The more advanced of the 2 stars close together after the latter	11(330)	5	22	S	12	0	5
32	The rearmost of them	11(330)	5	52	S	10	50	5
33	The northernmost of the 3 stars in the next group	11(330)	4	22	S	14	0	5
34	The middle one of the three	11(330)	4	52	S	14	45	5
35	The rearmost of them	11(330)	5	52	S	15	40	5
36	The northernmost of the next 3 [arranged] likewise	10(300)	29	42	S	14	10	4
37	The southernmost of the three	11(330)	0	12	S	15	0	4
38	The middle one of the three	11(330)	1	2	S	15	45	4
39	The most advanced of the 3 stars in the remaining group	10(300)	24	32	S	14	50	4
40	The southernmost of the other 2	10(300)	25	22	S	14	20	4
41	The northernmost of them	10(300)	25	52	S	14	0	4
42	The star at the end of the water and on the mouth of Piscis Austrinus called *al-Dhulaīm*	10(300)	19	42	S	23	0	1
42 stars, 1 of the 1st magnitude, 6 is of the 3rd magnitude, 19 the 4th magnitude, 12 of the 5th magnitude, 4 of the 6th magnitude.								
The ones surrounding the constellation Aquarius but not in it.								
1	The most advanced of the 3 stars to the rear of the bend in the water	11(330)	9	22	S	15	30	4(m)
2	The northernmost of the other 2	11(330)	12	22	S	14	20	4(m)
3	The southernmost of them	11(330)	11	42	S	18	15	4(m)
3 stars much more than the 4th magnitude.								



Folio 307

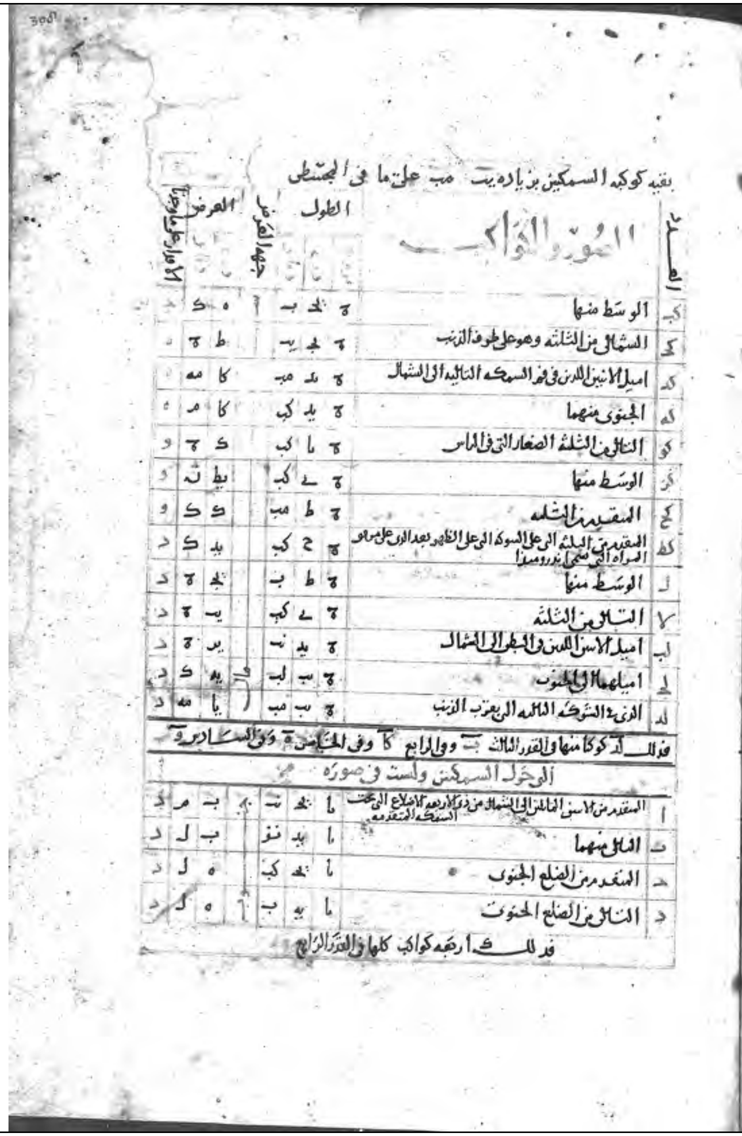
Constellation Pisces (al-*Samakatān and al-Ḥūt*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star in the mouth of the advanced fish	11(330)	4	22	N	9	15	4
2	The southernmost of the 2 stars in the top of its head	11(330)	6	52	N	7	30	4(s)
3	The northernmost of them	11(330)	8	42	N	9	20	4(s)
4	The more advanced of the 2 stars in the back	11(330)	10	52	N	9	30	4
5	The rearmost of them	11(330)	13	22	N	7	30	4
6	The more advanced of the 2 stars in the belly	11(330)	8	42	N	4	30	4
7	The rearmost of them	11(330)	12	22	N	3	30	4
8	The star in the tail of the same [advanced] fish	11(330)	18	42	N	6	20	4
9	The stars forming its fishing-line: the first after the tail	11(330)	23	42	N	5	45	6
10	The one to the rear	11(330)	25	42	N	3	45	6
11	The most advanced of the 3 following bright stars	11(330)	29	52	N	2	15	4
12	The middle one of these	0	3	12	N	1	10	4
13	The rearmost of the three	0	5	42	S	6	0	4
14	The northernmost of the 2 small stars under these, in the bend	0	9	12	S	2	0	6
15	The southernmost of them	0	5	42	S	5	0	5
16	The most advanced of the 3 stars after the bend	0	9	12	S	2	20	4(s)
17	The middle one of these	0	11	22	S	4	40	4
18	The rearmost of the three	0	13	22	S	7	45	4
19	The star on the knot joining the 2 fishing-lines	0	15	12	S	8	30	4(m)
20	The first of the stars in the northerly fishing line, beginning at the knot	0	13	12	N	1	20	4
21	The southernmost of the 3 stars following this	0	12	52	N	1	50	5(s)


كوكبة السمكتين وهما الحوت نزاد يب مب على ما في المجسطي

Folio 308

Remaining stars of the constellation Pisces with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
22	The middle one of these	0	13	2	N	5	20	4(m)
23	The northernmost of the 3, which is also on the end of the tail	0	13	12	N	9	0	5
24	The northernmost of the 2 stars in the mouth of the rear fish	0	13	42	N	21	45	5
25	The southernmost of them	0	13	22	N	21	40	5
26	The rearmost of the 3 small stars in the head	0	11	22	N	20	0	6(s)
27	The middle one of these	0	10	22	N	19	50	6(s)
28	The most advanced of the three	0	9	42	N	20	20	6(s)
29	The most advanced of the 3 stars on the spine in the back, following [i.e. to the rear of] the star on the elbow of Andromeda [345 And 11]	0	8	22	N	14	20	4
30	The middle one of the three	0	9	2	N	13	0	4
31	The rearmost of the three	0	10	22	N	12	0	4
32	The northernmost of the 2 stars in the belly	0	14	52	N	17	0	4
33	The southernmost of them	0	12	32	N	15	20	4
34	The star in the rear spine, near the tail	0	12	42	N	11	45	4
34 stars, 2 are of the 3rd magnitude, 21 the 4th magnitude, 5 of the 5th magnitude, 6 of the 6th magnitude.								
The ones surrounding the constellation Aquarius but not in it.								
1	The quadrilateral under the advance fish: the more advanced of the 2 northern stars	11(330)	13	52	S	2	40	4
2	The rearmost of them	11(330)	14	57	S	2	30	4
3	The more advanced star on the southern side	11(330)	13	22	S	5	30	4
4	The rearmost one on the southern side	11(330)	15	2	S	5	30	4
4 stars, all of the 4th magnitude.								


بقية كواكب السمكتين بزيادة يب مب على ما في المجسطي

Folio 317

Constellation Cetus (*Qīṭus*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star on the tip of the nostrils	1(30)	0	22	S	7	45	4
2	The three stars in the snout: the rearmost, on the end of the jaw"	1(30)	0	22	S	12	20	3
3	The middle one, in the middle of the mouth"	0	25	22	S	11	30	3
4	The most advanced of the 3, on the cheek"	0	23	12	S	14	0	3(s)
5	The star on the eyebrow and the eye	0	22	2	S	8	10	4
6	The one to the north of this, approximately on the hair"	0	25	22	S	6	20	4
7	The one in advance of these, approximately on the mane"	0	20	22	S	4	10	4(s)
8	The quadrilateral in the chest: the northernmost star on the forward side	0	15	42	S	24	30	4
9	The one on the end of the southern tail-fin	0	16	2	S	28	0	4
10	The northernmost one on the rear side	0	19	22	S	25	10	4
11	The southernmost one on the rear side	0	19	42	S	27	30	4(k)
12	The middle one of the 3 stars in the body	0	4	42	S	25	20	3(s)
13	The southernmost of them	0	5	42	S	30	50	4
14	The northernmost of the three	0	7	42	S	20	0	3(s)
15	The rearmost of the 2 stars by the section next to the tail	0	2	22	S	15	20	3(s)
16	The more advanced of them	11(330)	27	42	S	15	40	3(s)
17	The quadrilateral in the section next to the tail: the northernmost star on the rear side	11(330)	23	42	S	13	40	6
18	The southernmost one on the rear side	11(330)	21	22	S	14	40	6
19	The northernmost one on the forward side	11(330)	22	2	S	13	0	5(s)
20	The southernmost one on the forward side	11(330)	21	42	S	14	0	5(s)
21	The 2 stars at the ends of the	11(330)	17	2	S	9	40	3(s)

	tail-fins: the one on the northern [tail-fin]							
22	The one on the end of the southern tail-fin	11(330)	18	22	S	20	20	3(m)
22 stars, 9 of the 3rd magnitude, 9 of the 4th magnitude, 2 of the 5th magnitude. and 2 of the 6th magnitude								

Folio 318 (Manuscript Marsh144)
The constellation Orion (*Jabbār)* or *(al-Jauzā')*

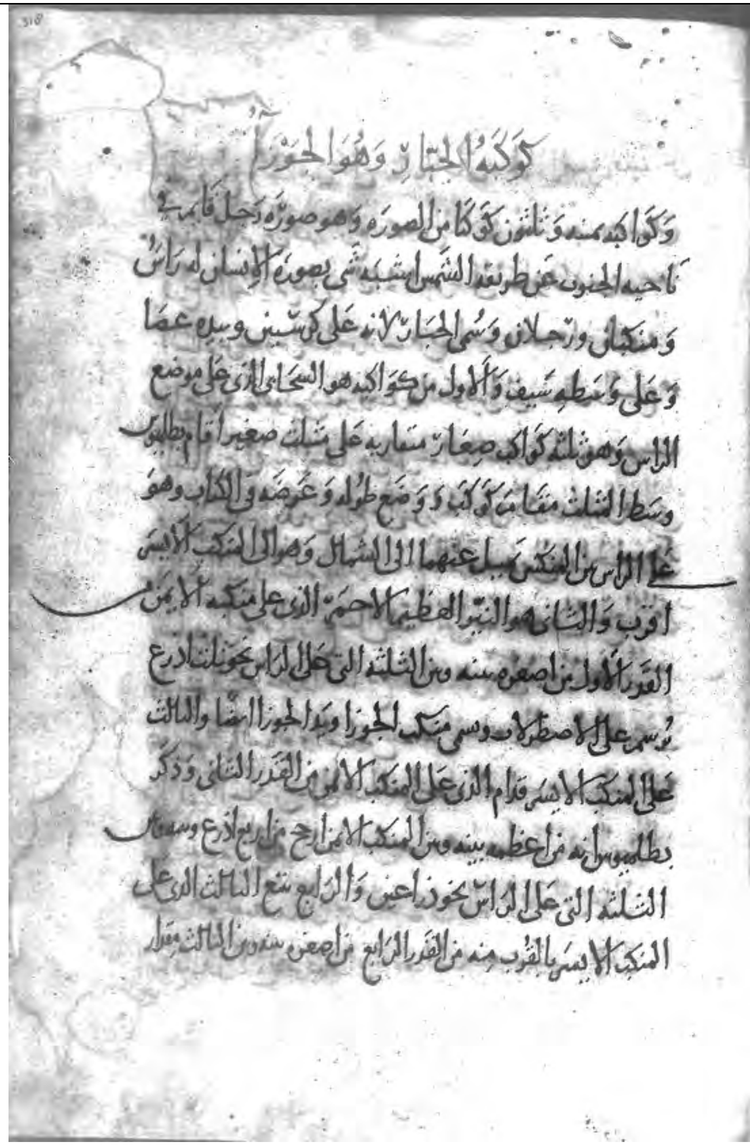
Its stars are thirty-eight stars in the constellation. It is the image of a man standing south of the path of the Sun. It most resembles an image of a human with a head, two shoulders and two legs. It was called *al-Jabbār* because it is (standing) on two legs with a stick in his hands and a sword on his middle.

The first of its stars is the *Saḥābi* (nebula) on the head. This nebula is made up of three small stars close together forming a small *Muthallath* (triangle). Ptolemy mentioned it to be one star located in the middle of the triangle and he indicated its longitude and latitude in his book. It is located on the head between the two shoulders and further away towards the north but closer to the left shoulder.

The second is the great bright red star located on the right *Mankib* (shoulder). It is less than the 1st magnitude. The distance between it and the three stars on the head is three *dhirā'*. It is (one of the stars that are) drawn on an astrolabe. It is called *Mankib al-Jauzā'* (the shoulder of Orion) and also *Yad al-Jauzā'* (the hand of Orion).

The third is located on the left shoulder next to the star on the right shoulder. It is of the 2nd magnitude. Ptolemy mentioned that it is much more (than the 2nd magnitude). The distance between it and the star on the right shoulder is a little more than four *dhirā'*. The distance between it and the three stars on the head is two *dhirā'*.

The fourth (star) is next to the third (star) which is on the left shoulder and is close to it. It is less than the 4th magnitude. The distance between it and the third star is two-thirds of a *dhirā'*.


كوكبة الجبار وهو الجوزاء

Folio 319

The fifth is north of the second star and is inclined a little towards the east. It is located on the right elbow. It is of the 4th magnitude. The distance between it and the second star in the north-east is a little more than one *dhirā‘*.
The sixth is north of the fifth, located on the right *sa'ed* (forearm). It is of the 6th magnitude. The distance between it and the fifth star is close to two *dhirā‘*. It forms together with the fifth and the second (stars) a line with a slight curve with its curve pointed towards the north.
The seventh is the *tālī* (rearmost) of the two close stars north of the sixth star. The distance between it and the sixth star is less than one *dhirā‘*. It is of the 5th magnitude. Ptolemy mentioned that it of the 4th magnitude. It is located on the right hand.
The eighth is close to the seventh star. It is of the 5th magnitude. Ptolemy mentioned that it is of the 4th magnitude. It is also located on the right hand. The distance between it and the seventh towards the north-west is one *dhirā‘*.
The ninth is to the rear of the two close-by stars. It is north of the seventh and eighth stars. The distance between it and seventh star in the north is a little less then one *dhirā‘*. It is of the 6th magnitude. It is also located on the right hand.
The tenth is *al-mutaqadem* (in-advance) of the ninth star and close to it. It is also of the 6th magnitude. It is also located on the right hand.
The eleventh is the more advanced of the two stars that are north of the four stars on the right hand. They are inclined towards the west. It (the eleventh star) is to the rear of the nineteenth star which is on the eastern horn of (the constellation) Taurus.

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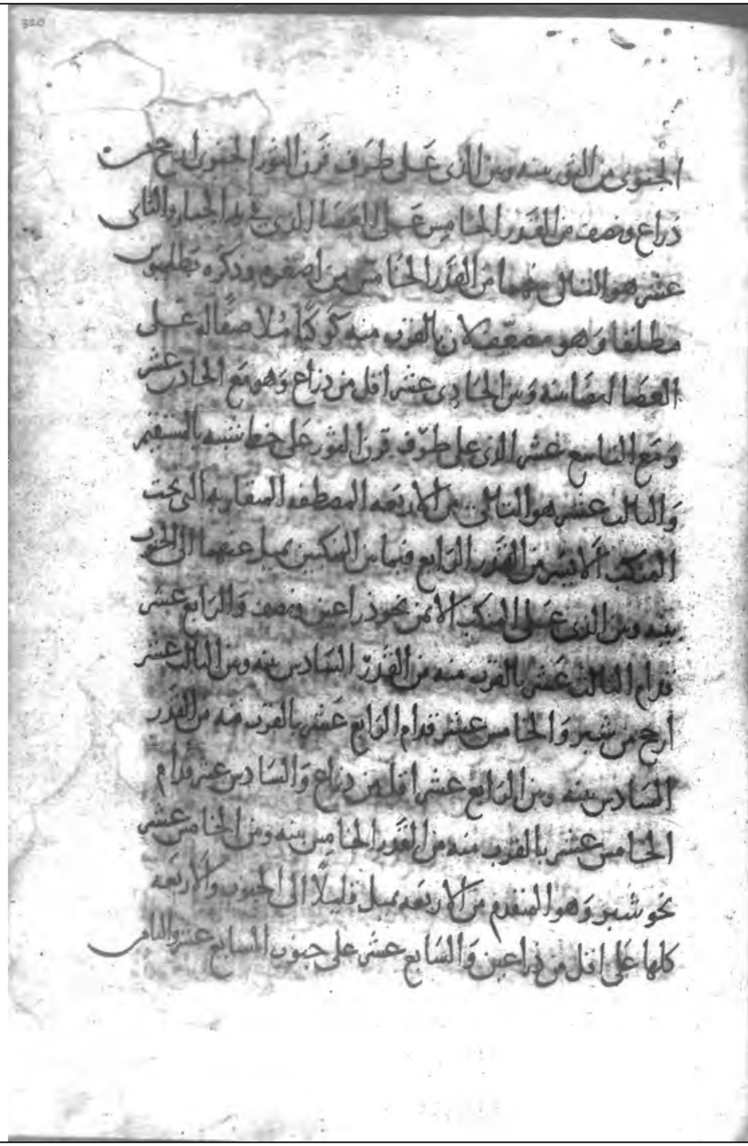
The distance between it and the star which is on the eastern horn of (the constellation) Taurus is more than one and a half *dhirā‘*. It is of the 5th magnitude. It is located on *al-‘Sā* (the staff) held by Orion.
The twelfth is to the rear of the two. It is less than the 5th magnitude. Ptolemy mentioned that it is exactly 5th magnitude. It is a *Muḍ’af* (double star) because there is a star next to it. It is also located on the staff. The distance between it and eleventh is less than one *dhirā‘*. It forms together with the eleventh (of Orion) and the nineteenth which is on the tip of the horn of (the constellation) Taurus a slightly straight line.
The thirteenth is the rearmost of the four stars that form a straight line under the left shoulder. It is of the 4th magnitude. It is located between the two shoulders towards the south. The distance between it and the star on the right shoulder is a distance of two and half *dhirā‘*.
The fourteenth is in advance of the thirteenth and close by it. It is of the 6th magnitude. The distance between it and thirteenth is more than one *dhirā‘*.
The fifteenth is in advance of the fourteenth and close by it. It is of the 6th magnitude. The distance between it and fourteenth is less than one *dhirā‘*.
The sixteenth is in advance of the fifteenth and close by it. It is of the 5th magnitude. The distance between it and fifteenth is about one *Shibr*.
It is the one in advance of the four stars towards the south. All the four (stars) are less than two *dhirā‘* in distance.

The seventeenth is south of the seventeenth and eighteenth stars that are on the middle of the southern horn of the (constellation) Taurus.



Folio 321

The distance between it and the seventeenth (star) that is on the middle of the southern horn of the (constellation) Taurus is more than one *dhirā'*. It is the northernmost star of the nine curved stars that are on the left *Kum* (pelt). It is of the 4th magnitude.

The eighteenth is in advance of the seventeenth and close by it. It is the second of the nine stars. It is south-east of the seventeenth by a distance of more than one *Shibr*. It is also of the 4th magnitude.

The nineteenth is south of the eighteenth and close by it. It is of the 4th magnitude. It is south of the eighteenth by a distance of more than one *dhirā'*. It is the third of the nine stars.

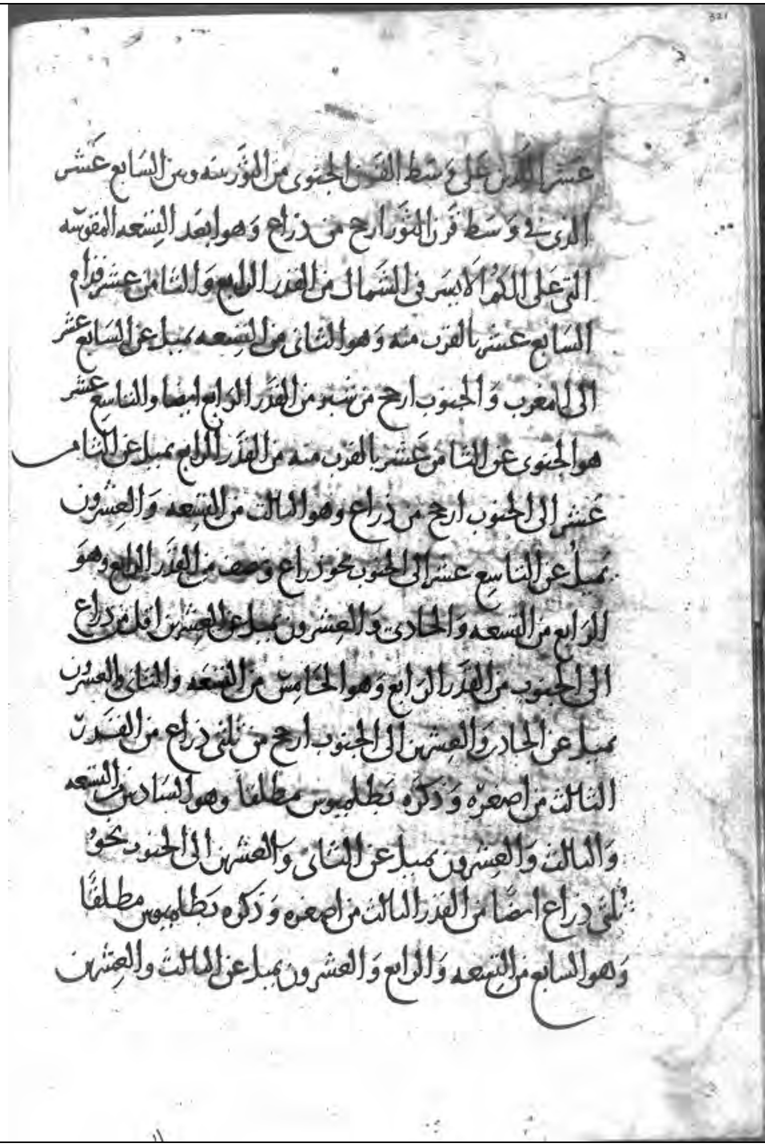
The twentieth is south of the nineteenth by a distance of one and a half *dhirā'*. It is of the 4th magnitude. It is the fourth of the nine stars.

The twenty-first is south of the twentieth by a distance of less than one *dhirā'*. It is of the 4th magnitude. It is the fifth of the nine stars.

The twenty-second is south of the twenty-first by a distance of more than two-third a *dhirā'*. It is less than 3rd magnitude. Ptolemy mentioned that it is exactly 3rd magnitude. It is the sixth of the nine stars.

The twenty-third is south of the twenty-second by a distance of two-third a *dhirā'*. It is also less than 3rd magnitude. Ptolemy mentioned that it is exactly 3rd magnitude. It is the seventh of the nine stars.

The twenty-fourth is south of the twenty-third by a distance of one and a third *dhirā'*.



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It is also less than 3rd magnitude. Ptolemy mentioned that it is exactly 3rd magnitude. It is the eighth of the nine stars.

The twenty-fifth is south-east of the twenty-fourth by a distance of half a *dhirā'*. It is of the 4th magnitude. Ptolemy mentioned that it is of the 3rd magnitude. It is the southernmost star of the nine curved stars.

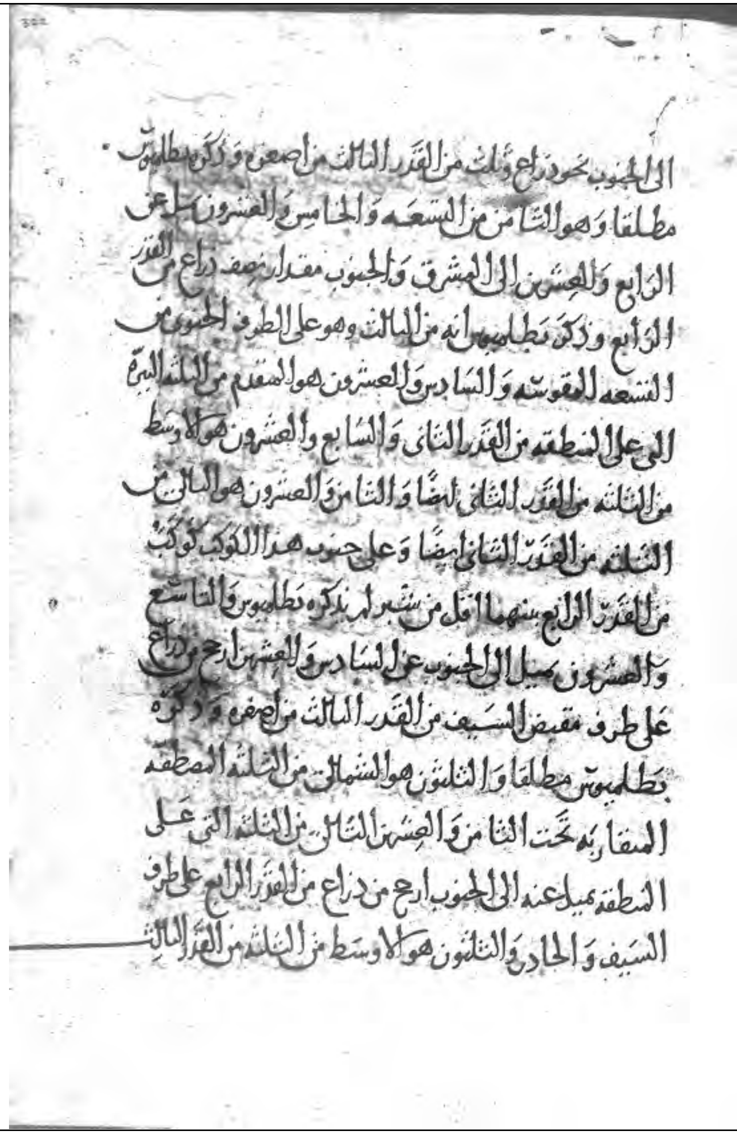
The twenty-sixth is the most advanced of the three bright stars on the belt. It is of the 2nd magnitude.

The twenty-seventh is the middle of the three stars. It is also of the 2nd magnitude.

The twenty-eighth is the rearmost of the three stars. It is also of the 2nd magnitude. South of this star is a star of the 4th magnitude. The distance between them is less than one *Shibr*. It was not mentioned by Ptolemy.

The twenty-ninth is south of the twenty-sixth by a distance of more than one *dhirā'*. It is located on the tip of the handle of the sword. It is less than 3rd magnitude. Ptolemy mentioned that it is exactly 3rd magnitude.

The thirtieth is the northernmost of the three aligned stars under the twenty-eighth star which is the rearmost of the three stars on the *Minṭaqa* (belt).
It is south of it by a distance of more than one *dhirā'*. It is of the 4th magnitude. It is located on the tip of the sword.
The thirty-first is the middle of the three. It is less than 3rd magnitude.


الى الجنوب نحو ذراع وثلث من القدر الثالث من اصغر وذكر بطلميوس
مطلقا وهو الثامن من التسعة والخامس والعشرون يميل عن
الرابع والعشرين الى المشرق والجنوب مقدار نصف ذراع من القدر
الرابع وذكر بطلميوس انه من الثالث وهو على الطرف الجنوبي من
التسعة المقوسة والسادس والعشرون هو المتقدم من الثلثة النيرة
التي على المنطقة من القدر الثاني والسابع والعشرون هو الاوسط
من الثلثة من القدر الثاني ايضا والثامن والعشرون هو التالي من
الثلثة من القدر الثاني ايضا وعلى جنوب هذا الكوكب كوكب
من القدر الرابع بينهما اقل من شبر لم يذكره بطلميوس والتاسع
والعشرون يميل الى الجنوب عن السادس والعشرين اكثر من ذراع
على طرف مقبض السيف من القدر الثالث من اصغر وذكره
بطلميوس مطلقا والثلثون هو الشمالي من الثلثة المصطفة
المتقاربة تحت الثامن والعشرين التالي من الثلثة التي على
المنطقة يميل عنه الى الجنوب اكثر من ذراع من القدر الرابع على طرف
السيف والحادي والثلثون هو الاوسط من الثلثة من القدر الثالث

Folio 323
The distance between it and the thirtieth is less than one *Shibr*

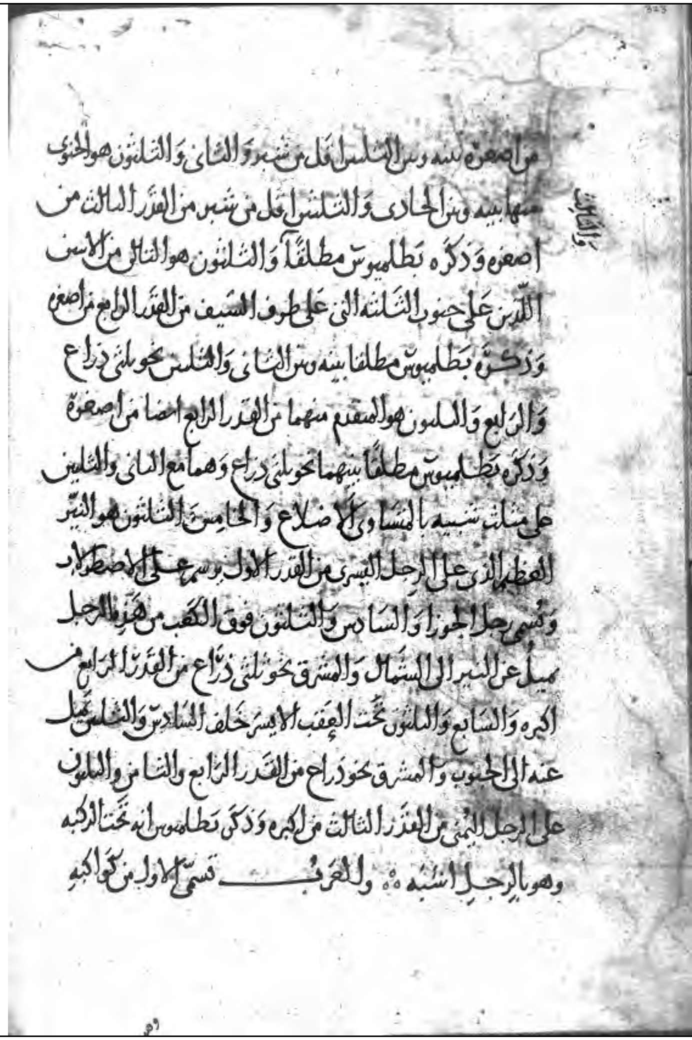
The thirty-second is the southernmost of them. The distance between it and the thirty-first is less than one *Shibr*. It is less than the 3rd magnitude. Ptolemy mentioned that it is exactly 3rd magnitude.

The thirty-third is the rearmost of the two stars that are south of the three which are on the tip of *al-Saif* (the sword). It is less than the 4th magnitude. Ptolemy mentioned that it is exactly 4th magnitude. The distance between it and the thirty-second is about two-thirds of a *dhirā'*.

The thirty-fourth is the more advanced of them. It is also less than the 4th magnitude. Ptolemy mentioned that it is exactly 4th magnitude. The distance between them is about two-thirds of a *dhirā'*. They form together with the thirty-second an almost *Muthallath Mutasāwi al-Aḍla'* (equilateral triangle).

The thirty-fifth is the large bright star on the left leg. It is of the 1st magnitude. It is (one of the stars that are) drawn on an astrolabe. It is called *Rijl al-Jauzā'* (the leg of Orion).

The thirty-sixth is above the *K'eb* (ankle-joint) of this leg. It is south-east of the bright star by two-third a *dhirā'*. It is greater than the 4th magnitude.
The thirty-seventh is under the left '*Akeb* (heel) and behind the thirty-sixth. It is south-east of it by one *dhirā'*. It is of the 4th magnitude.
The thirty-eighth is on the right *Rijl* (leg). It is greater than the 3rd magnitude. Ptolemy mentioned that it is under the *Rukba* (knee), but it is more likely on the leg.



Folio 324

The Arabs call the first of its stars which are the three small close-by stars which resemble the points of the letter *Tha* (ث) and which are located on the head, *al-Haq'a* and also *Haq'at al-Jauzā*. It was also mentioned as *al-Taḥātī*, *al-Taḥiyat* , *al-Taḥia* and also *al-Athāfī* because it resembles it. It is the fifth of the lunar mansions.

The great bright star (the second star) is called *Mankib al-Jauzā'* and also *Yad al-Jauzā'*. It was mentioned as *Mirzam al-Jauzā'* and this is wrong, because it was their practice to begin the name of any bright star by *Mirzam* like the two (stars) *Mirzam al-Shi'rayan*.

They called the third star which is on left shoulder *al-Nājid* and it was also called by *al-Mirzam.*

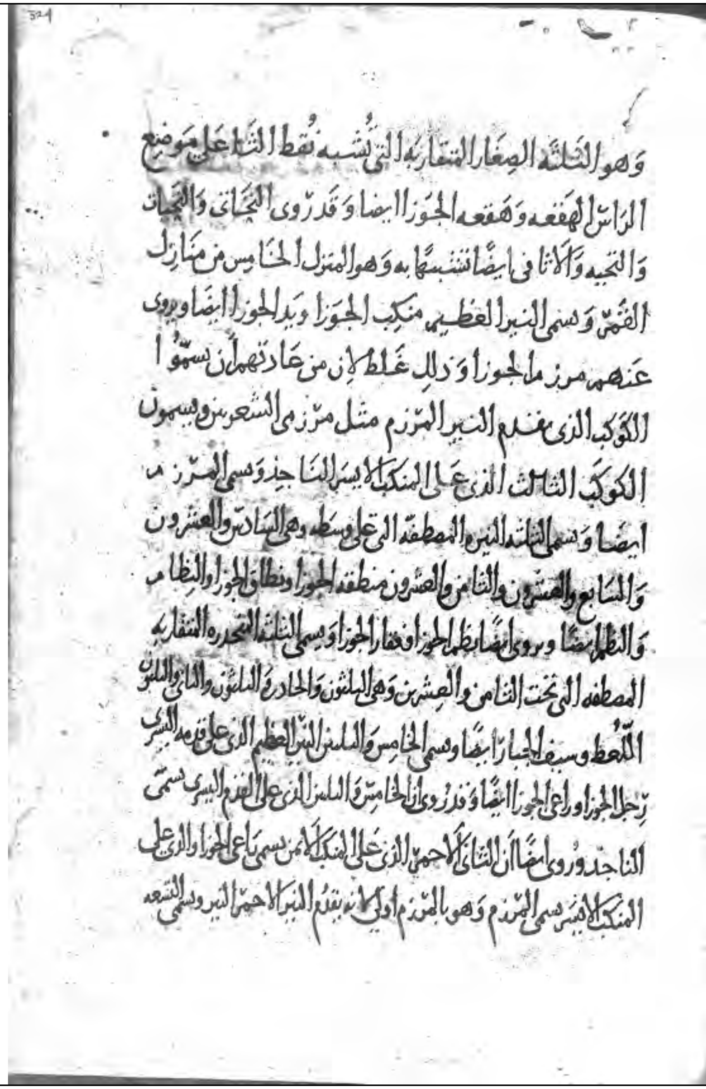
The three bright stars that are aligned on its middle and which are the twenty-sixth, the twenty-seventh and the twenty-eighth were called *Minṭaqat al-Jauzā'*, *Niṭāq al-Jauzā'* and *al-Niẓām* and also *al-Naẓm*. They were also mentioned as *Naẓm al-Jauzā'* and *Faqār al-Jauzā'*.

The three stars that are close-by and vertically aligned, located under the twenty-eighth, which are the thirtieth, the thirty-first and the thirty-second, were called *al-Laqaṭ* and also *Saif al-Jabbār*.

The thirty-fifth which is the great bright star on the left leg was called *Rijl al-Jauzā'* and *Rā'ī al-Jauzā'*. It was also mentioned that the thirty-fifth which is on the left leg was called *al-Nājid*.

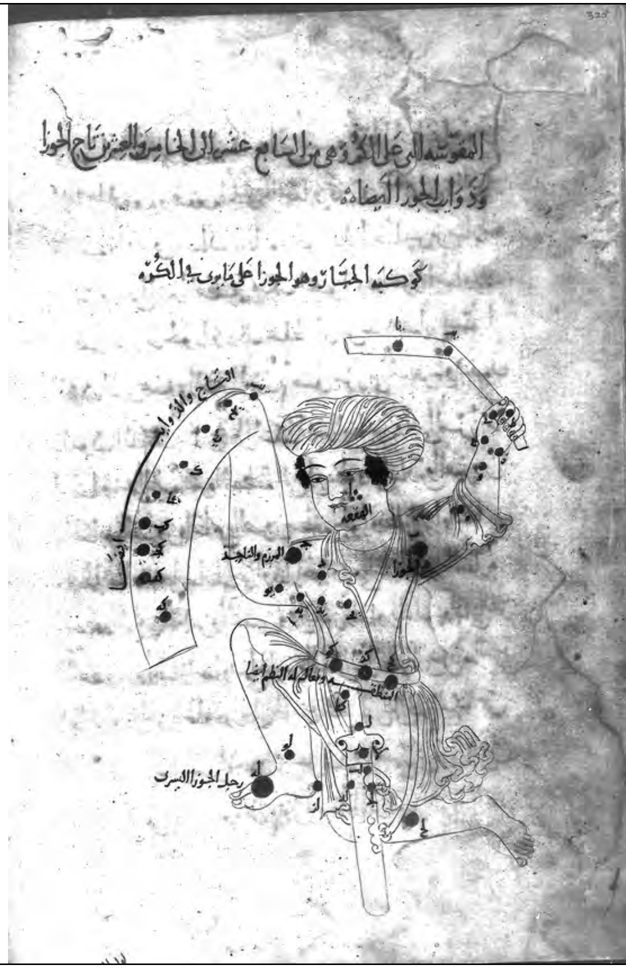
It was also mentioned that the second star that is the red star on the right shoulder was called *Rā'ī al-Jauzā'* and the one on the left shoulder was called *al-Mirzam* which is the first *Mirzam* because it proceeds the bright red star.

The nine curved stars that are on the pelt, which start from the seventeenth until the twenty-fifth, were called *Tāj al-Jauzā'* and also *Dhawā'īb al-Jauzā'*.



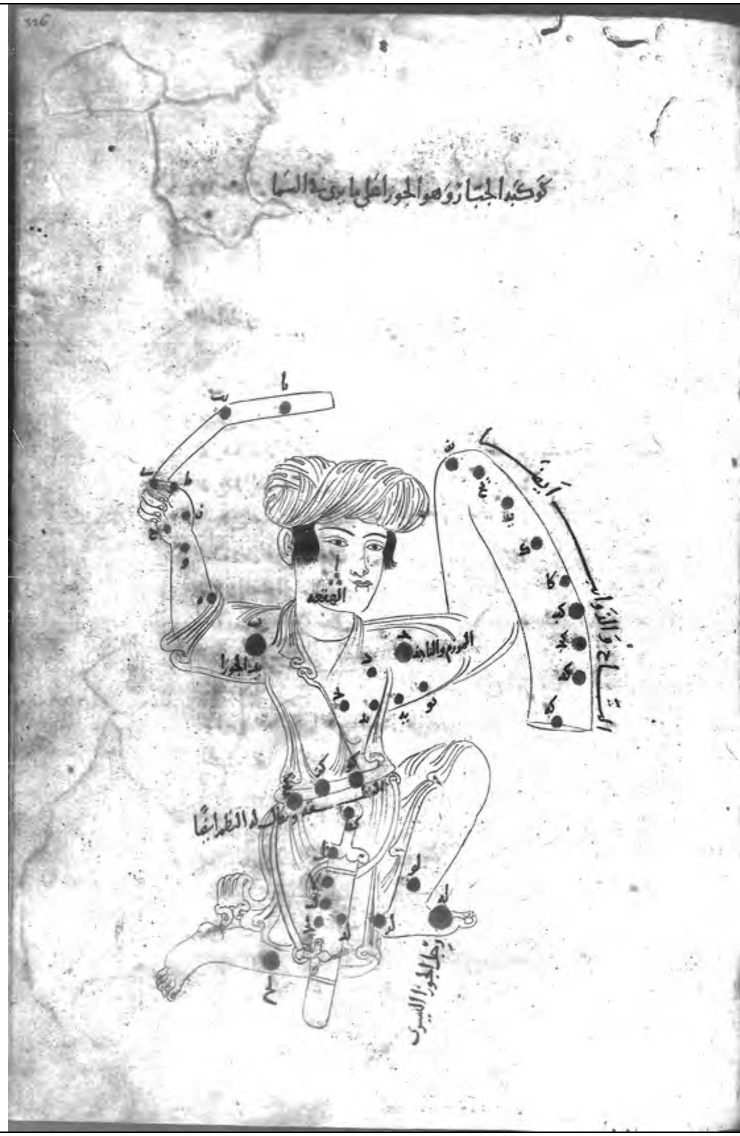
Folio 325

The constellation Orion (*al-Jabbār)* or *(al-Jauzā')* as seen on the globe.



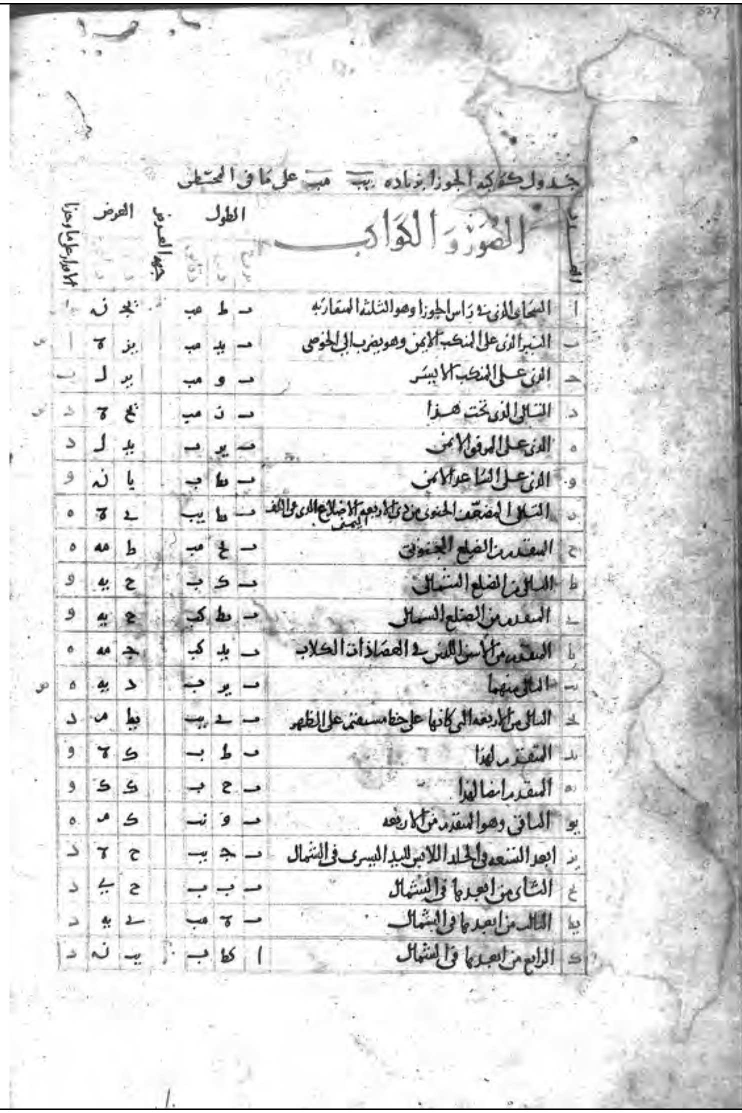
Folio 326

The constellation Orion (*al-Jabbār)* or *(al-Jauzā')* as seen in the sky.



Folio 327

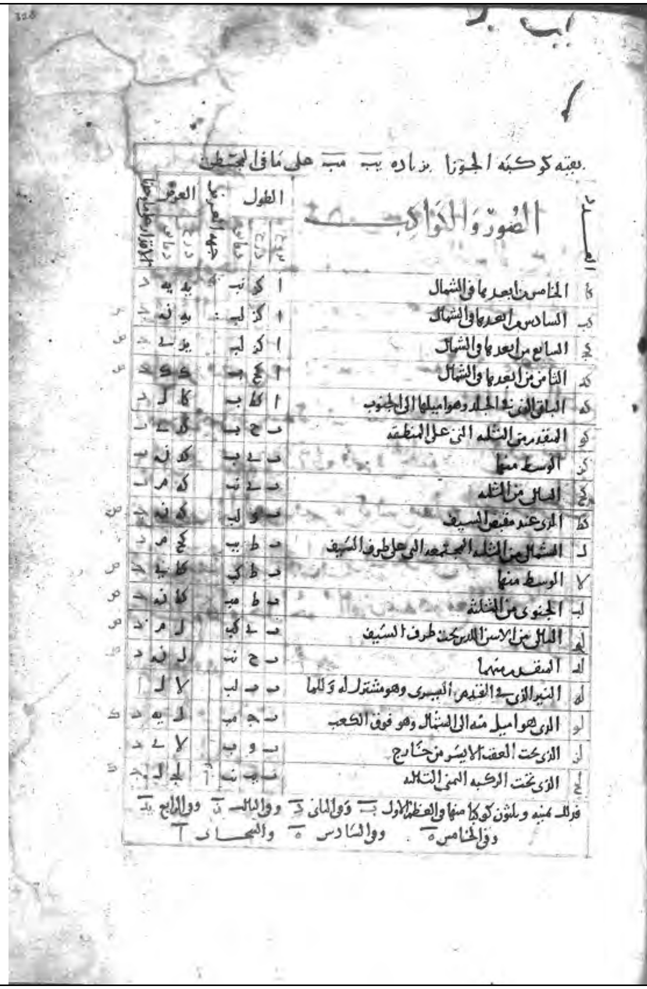
Table of the constellation Orion with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
number	Names of the stars	longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The nebulous star in the head of Orion, which are the three close stars	2(60)	09	42	S	13	50	nebula
2	The bright reddish star on the right shoulder	2(60)	14	42	S	17	00	1(s)
3	The star on the left shoulder	2(60)	06	42	S	17	30	2
4	The one under this to the rear	2(60)	50	42	S	18	00	4(s)
5	The star on the right elbow	2(60)	06	02	S	14	30	4
6	The star on the right forearm	2(60)	19	02	S	11	50	6
7	The quadrilateral in the right hand: The rear , double star on the southern side	2(60)	19	12	S	10	00	5
8	The advanced star on the southern side	2(60)	38	42	S	09	45	5
9	The rear one on the northern side	2(60)	20	02	S	08	15	6
10	The advanced one on the northern side	2(60)	19	22	S	08	15	6
11	The more advanced of the 2 stars in the staff	2(60)	14	22	S	03	45	5
12	The rearmost of them	2(60)	17	02	S	04	15	5(s)
13	The rearmost of the 4 stars almost on a straight line just over the back	2(60)	10	12	S	19	40	4
14	The one in advance of this	2(60)	09	02	S	20	00	6
15	The one in advance again of this	2(60)	08	02	S	20	20	6
16	The last and most advanced of the 4	2(60)	06	52	S	20	40	5
17	The stars in the pelt on the left arm: The northernmost	2(60)	03	12	S	08	00	4
18	The 2nd from the northernmost	2(60)	02	02	S	08	10	4
19	The 3rd from the northernmost	2(60)	00	42	S	10	15	4
20	The 4th from the northernmost	1(30)	29	02	S	12	50	4



Folio 328

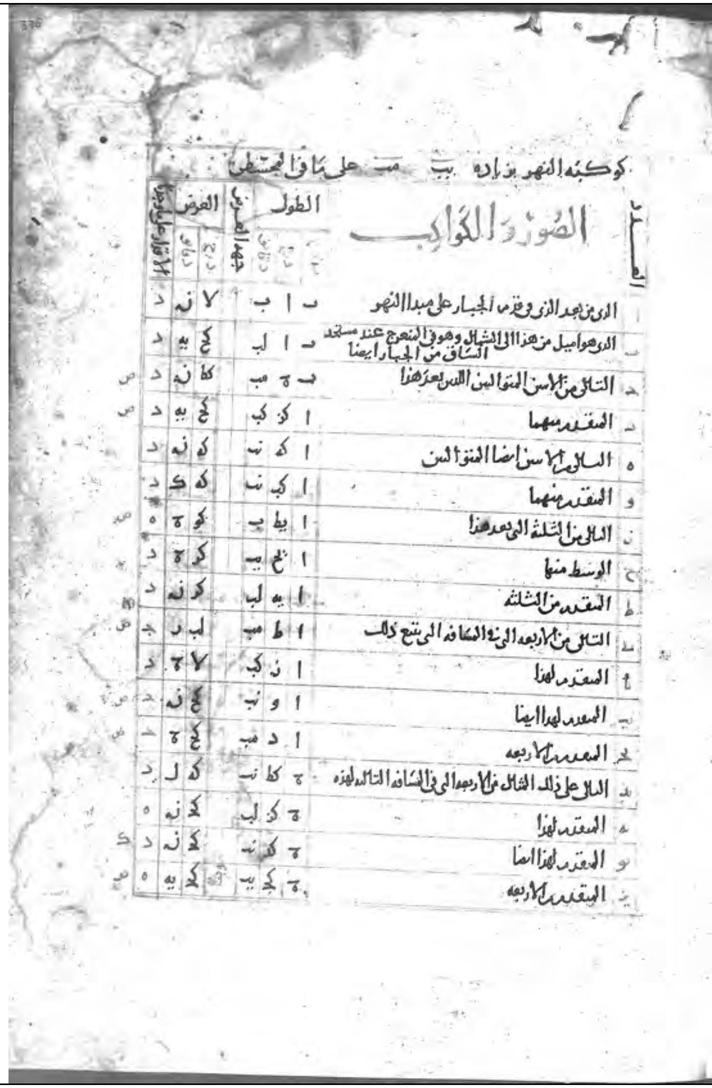
Table of the constellation Orion with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*

number	Names of the stars	longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
21	The 5th from the northernmost	1(30)	27	52	S	14	15	4
22	The 6th from the northernmost	1(30)	27	32	S	15	50	3(s)
23	The 7th from the northernmost	1(30)	27	32	S	17	10	3(s)
24	The 8th from the northernmost	1(30)	18	02	S	20	20	3(s)
25	The last and the southernmost of those in the pelt	1(30)	29	02	S	21	30	4
26	The most advanced of the 3 stars on the belt	2(60)	08	02	S	24	10	2
27	The middle one	2(60)	10	02	S	24	50	2
28	The rearmost of the three	2(60)	10	52	S	25	40	2
29	The star near the handle of the sward	2(60)	06	32	S	25	50	3(s)
30	The northernmost of the 3 stars joined together at the tip of the dagger	2(60)	09	12	S	28	40	4
31	The middle one	2(60)	09	22	S	29	10	3(s)
32	The southernmost of the three	2(60)	09	42	S	29	50	3(s)
33	The rearmost of the 2 stars under the tip of the sword	2(60)	10	22	S	30	40	4(s)
34	The more advanced of them	2(60)	08	52	S	30	50	4(s)
35	The bright star in the left foot, which is (applied in) common to the water (of Eridanus)	2(60)	02	32	S	31	30	1
36	The star to the north of it in the lower leg over the ankle-joint	2(60)	03	42	S	30	15	4(k)
37	The star under the left heel to the outside	2(60)	06	02	S	31	10	4
38	The star under the right rear knee	2(60)	12	52	S	33	30	3(k)
38 stars, 2 of the 1st magnitude, 4 of the 2nd, 7 of the 3rd, 14 of the 4th, 5 of the 5th, 5 of the 6th and 1 nebula.								



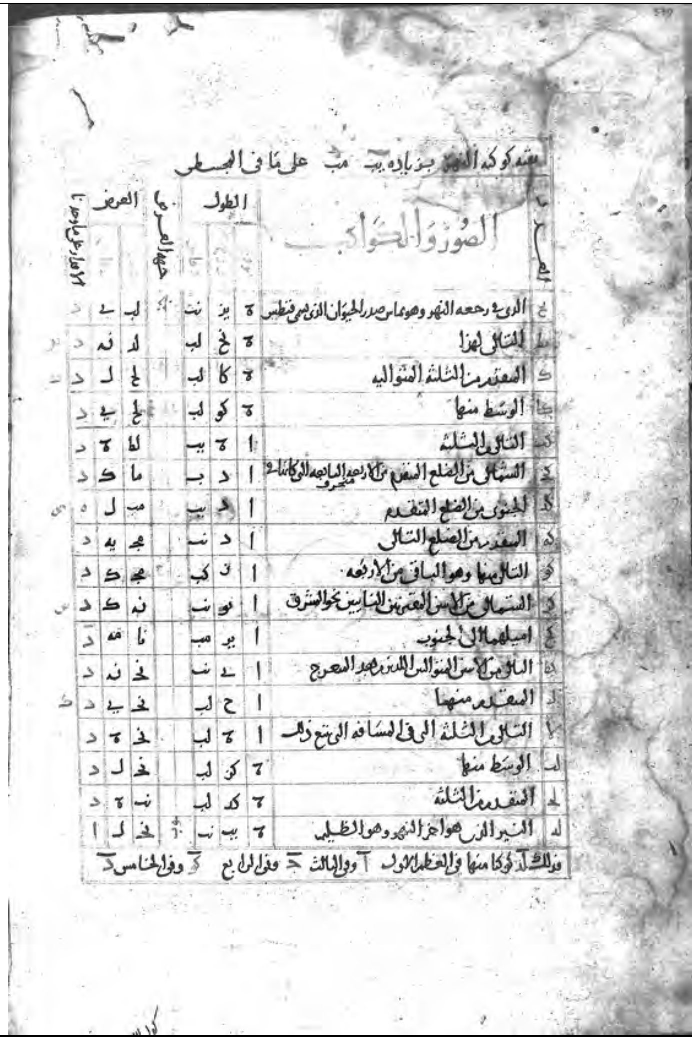
Folio 338

Constellation Eridanus (*al-Nahr*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star after the one in the foot of Orion [HR1713], at the beginning of the river"	2(60)	1	2	S	31	50	4
2	The one north of this, in the curve near the shin of Orion"	2(60)	1	32	S	28	15	4
3	The rearmost of the 2 stars next in order after this	2(60)	0	42	S	29	50	5
4	The more advanced of them	1(30)	27	22	S	28	15	4(s)
5	The rearmost of the next 2 in order again	1(30)	25	52	S	25	50	4
6	The more advanced of them	1(30)	22	52	S	25	20	4
7	The rearmost of the 3 stars after this	1(30)	19	2	S	26	0	5(s)
8	The middle one of these	1(30)	18	12	S	27	0	4
9	The most advanced of the three	1(30)	15	32	S	27	50	4
10	The rearmost of the four stars in the next interval	1(30)	9	42	S	32	7	3(s)
11	The one in advance of this	1(30)	7	22	S	31	0	4
12	The one in advance again of this	1(30)	6	52	S	28	50	4(m)
13	The most advanced of the 4	1(30)	4	42	S	28	0	3(s)
14	The rearmost of the 4 stars in the next interval again	0	29	52	S	25	30	4
15	The one in advance of this	0	27	32	S	23	50	5
16	The one in advance again of this	0	24	52	S	23	50	4(m)
17	The most advanced of the 4	0	23	12	S	23	15	6



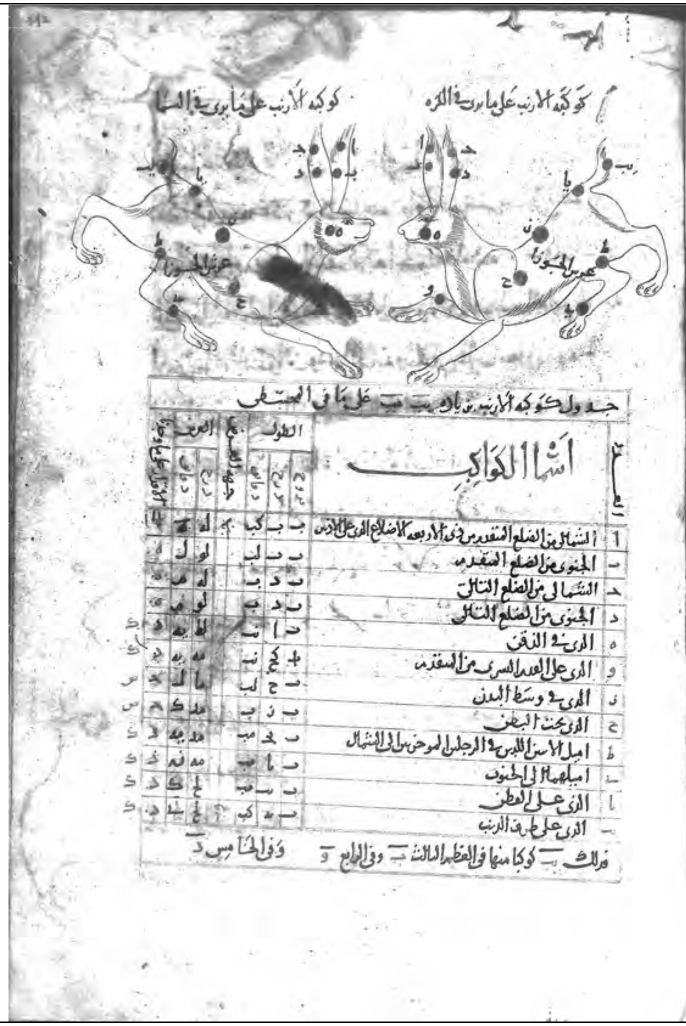
Folio 339

Remaining stars in the constellation Eridanus (*al-Nahr*) with with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
18	The first star in the bend of the river, which [star] touches the chest of Cetus"	0	17	52	S	32	10	4
19	The one to the rear of this	0	18	32	S	34	50	4(s)
20	The most advanced of the next [group of] three	0	21	32	S	38	30	4(m)
21	The middle one of these	0	26	32	S	38	10	4
22	The rearmost of the three	1(30)	0	12	S	39	0	4
23	The next four stars, nearly forming a trapezium: the northern one on the forward side"	1(30)	4	2	S	41	20	4
24	The southernmost on the forward side	1(30)	4	12	S	42	30	5(s)
25	The more advanced one on the rear side	1(30)	4	52	S	43	15	4
26	The last of the 4, the rear one on that side"	1(30)	7	22	S	43	20	4
27	The northernmost of the 2 stars close together at some distance to the east	1(30)	16	52	S	50	20	4(s)
28	The southernmost of them	1(30)	17	42	S	51	45	4
29	The rearmost of the next 2 stars after the bend	1(30)	10	52	S	53	50	4
30	The more advanced of them	1(30)	8	32	S	53	10	4(m)
31	The rearmost of the 3 stars in the next interval	1(30)	0	32	S	53	0	4
32	The middle one	0	27	32	S	53	30	4
33	The most advanced of the three	0	24	32	S	52	0	4
34	The last star of the river, the bright one	0	12	52	S	53	30	1
34 stars, 1 of the 1st magnitude, 3 of the 3rd magnitude, 26 of the 4th magnitude, 4 of the 5th magnitude.								



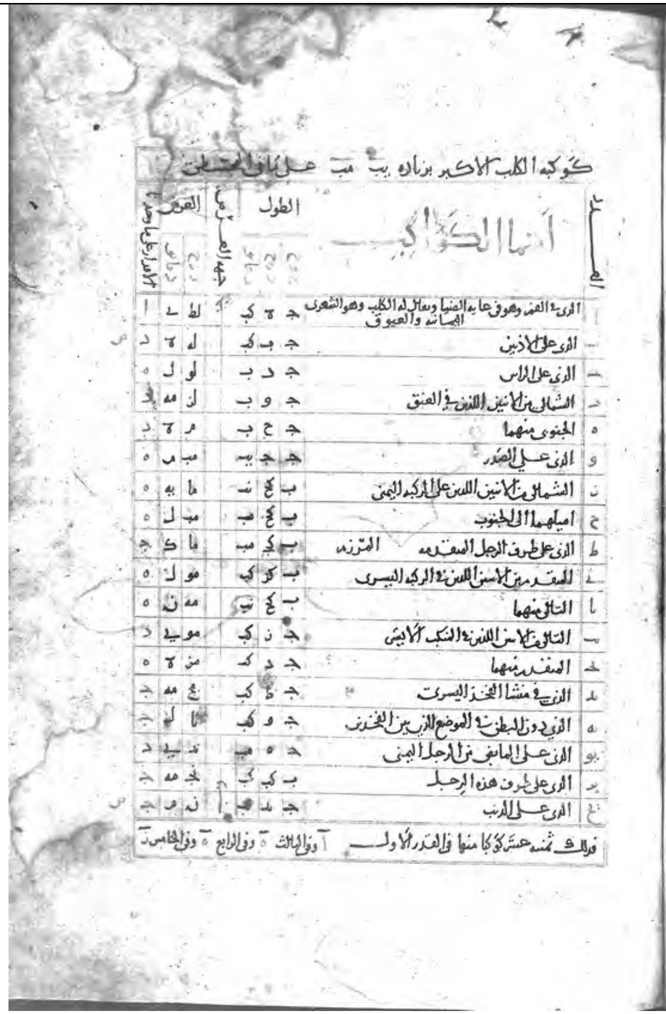
Folio 342

Table for the Constellation Lepus (*al-Arnab*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The quadrilateral just over the ears: the northern star on the forward side	2(60)	2	22	S	35	0	5
2	The southern star on the forward side	2(60)	2	32	S	36	30	5
3	The northern star on the rear side	2(60)	4	2	S	35	40	5
4	The southern star on the rear side	2(60)	4	2	S	36	40	5
5	The star in the cheek	2(60)	1	52	S	39	15	4(k)
6	The star on the left front foot	2(60)	28	52	S	45	15	4(m)
7	The star in the middle of the body	2(60)	8	32	S	41	30	3(s)
8	The star under the belly	2(60)	7	2	S	44	20	3(s)
9	The northernmost of the 2 stars in the hind legs	2(60)	18	42	S	44	15	4(k)
10	The southernmost of them	2(60)	11	42	S	45	50	4(k)
11	The star on the rump	2(60)	12	42	S	38	20	4(k)
12	The star on the tip of the tail	2(60)	15	22	S	38	10	4(k)
12 stars, 2 of the 3rd magnitude, 6 of the 4th magnitude, 4 of the 5th magnitude								



Folio 350

Constellation Canis Major (*al-Kalb al-Akbar*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star in the mouth, the brightest, which is called *al-Kalb* (Dog) and *al-Shi'ra al-Yamāniya* and *al-'Ayyūq*	3(90)	0	22	S	39	10	1
2	The star on the ears	3(90)	2	22	S	35	0	4(s)
3	The star on the head	3(90)	4	2	S	36	30	5
4	The northernmost of the 2 stars in the neck	3(90)	6	2	S	37	45	4
5	The southernmost of them	3(90)	8	2	S	40	0	4
6	The star on the chest	3(90)	3	12	S	42	40	5
7	The northernmost of the 2 stars on the right knee	2(60)	28	52	S	41	15	5
8	The southernmost of them	2(60)	28	42	S	42	30	5
9	The star on the end of the front leg *al-Mirzam*	2(60)	23	42	S	41	20	3
10	The more advanced of the 2 stars in the left knee	2(60)	27	22	S	46	30	5
11	The rearmost of them	2(60)	28	52	S	45	50	5
12	The rearmost of the 2 stars in the left shoulder	3(90)	7	22	S	46	10	4
13	The more advanced of them	3(90)	4	22	S	47	0	5
14	The star in the place where the left thigh joins [the body]	3(90)	9	22	S	48	45	3
15	The star below the belly, in the middle of the thighs	3(90)	6	22	S	51	30	3
16	The star on the joint of the right leg	3(90)	5	42	S	54	10	4
17	The star on the end of the right leg	2(60)	22	22	S	53	45	3
18	The star on the tail	3(90)	14	52	S	50	40	3(s)
18 stars, 1 of the 1st magnitude, 5 of the 3rd magnitude, 5 of the 4th, 7 of the 5th magnitude.								

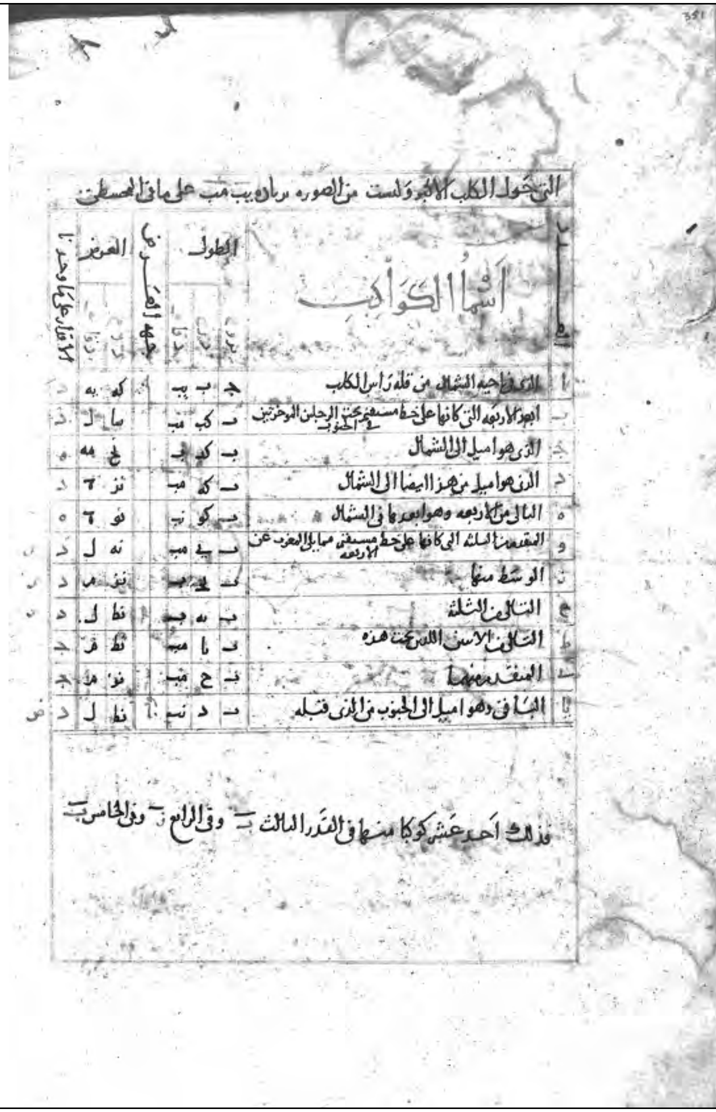


Folio 351

The ones surrounding the constellation Canis Major but not in it with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star to the north of the top of Canis Major	3(90)	2	12	S	25	15	4
2	The southernmost of the 4 stars almost on a straight line under the hind legs	2(60)	22	42	S	61	30	4
3	The one north of this	2(60)	24	2	S	58	45	5
4	The one north again of this	2(60)	25	42	S	57	0	4
5	The last and northernmost of the 4	2(60)	26	52	S	56	0	5
6	The most advanced of the 3 stars almost on a straight line to the west of the [above] four	2(60)	10	42	S	55	30	4(s)
7	The middle one	2(60)	13	2	S	57	40	5
8	The rearmost of the three	2(60)	15	2	S	59	30	4(s)
9	The rearmost of the 2 bright stars under these	2(60)	11	42	S	59	40	3
10	The more advanced of them	2(60)	8	42	S	57	40	3
11	The last star, to the south of the above	2(60)	4	52	S	59	30	4(s)

11 stars, 2 of the 3rd magnitude, 7 of the 4th magnitude, 2 of the 5th magnitude.

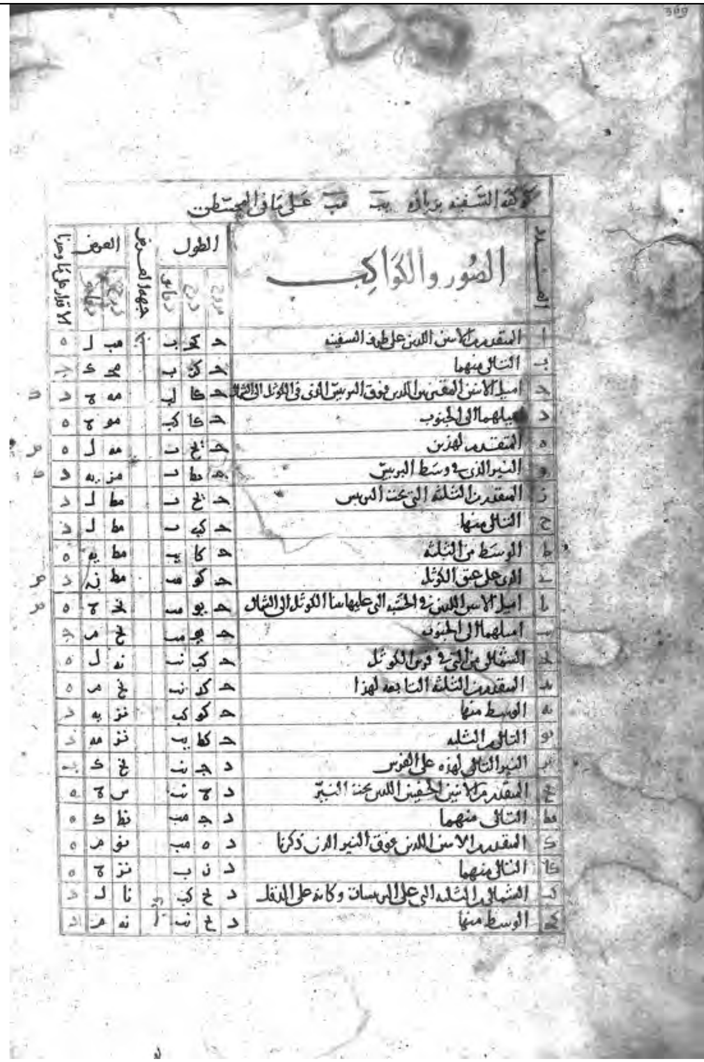


Folio 353

Constellation Canis Minor (*al-Kalb al-Mutaqadem) (al-Kalb al-Aṣghar)* with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star in the neck called *al-Mirzam*	3(90)	7	42	S	14	0	4
2	The bright star just over the hindquarters, called *al-Shi'ra al-Shāmīya* and *al-Ghumaiṣa* (Procyon)	3(90)	11	52	S	16	10	1
2 stars, 1 of the 1st magnitude, 1 of the 4th magnitude								

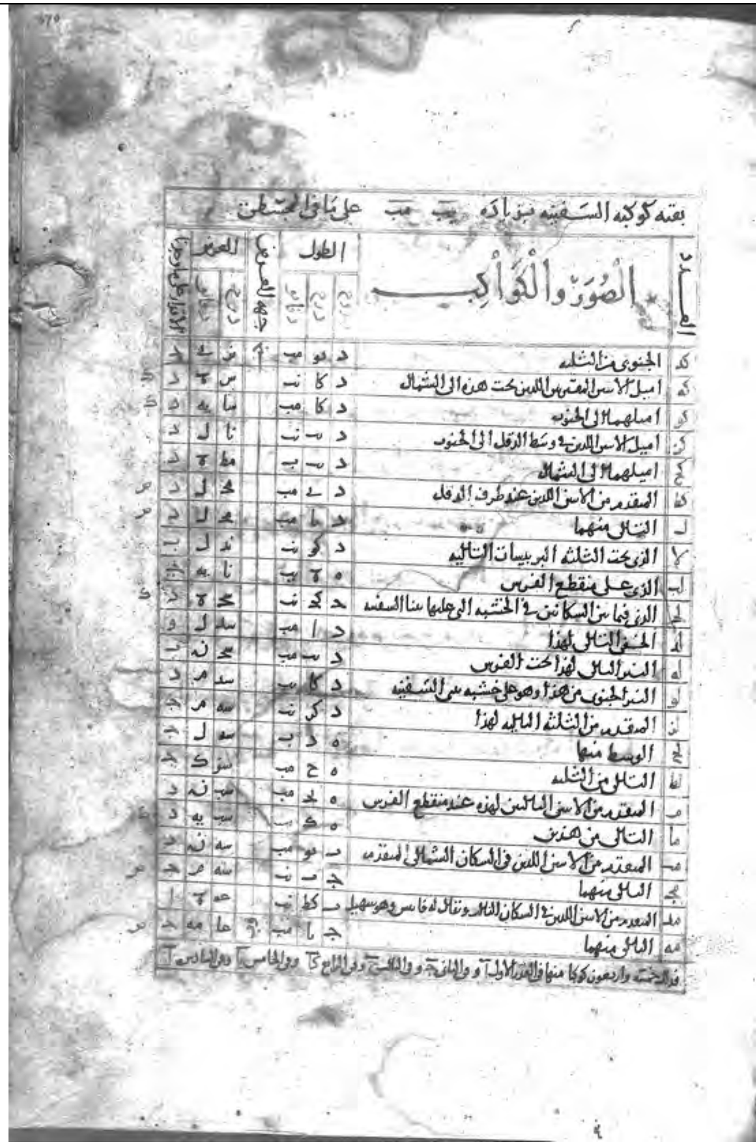
Folio 369

Constellation Argo Navis (*al-Safina*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The more advanced of the 2 stars in the stern-ornament	3(90)	23	2	S	42	30	5
2	The rearmost of them	3(90)	27	2	S	43	20	3
3	The northernmost of the 2 stars close together over the little shield in the poop	3(90)	21	31	S	45	0	4(m)
4	The southernmost of them	3(90)	21	22	S	46	0	5
5	The star in advance of these	3(90)	18	2	S	45	30	5(s)
6	The bright star in the middle of the little shield	3(90)	19	2	S	47	15	4(m)
7	The most advanced of the 3 stars under the little shield	3(90)	18	2	S	49	30	4
8	The rearmost of them	3(90)	22	2	S	49	30	4
9	The middle one of the three	3(90)	21	12	S	49	15	5
10	The star on the goose [-neck]	3(90)	26	42	S	49	50	4(s)
11	The northernmost of the 2 stars in the stern-keel	3(90)	16	42	S	53	0	5(s)
12	The southernmost of them	3(90)	16	42	S	58	40	3
13	The northernmost of the stars in the poop-deck:	3(90)	22	52	S	55	30	5
14	The most advanced of the next 3	3(90)	24	52	S	58	40	5
15	The middle one	3(90)	26	22	S	57	15	4
16	The rearmost of the three	3(90)	29	12	S	57	45	4
17	The bright star on the deck to the rear of these	4(120)	3	52	S	58	20	2
18	The more advanced of the 2 faint stars under the bright one	4(120)	0	52	S	60	0	5
19	The rearmost of them	4(120)	3	42	S	59	20	5
20	The more advanced of the 2 stars over the above-mentioned bright one	4(120)	5	42	S	56	40	5
21	The rearmost of them	4(120)	7	2	S	57	0	5
22	The northernmost of the 3 stars on the little shields, approximately on the mast-holder"	4(120)	18	22	S	51	30	4
23	The middle one	4(120)	18	52	S	55	40	4



Folio 370

Remaining stars of the constellation Argo Navis with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
24	The southernmost of the three	4(120)	16	42	S	57	10	4
25	The northernmost of the 2 stars close together under these	4(120)	21	52	S	60	0	4(k)
26	The southernmost of them	4(120)	21	42	S	61	15	4(k)
27	The southernmost of the 2 stars in the middle of the mast	4(120)	12	52	S	51	30	4
28	The northernmost of them	4(120)	12	2	S	49	0	4
29	The more advanced of the 2 stars by the tip of the mast	4(120)	10	42	S	43	30	4(s)
30	The rearmost of them	4(120)	11	42	S	43	30	4(s)
31	The star below the 3rd and rearmost little shield	4(120)	26	52	S	54	30	2
32	The star on the cut-off of the deck	5(150)	0	12	S	51	15	3
33	The star between the steering-oars in the keel	3(90)	23	52	S	63	0	4(m)
34	The faint star to the rear of this	4(120)	1	42	S	64	30	6
35	The bright star to the rear of this, under the deck	4(120)	12	42	S	63	50	2
36	The bright star to the south of this, on the lower [part of the] keel	4(120)	21	12	S	64	40	4
37	The most advanced of the 3 stars to the rear of this	4(120)	27	52	S	65	40	3
38	The middle one	5(150)	4	2	S	65	30	3
39	The rearmost of the three	5(150)	8	42	S	66	20	3
40	The more advanced of the 2 stars to the rear of these, near the cut-off	5(150)	13	42	S	62	50	4
41	The rearmost of them	5(150)	20	42	S	62	15	4(m)
42	The more advanced of the 2 stars in the northern, forward steering-oar	2(60)	16	42	S	65	50	4
43	The rearmost of them	3(90)	2	52	S	65	40	3(s)
44	The more advanced of the 2 stars in the other steering-oar, called *Suhail* (Canopus)	2(60)	29	52	S	75	0	1
45	The other, rearmost star	3(90)	11	42	S	71	45	3(s)
45 stars, 1 of the 1st magnitude, 3 of the 2nd, 8 of the 3rd, 21 of the 4th, 11 of the 5th, 1 of the 6th.								



Folio 381

Constellation Hydra (*al-Shujāʿ*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*

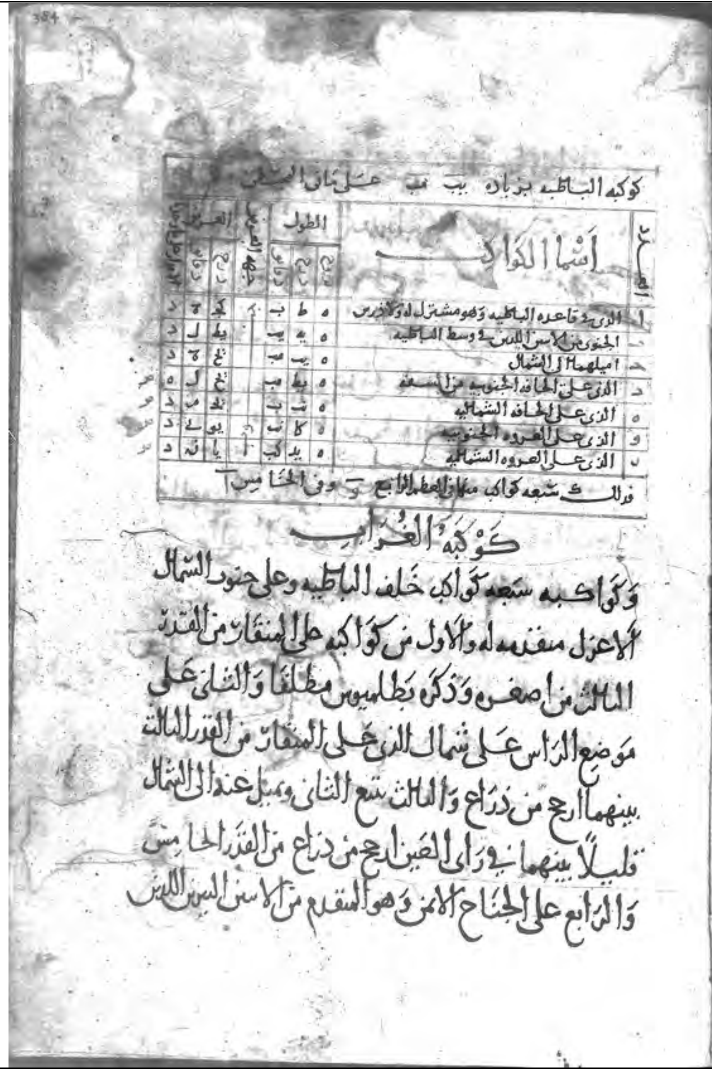
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The 5 stars in the head: the southernmost of the 2 advance ones, which is on the nostrils	3(90)	26	42	S	15	0	4(s)
2	The northernmost of these [2], which is above the eye	3(90)	26	2	S	13	10	4
3	The northernmost of the 2 to the rear of these, which is approximately on the skull	3(90)	28	2	S	11	30	4
4	The southernmost of them, on the gaping jaws	3(90)	28	12	S	14	45	5
5	The rearmost of all, approximately on the cheek	4(120)	0	32	S	12	0	4(m)
6	The more advanced of the 2 stars in the place where the neck joins [the head]	4(120)	3	2	S	14	40	6
7	The rearmost of them	4(120)	6	2	S	19	20	4
8	The middle star of the following three in the bend of the neck	4(120)	11	32	S	15	20	4(s)
9	The rearmost of the 3	4(120)	13	22	S	14	50	4(s)
10	The southernmost of them	4(120)	11	12	S	17	10	4(s)
11	The faint, northernmost star of the 2 close together to the south	4(120)	11	52	S	19	45	6(s)
12	The bright one of these two close stars called *al-Fard*	4(120)	12	42	S	20	30	2
13	The most advanced of the 3 stars to the rear, after the bend [in the neck]	4(120)	18	42	S	26	30	4
14	The middle one	4(120)	21	22	S	26	0	4
15	The rearmost of the three	4(120)	23	52	S	23	15	4(k)
16	The most advanced of the next 3 stars almost on a straight line	5(150)	0	42	S	24	40	3(s)
17	The middle one	5(150)	2	42	S	23	0	4(s)
18	The rearmost of the three	5(150)	5	42	S	22	10	3
19	The northernmost of the 2 stars after [i.e. to the rear of] the base of Crater	5(150)	14	12	S	25	45	4
20	The southernmost of them	5(150)	15	2	S	30	10	4

21	The most advanced of the 3 stars after these, as it were in a triangle	5(150)	24	52	S	31	20	4(k)
22	The middle and southernmost one	5(150)	27	12	S	33	10	4
23	The rearmost of the three	5(150)	28	52	S	31	20	3
24	The star after Corvus, in the section by the tail	6(180)	12	42	S	13	40	3(s)
25	The star on the tip of the tail	6(180)	26	12	S	17	40	3(s)
25 stars, 1 is of the 2nd magnitude, 5 of the 3rd magnitude, 16 of the 4th magnitude, 1of the 5th magnitude. and 2 of the 6th magnitude								
The ones surrounding the constellation Hydra but not in it.								
1	The star to the south of the head	3(90)	25	12	S	23	15	3
2	The star some distance to the rear of those in the neck [nos. 6-15]	4(120)	23	42	S	16	0	4
2 stars 1 of the 3rd magnitude and 1 of the 4th magnitude.								

Folio 384

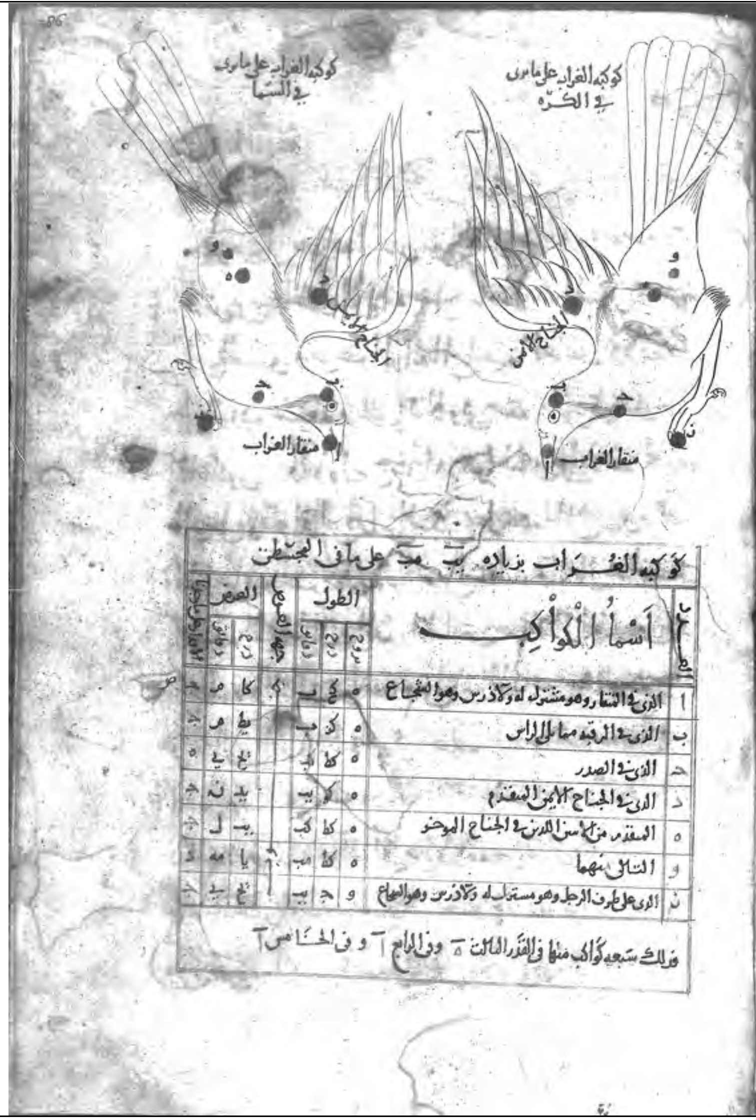
Constellation Crater (*al-Bāṭīya*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star in the base of bowl, which is common to Hydra	5(150)	9	2	S	23	0	4
2	The southernmost of the 2 stars in the middle of the bowl	5(150)	15	12	S	19	30	4
3	The northernmost of them	5(150)	12	42	S	18	0	4
4	The star on the southern rim of the mouth (of the bowl)	5(150)	19	42	S	18	30	5(s)
5	The star on the northern rim	5(150)	52	2	S	13	40	4(s)
6	The star on the southern handle	5(150)	21	52	S	16	10	4(s)
7	The star on the northern handle	5(150)	14	22	S	11	50	4(s)
7 stars, 6 of the 4th magnitude, 1of the 5th magnitude								



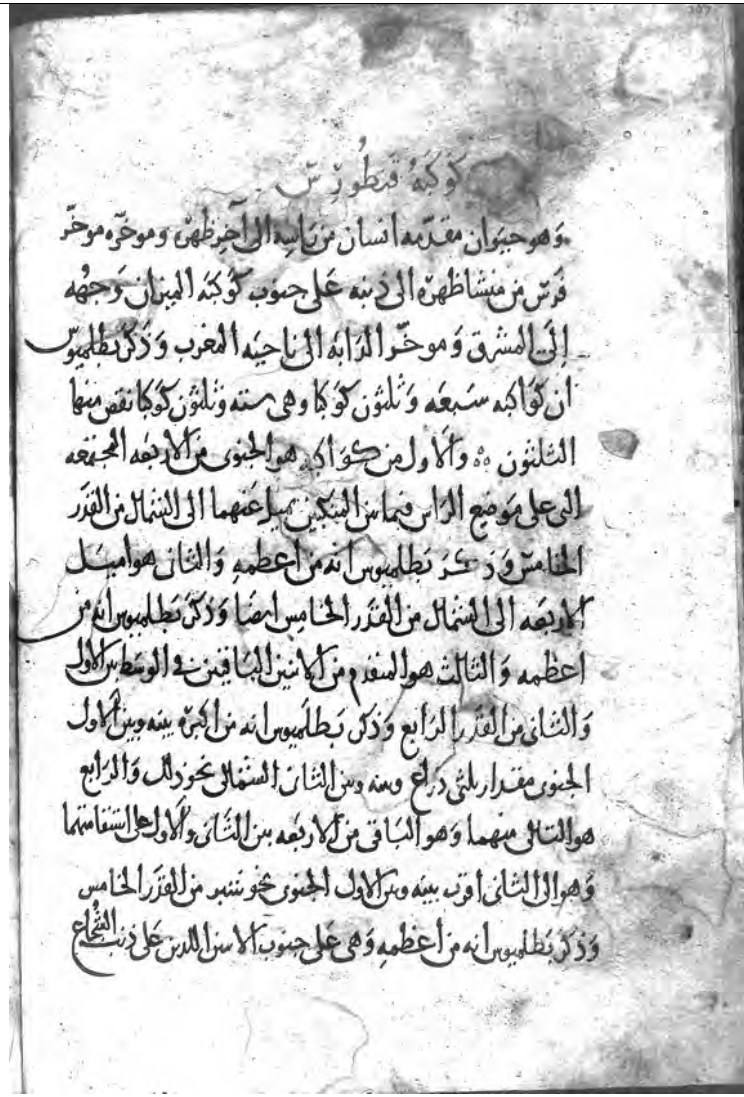
Folio 386

Constellation Corvus (*al-Ghurāb*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star in the beak, which is common to Hydra	5(150)	28	2	S	21	40	3(s)
2	The star in the neck, by the head	5(150)	27	2	S	19	40	3
3	The star in the breast	5(150)	29	22	S	18	10	5
4	The star in the forward right wing	5(150)	26	12	S	14	50	3
5	The more advanced of the 2 stars in the rear wing	5(150)	29	22	S	12	30	3
6	The rearmost of them	5(150)	29	42	S	11	45	4
7	The star on the end of the leg, which is common to Hydra	6(180)	3	12	S	18	10	3
7 stars, 5 of the 3rd magnitude, 1 of the 4th magnitude and 1 of the 5th magnitude								



Folio 387 (Manuscript Marsh144)
The constellation Centaurus (*Qanṭūris*)

It is (the image of) an animal, with its forward part resembling a human being from its head until the end of its back. Its rearward part resembles a horse from the start of its back until its tail. It is south of the constellation *al-Mīzān* (Libra). Its head is pointing towards the east and the rear of the animal is pointing towards the west. Ptolemy mentioned that its stars are thirty-seven stars; however there are thirty-six stars with the thirtieth (star) missing.
The first of its stars is the southernmost of the four that are clustered on the head, which is located between the two shoulder-blades and inclined towards the north of the two (shoulder-blades). It is of the 5^{th} magnitude. Ptolemy mentioned that it is much greater than the 5^{th} magnitude.
The second is the northernmost of the four. It is also of the 5^{th} magnitude. Ptolemy mentioned that it is much greater than the 5^{th} magnitude.
The third is the more advanced of the remaining two (stars) located in the middle between the first and the second. It is of the 4^{th} magnitude. Ptolemy mentioned that it is greater than the 4^{th} magnitude.
The distance between it and the first southerly star is a distance of two-third of a *dhirā'*. The distance between it and the second northerly star is the same distance.
The fourth (star) is the rearmost of these. It is the last of the four stars. It is located on a straight line between the first and the second. It is closer to the second star. The distance between it and the first southerly star is one *Shibr*. It is of the 5^{th} magnitude. Ptolemy mentioned that it is much greater than the 5^{th} magnitude. It is located south of the two stars on the tail of *al-Shujā'* (the constellation Hydra).



Folio 388

It is closer to the twenty-fifth star which is on the tip of the tail (of the constellation Hydra).

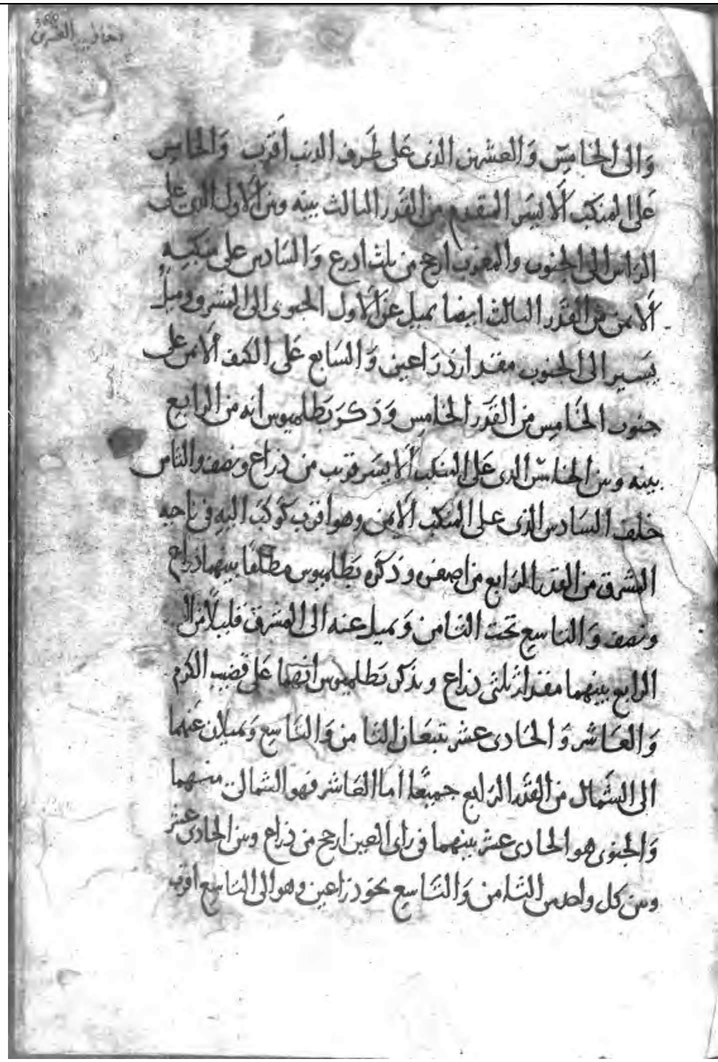
The fifth is on the left advanced shoulder. It is of the 3rd magnitude. The distance between it and the first star on the head towards the south-west is a distance of one third of a *dhirā‘*.

The sixth star is on the right shoulder. It is also of the 3rd magnitude. It is located east of the southerly first star and slightly towards the south by a distance of two *dhirā‘*.

The seventh is on the right shoulder-blade south of the fifth star. It is of the 5th magnitude. Ptolemy mentioned that it is of the 4th magnitude. The distance between it and the fifth star which is on the left shoulder is close to one and a half *dhirā‘*.

The eighth star is behind the sixth star that is on the right shoulder. It is the closest star to it from the east. It is less than the 4th magnitude. Ptolemy mentioned that it is exactly 4th magnitude. The distance between them is one and half *dhirā‘*.

The ninth is under the eighth star and slightly towards the east from it. It is of the 4th magnitude. The distance between them is two-thirds of a *dhirā‘*. Ptolemy mentioned that they are located on the *Kaḍīb al-Karm* (thyrsus or vine leaves). The tenth and the eleventh follow the eighth and the ninth towards the north. Both are of the 4th magnitude. As for the tenth it is the northerly of the two, and the southerly is the eleventh. The distance between them as the eye can see is a distance of one *dhirā‘*. The distance between the eleventh star and both the eighth and the ninth stars is a distance of two *dhirā‘*. It is closer to the ninth.


والى الخامس والعشرين الذي على طرف الذنب اقرب والخامس
على المنكب الايسر المتقدم من القدر الثالث بينه وبين الاول الذي على
الراس الى الجنوب والمغرب اقرب من ثلث ذراع والسادس على منكبه
الايمن من القدر الثالث ايضا يميل عن الاول الجنوبي الى المشرق ويميل
يسيرا الى الجنوب مقدار ذراعين والسابع على الكتف الايمن على
جنوب الخامس من القدر الخامس وذكر بطلميوس انه من الرابع
بينه وبين الخامس الذي على المنكب الايسر قريب من ذراع ونصف والثامن
خلف السادس الذي على المنكب الايمن وهو اقرب كوكب اليه في ناحية
المشرق من القدر الرابع من اصغر وذكر بطلميوس مطلقا بينهما ذراع
ونصف والتاسع تحت الثامن ويميل عنه الى المشرق قليلا من
الرابع بينهما مقدار ثلثي ذراع وذكر بطلميوس انهما على قضيب الكرم
والعاشر والحادي عشر يتبعان الثامن والتاسع ويميلان عنهما
الى الشمال من القدر الرابع جميعا اما العاشر فهو الشمالي منهما
والجنوبي هو الحادي عشر بينهما في راي العين اقرب من ذراع وبين الحادي عشر
وبين كل واحد من الثامن والتاسع نحو ذراعين وهو الى التاسع اقرب

Folio 389
Ptolemy mentioned that they are on the tip of the thyrsus (vine leaves).

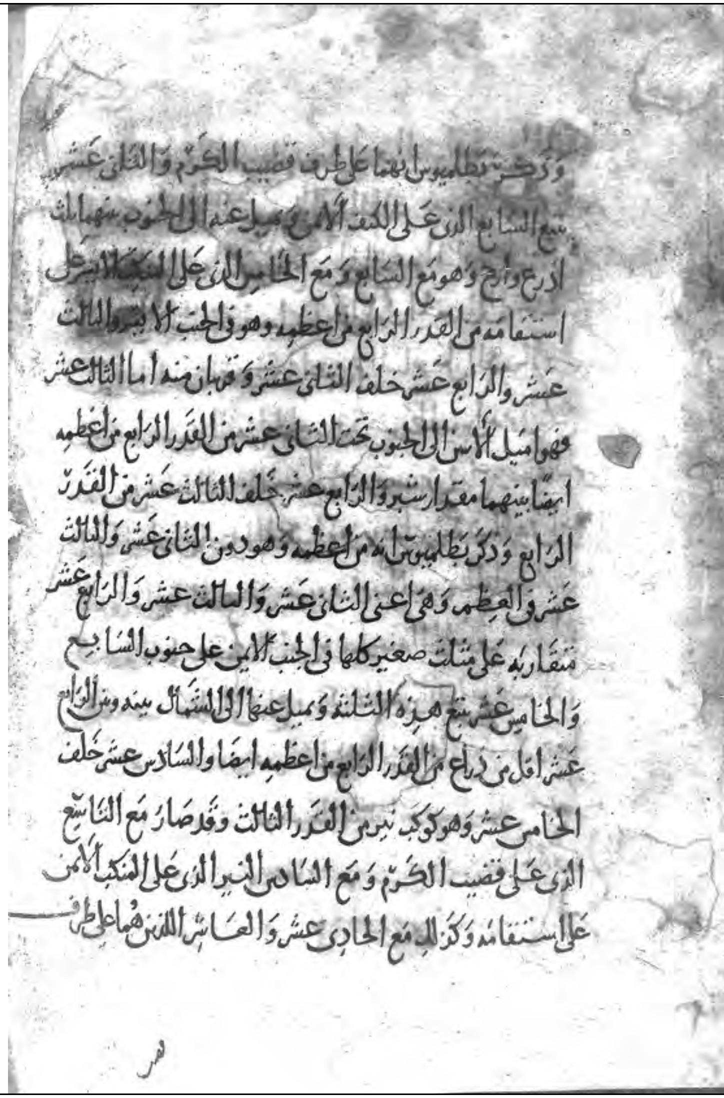
The twelfth is below the seventh star which is on the right shoulder. It is to the south of it and the distance between them is one-third of a *dhirā‘* and slightly more. It forms a straight line together with the seventh and the fifth star which is on the left shoulder. It is much greater than the 4th magnitude. It is on the left hand side.

The thirteenth and fourteenth stars are next to and close to it (twelfth). As for the thirteenth it is the southernmost of the two below the twelfth. It is also much greater than the 4th magnitude. The distance between them is one *Shibr.*

The fourteenth is next to the thirteenth. It is of the 4th magnitude. Ptolemy mentioned that it is much greater (than 4th magnitude); however it is less than the twelfth and the thirteenth in magnitude. The twelfth, thirteenth and the fourteenth are close together and they form a small triangle. They are all on the right side and south of the seventh star.

The fifteenth star follows these three stars towards the south. The distance between it and the fourteenth is less than one *dhirā‘*. It is also much greater than the 4th magnitude.

The sixteenth is behind the fifteenth and it is a bright star of the 3rd magnitude. It forms a straight line together with the ninth star which is on the thyrsus and with the bright sixth star which is on the right shoulder. It also forms a straight line together with the eleventh star and with the tenth star which are on the tip of the thyrsus


وذكر بطلميوس انهما على طرف قضيب الكرم والثاني عشر
يتبع السابع الذي على الكتف الايمن ويميل عنه الى الجنوب بينهما ثلث
ذراع وارجح وهو مع السابع ومع الخامس الذي على المنكب الايسر على
استقامة من القدر الرابع من اعظمه وهو في الجنب الايسر والثالث
عشر والرابع عشر خلف الثاني عشر وقريبان منه اما الثالث عشر
فهو اميل الاثنين الى الجنوب تحت الثاني عشر من القدر الرابع من اعظمه
ايضا بينهما مقدار شبر والرابع عشر خلف الثالث عشر من القدر
الرابع وذكر بطلميوس انه من اعظمه وهو دون الثاني عشر والثالث
عشر في العظم وهي اعني الثاني عشر والثالث عشر والرابع عشر
متقاربة على مثلث صغير كلها في الجنب الايمن على جنوب السابع
والخامس عشر يتبع هذه الثلثة ويميل عنها الى الشمال بينه وبين الرابع
عشر اقل من ذراع من القدر الرابع من اعظمه ايضا والسادس عشر خلف
الخامس عشر وهو كوكب نير من القدر الثالث وقد صار مع التاسع
الذي على قضيب الكرم ومع السادس النير الذي على المنكب الايمن
على استقامة وكذلك مع الحادي عشر والعاشر اللذين هما على طرف

Folio 390

It is as if it forms an equilateral triangle together with tenth star and the sixth star which is on the right shoulder, with this bright sixteenth star on the its head. It is located on the right arm.

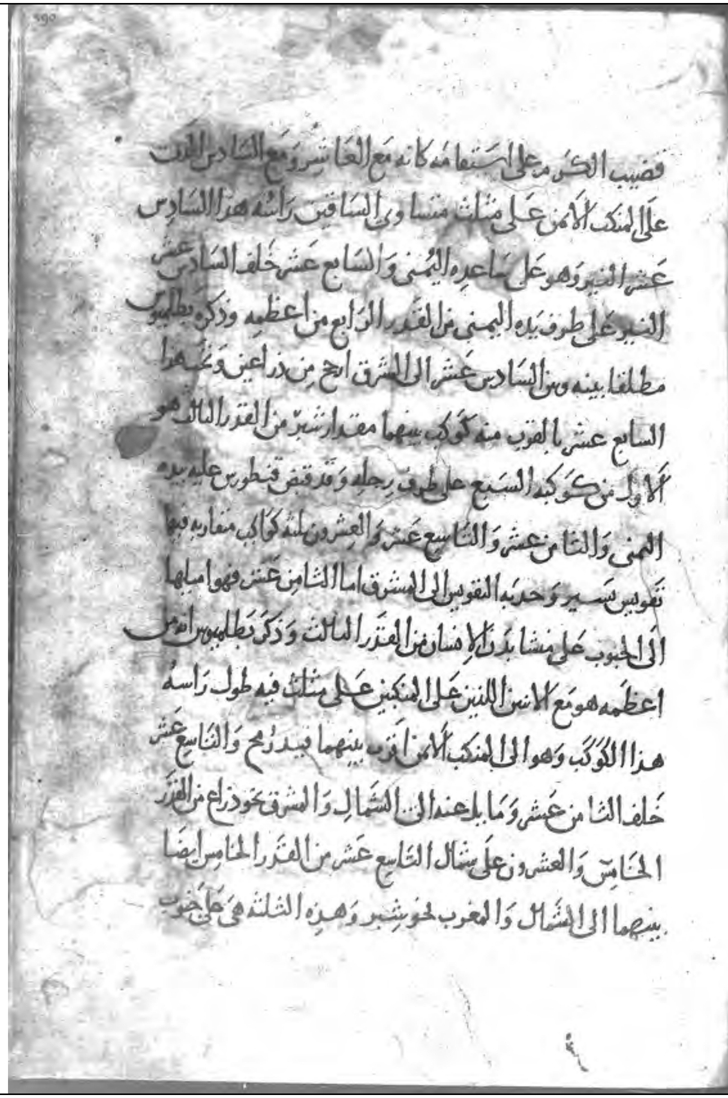
The seventeenth (star) is behind the bright sixteenth (star). It is located on the tip of its hand. It is much greater than the 4th magnitude. Ptolemy mentioned that it is exactly 4th magnitude. The distance between it and the sixteenth (star) towards the east is more than two *dhirā'*. Under this seventeenth star and close by is a star with a distance between them of one *Shibr*. It is of the 3rd magnitude. It is the first star on the leg of the constellation al-Sab' (constellation Lupus), with Centaurus grabbing it with his right hand.

The eighteenth, nineteenth and the twentieth (stars) are three close-by stars forming a line with a slight curve with its curve pointed towards the east.

As for the eighteenth (star) it is the southernmost of the three located on place where the human body joins the horse. It is of the 3rd magnitude. Ptolemy mentioned that it is much greater than the 3rd magnitude. It forms a large triangle together with the two stars on the shoulders with this star on its head. It is closer to the right shoulder. The distance between them is one *Rumḥ*.

The nineteenth is behind the eighteenth star and is located towards the north-east by one *dhirā'*. It is of the 5th magnitude.

The twentieth is north of the nineteenth. It is also of the 5th magnitude. The distance between them towards the north-west is one *Shibr*.



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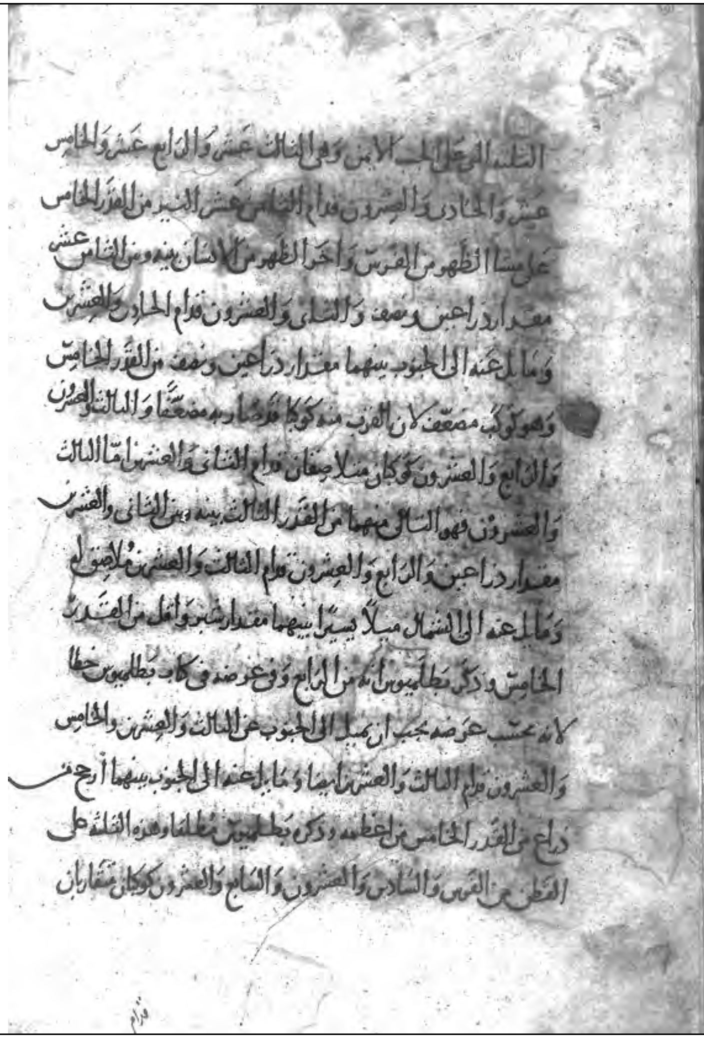
All these three stars are south of the three stars which are located on the left hand side and which are the thirteenth, fourteenth and the fifteenth.
The twenty-first is in front of the bright eighteenth (star). It of the 5th magnitude. It is located where the back joins the body of the horse and at the end of the human form. The distance between it and the eighteenth (star) is two and half *dhirā'*.
The twenty-second is in front of the twenty-first and oriented towards the south. The distance between them is two and half *dhirā'*. It is of the 5th magnitude. It is a double star because next to it is star which makes it a double star.
The twenty-third and the twenty-fourth are two close stars in front of the twenty-second (star). As for the twenty-third it is the rearmost of the two. It is of the 3rd magnitude. The distance between it and the twenty-second is two *dhirā'*.
The twenty-fourth is in front of the twenty-third and close to it and is located towards the north a little. The distance between them is less than one *Shibr*. It is of the 5th magnitude. Ptolemy mentioned that it is of the 4th magnitude. Its latitude in the book of Ptolemy is wrong because according to that latitude it should be located south of the twenty-third (star).
The twenty-fifth is also in front of the twenty-third and is located south of it. The distance between them is a little more than *dhirā'*. It is much greater than the 5th magnitude. Ptolemy mentioned that it is exactly 5th magnitude.
All these three stars are on the *Qaṭen* (rump) of the horse.
The twenty-sixth and the twenty-seventh are two close stars.



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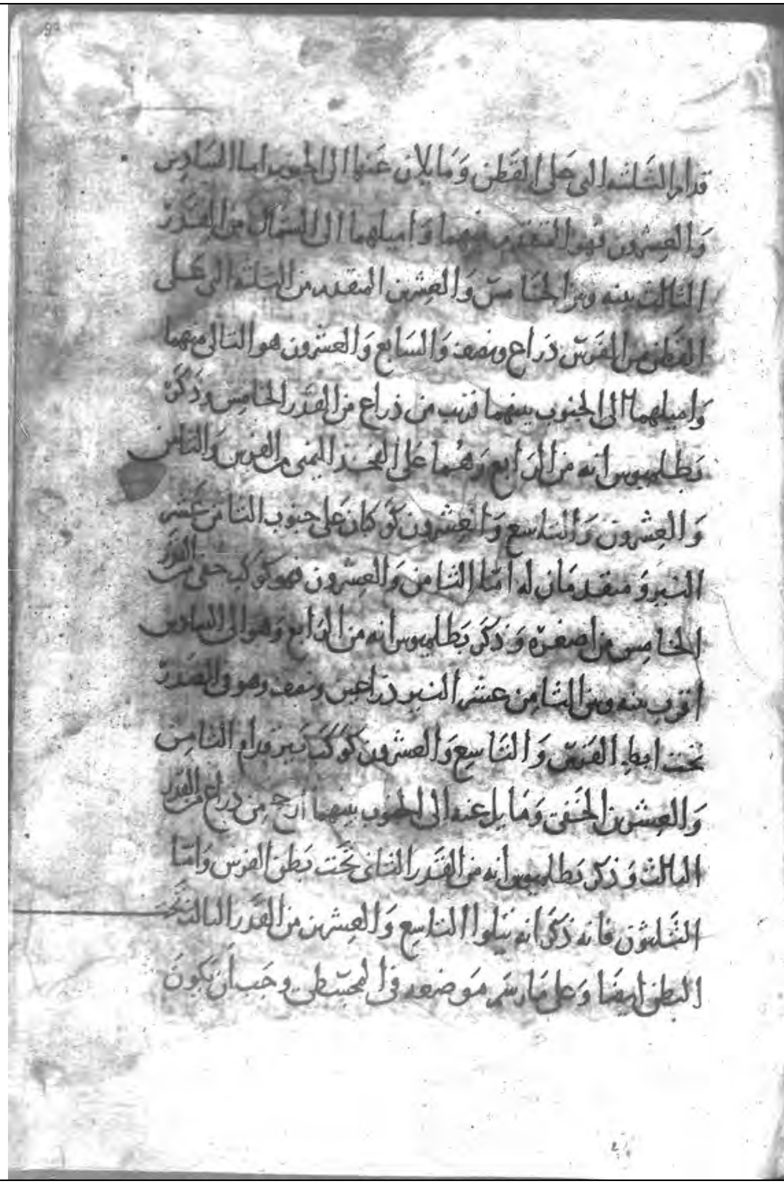
They are located next to the three stars on the rump towards the south.
As for the twenty-sixth it is the more advanced and northernmost of the two. It is of the 3rd magnitude. The distance between it and the twenty-fifth which is the most advanced of the three on the rump is a distance of one and a half *dhirā‘*.

The twenty-seventh is the rearmost and the southernmost of the two. The distance between them is close to one *dhirā‘*. It is of the 5th magnitude. Ptolemy mentioned that it is the 4th magnitude. They are located on the right *Fakhed* (thigh) of the horse.

The twenty-eighth and the twenty-ninth are two stars that are located south of the bright eighteenth star and are in advance of it.
As for the twenty-eighth it is a dim star. It is less than the 5th magnitude. Ptolemy mentioned that it is of the 4th magnitude; however it is closer to the 6th magnitude. The distance between it and the bright eighteenth star is two and half *dhirā‘*. It is located on the chest under the armpit of the horse.

The twenty-ninth is a bright star in front of the dim twenty-eighth star and south of it. The distance between them is a little more than one *dhirā‘*. It is of the 3rd magnitude. Ptolemy mentioned that it is of the 2nd magnitude and under the horse's belly.

As for the thirtieth (Ptolemy) mentioned that it is to the rear of the twenty-ninth and that it is of the 3rd magnitude and that it is also located under the belly. However when its location according the *Almagest* is drawn on the globe the distance between them would be less than one *dhirā‘*.



Folio 393

However there is no star that can be seen at that location, nor is there any star around it which can be considered to be it except those well known stars.

The thirty-first, thirty-second, thirty-third and the thirty-fourth are four stars south of the twenty-sixth and the twenty-seventh stars.
As for the thirty-first it is the northernmost of them. It is of the 2nd magnitude. It forms an elongated triangle together with the twenty-third and the bright twenty-sixth with this star on its head. The distance between it and the twenty-sixth is five *dhirāʻ*. The distance between it and the twenty-third is six *dhirāʻ*. It is located on the knee-bend of the right hind leg.

The thirty-second is the rearmost of the four. The distance between it and the thirty-first towards the south-west is a distance of two *dhirāʻ*. It is of the 2nd magnitude. It is located on the hock of the right leg.

The thirty-third is the most advanced of the four. The distance between it and the thirty-first towards the south-west is a distance of one and a half *dhirāʻ*. It is less than 3rd magnitude. Ptolemy mentioned that it is of the 4th magnitude. It is located on the knee-bend of the left hind leg.

As for the thirty-fourth it is the southernmost of the four. It is of the 2nd magnitude. It forms together with the thirty-second and the thirty-third an Isosceles triangle.

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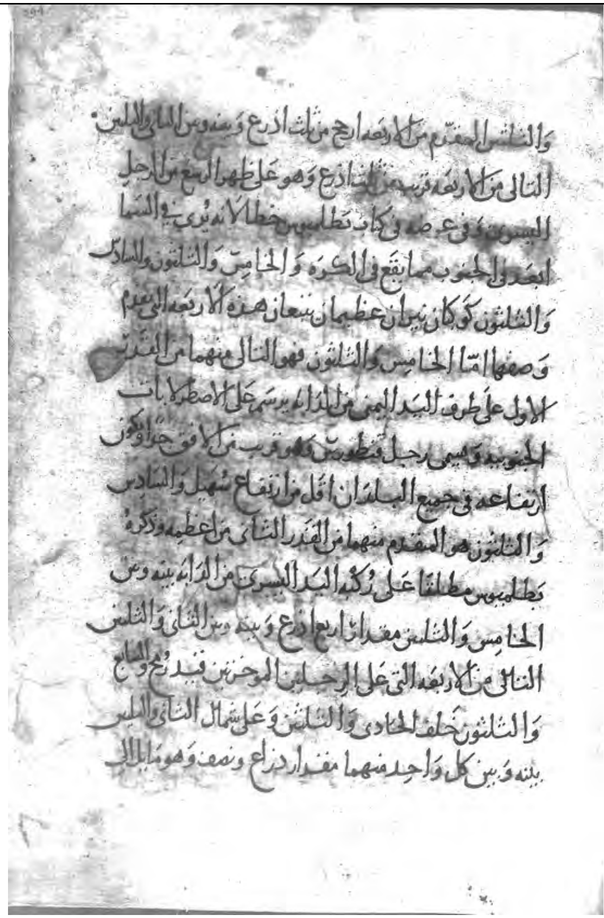
The distance between it (thirty-fourth) and the thirty-third which is the most advanced of the four is a distance of one-third of a *dhirā‘*. The distance between it and the thirty-second which is the rearmost of the four is a distance of one-third of a *dhirā‘*. It is located on the frog of the hoof on the left leg. Its latitude in the book of Ptolemy is wrong because in the sky it is seen further to the south than its location (if it was drawn from Ptolemy's data) on the globe.

The thirty-fifth and the thirty-sixth are two bright and great stars which are in front of these four stars that were mentioned before.
As for the thirty-fifth it is the rearmost of the two. It is of the 1^{st} magnitude. It is located on the tip of the right hand of the animal. It is drawn on the southern Astrolabes. It is called *Rijl Qanṭūris* (leg of Centaurus). It is very close to the horizon. Its height in all localities is less then (the star) *Suhail*.

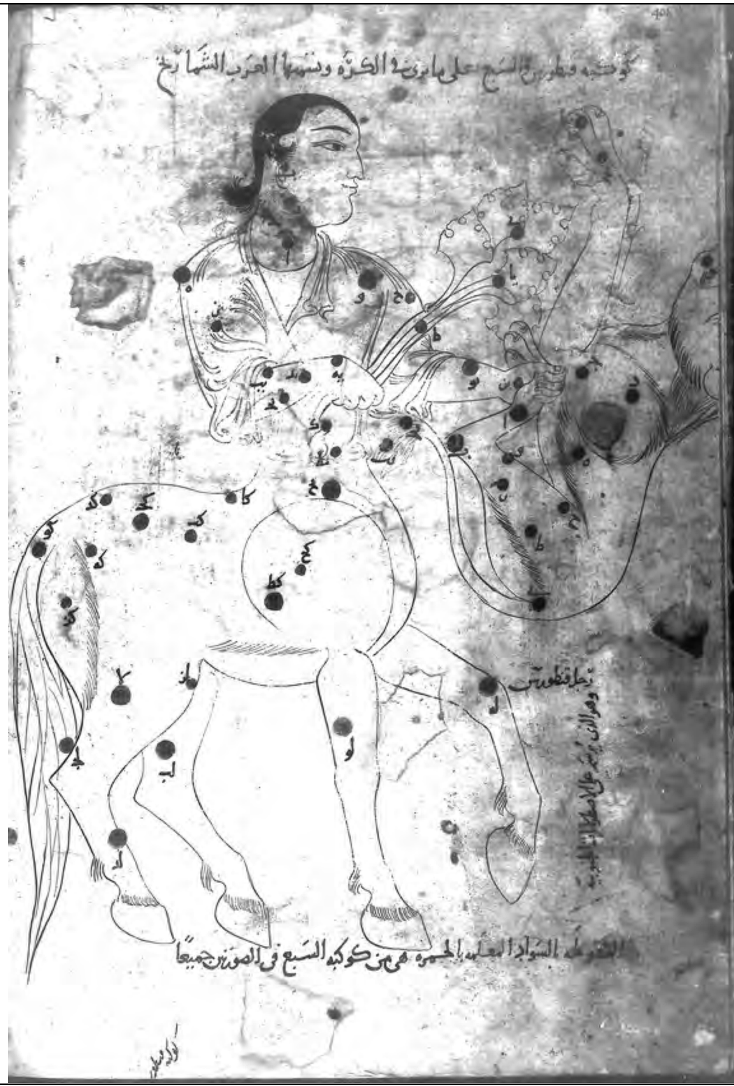
The thirty-sixth is the most advanced of the two. It is much greater than the 2^{nd} magnitude. Ptolemy mentioned that it is exactly 2^{nd} magnitude. It is located on the knee of the left front leg of the animal. The distance between it and the thirty-fifth is four *dhirā‘*. The distance between it and the thirty-second which is the rearmost of the four and on the two legs is a distance of one *Rumḥ*.

The thirty-seventh is behind the thirty-first and south of the thirty-second. The distance from each one of them is one and a half *dhirā‘*. It is also north of the thirty-first. It is less than the 4^{th} magnitude. Ptolemy mentioned that it is exactly 4^{th} magnitude.



Folio 401

The constellation Centaurus (*Qanṭūris)* and (constellation) Lepus as seen on the globe. The Arabs called them *al-Shamārīkh.*



Folio 402

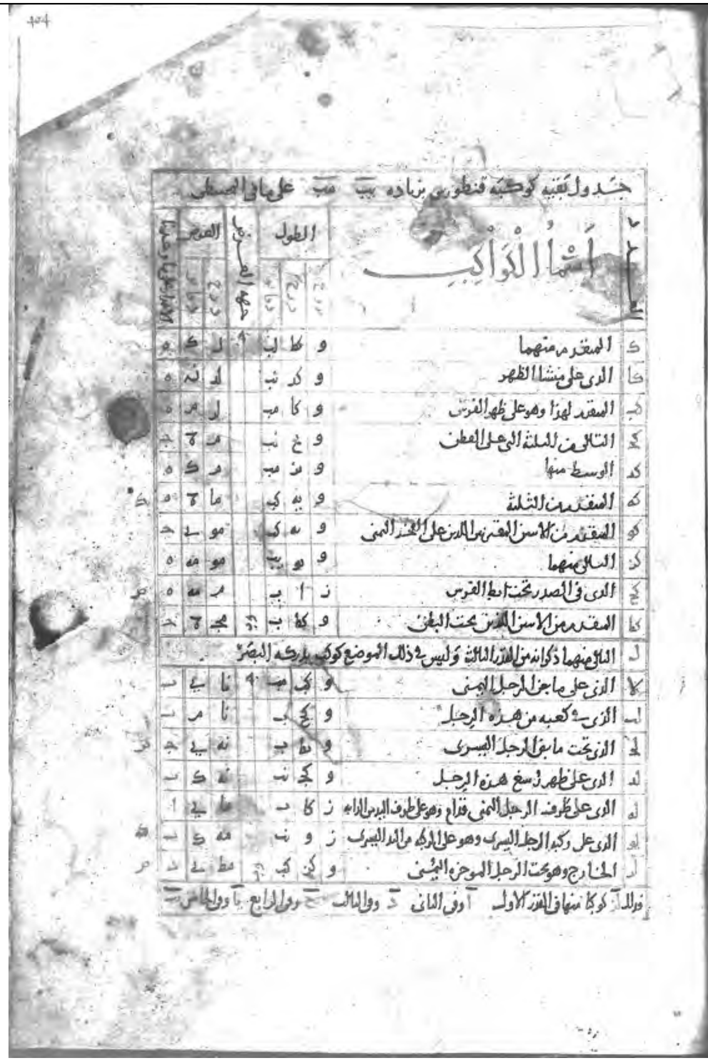
The constellation Centaurus (*Qanṭūris)* and (constellation) Lepus as seen in the sky. The Arabs called them *al-Shamārīkh.*

Folio 403

Table of the constellation Centaurus with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
number	Names of the stars	longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The southernmost of the 4 stars in the head	6(180)	23	12	S	21	40	5
2	The northernmost of them	6(180)	22	42	S	18	50	5
3	The more advanced of the other, middle 2	6(180)	21	52	S	20	30	4
4	The rearmost of the these, the last of the 4	6(180)	22	42	S	20	00	5
5	The star on the left advanced shoulder	6(180)	18	52	S	25	40	3
6	The star on the right shoulder	6(180)	28	22	S	22	30	3
7	The star on the left shoulder-blade	6(180)	21	52	S	27	30	5
8	The northernmost of the advanced two of the four stars in the thyrsus.	7(210)	00	52	S	22	20	4(s)
9	The southernmost of these	7(210)	01	52	S	23	45	4
10	The one of the other two which is at the tip of the thyrsus	7(210)	04	42	S	18	15	4
11	The last one south of the latter	7(210)	05	12	S	20	50	4
12	The most advanced of the 3 stars in the right side	6(180)	26	02	S	28	20	4(m)
13	The middle one	6(180)	26	42	S	29	20	4(m)
14	The rearmost of the three	6(180)	27	52	S	28	00	4
15	The star on the right upper arm	6(180)	29	02	S	26	30	4(m)
16	The star on the right forearm	7(210)	05	32	S	25	15	3
17	The star on the right hand	7(210)	10	12	S	24	00	4(m)
18	The bright star in the place where the human body joins the horse	7(210)	00	42	S	33	30	3
19	The rearmost of the 2 faint stars to the north of this	7(210)	00	22	S	31	00	5

Folio 404

Table of the constellation Centaurus with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
number	Names of the stars	longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
20	The more advanced of them	6(180)	29	32	S	30	20	5
21	The star on the place where the back joins the horse body	6(180)	24	52	S	34	50	5
22	The star in advanced of this on the horse back	6(180)	21	42	S	37	40	5
23	The rearmost of the stars on the rump	6(180)	18	52	S	40	00	3
24	The middle one	6(180)	17	42	S	40	20	5
25	The most advanced of the three	6(180)	15	22	S	41	00	5(m)
26	The more advanced of the 2 stars close together on the right thigh	6(180)	15	22	S	46	10	3
27	The rearmost of them	6(180)	16	12	S	46	45	5
28	The star in the chest under the horse armpit	7(210)	01	02	S	40	45	5(s)
29	The more advanced of the 2 stars under the belly	6(180)	29	02	S	43	00	3
30	The rearmost of them (Ptolemy) mentioned that it is of the 3rd magnitude however there is no star in this are which can be seen.							
31	The star on the knee-bend of the right hind leg	6(180)	22	42	S	51	10	2
32	The star in the hock of the same leg	6(180)	28	02	S	51	40	2
33	The star under the knee-bend of the left hind leg	6(180)	59	02	S	55	10	3(s)
34	The star on the frog of the hoof on the same leg	6(180)	23	52	S	55	20	2
35	The star on the end of the right front leg	7(210)	21	02	S	41	10	1
36	The star on the knee of the left front leg	7(210)	06	52	S	45	20	2(m)
37	The star outside under the right hind leg	6(180)	27	22	S	49	10	4(s)
36 stars, 1 of the 1st magnitude, 4 of the 2nd, 8 of the 3rd, 11 of the 4th, 12 of the 5th.								



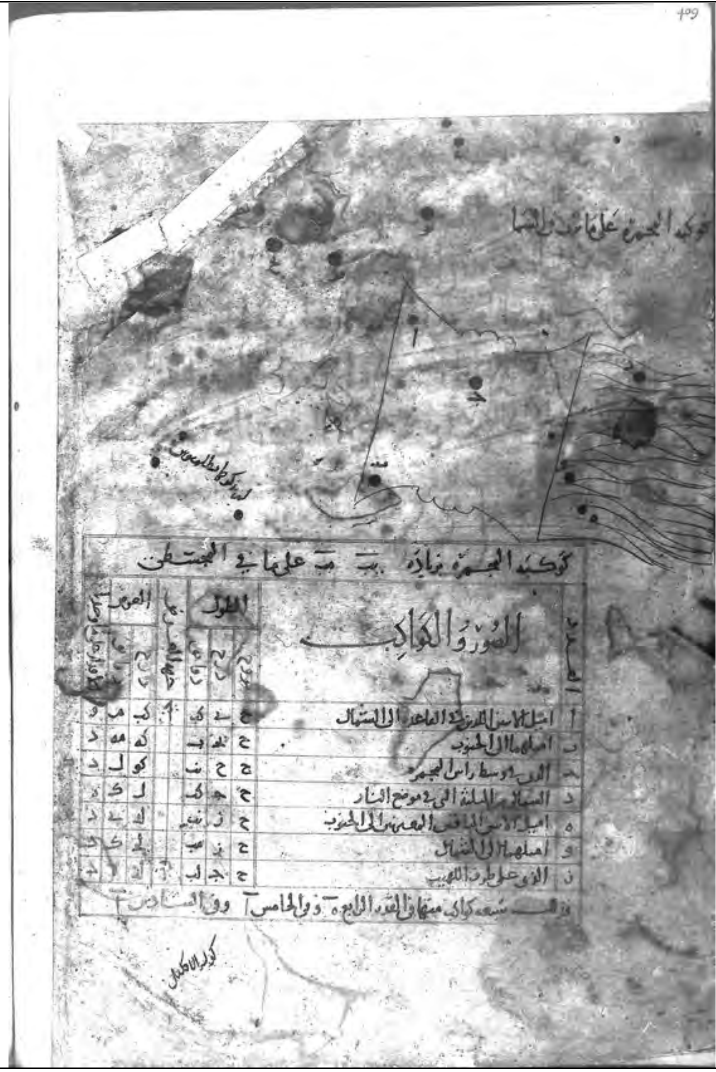
Folio 405

Table of the constellation Lupus (*al-Sab'*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star at the end of the hind leg, by the [right] hand of Centaurus	7(210)	10	42	S	24	50	3
2	The star on the bend in the same leg	7(210)	8	32	S	29	10	3
3	The more advanced of the 2 stars just over the shoulder-blade	7(210)	13	42	S	21	15	4(m)
4	The rearmost of them	7(210)	16	52	S	21	0	3(s)
5	The star in the middle of the body of Lupus	7(210)	15	42	S	25	10	4(m)
6	The star in the belly, under the flank	7(210)	12	52	S	27	0	5
7	The star on the thigh	7(210)	13	12	S	29	0	5
8	The northernmost of the 2 stars near the place where the thigh joins [the body]	7(210)	17	22	S	28	30	5
9	The southernmost of them	7(210)	16	22	S	30	10	5
10	The star on the end of the rump	7(210)	18	22	S	33	10	4(s)
11	(Ptolemy) mentioned that this is the southernmost of the 3 stars in the end of the tail; however there is no star that can be seen in this place.							
12	The middle one of the three	7(210)	4	32	S	30	30	4(s)
13	The northernmost of them	7(210)	5	42	S	29	20	5
14	The southernmost of the 2 stars in the neck	7(210)	21	32	S	17	0	4
15	The northernmost of them	7(210)	22	2	S	15	20	5
16	The more advanced of the 2 stars in the snout	7(210)	18	22	S	13	20	5(m)
17	The rearmost of them	7(210)	19	22	S	11	50	5(s)
18	The southernmost of the 2 stars in the front leg	7(210)	10	2	S	11	30	6
19	The northernmost of them	7(210)	12	12	S	10	0	5(s)
18 stars, 3 of the 3rd magnitude, 5 of the 4th magnitude, 9 of the 5th magnitude and 1 of the 6th magnitude.								

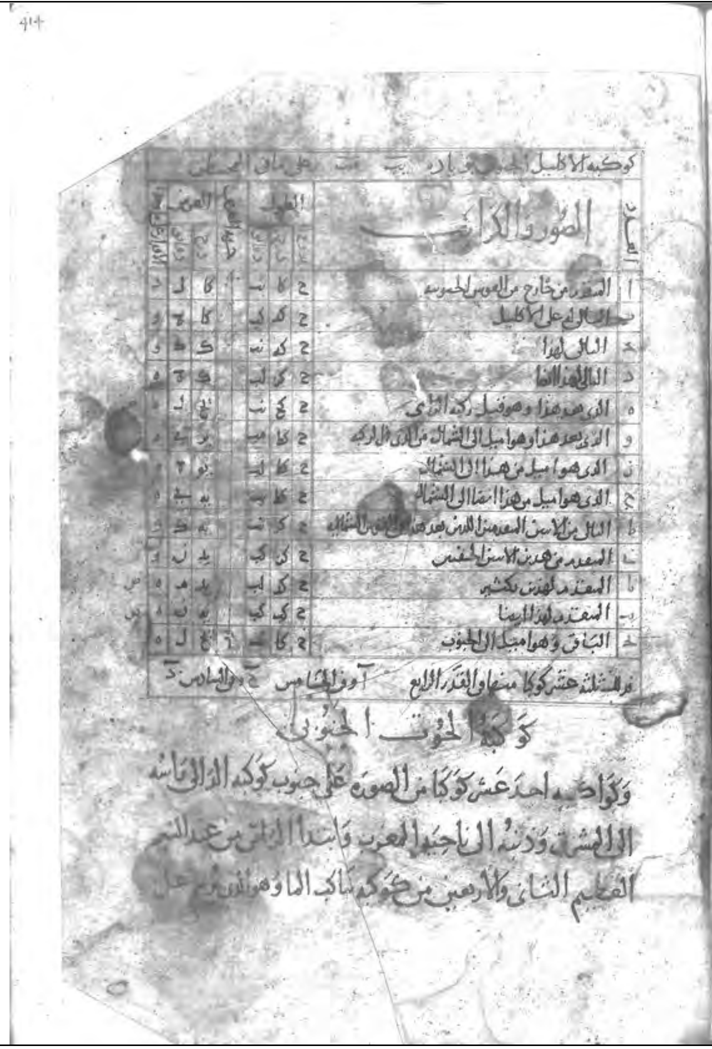
Folio 409

Constellation Ara (*al-Jamra*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The northernmost of the 2 stars in the base	8(240)	10	22	S	22	40	6
2	The southernmost of them	8(240)	13	2	S	25	45	4
3	The star in the middle of the little altar	8(240)	8	52	S	26	30	4(k)
4	The northernmost of the 3 stars in the brazier	8(240)	3	22	S	30	20	5(s)
5	The southernmost of the other 2 which are close together	8(240)	7	52	S	34	10	4(s)
6	The northernmost of these [2]	8(240)	7	42	S	33	20	4
7	The star on the end of the flame	8(240)	3	32	S	34	0	4
7 stars, 5 of the 4th magnitude, 1 of the 5th magnitude and 1 of the 6th magnitude.								



Folio 414

Constellation Corona Australis (*al-Iklīl al-Janūbī*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The most advanced of the stars on the southern rim, outside [the crown]"	8(240)	21	52	S	21	30	4
2	The star to the rear of this on the crown	8(240)	24	22	S	21	0	6
3	The one to the rear of this	8(240)	25	52	S	20	20	6
4	The one to the rear again of this	8(240)	27	32	S	20	0	5
5	The one after this, in front of the knee of Sagittarius	8(240)	28	52	S	18	30	5(s)
6	The one after this, which is north of the bright star in the knee [of Sagittarius, Sgr 24]	8(240)	29	42	S	17	10	5
7	The star to the north of this	8(240)	29	32	S	16	0	5
8	The one to the north again of this	8(240)	29	12	S	15	10	5
9	The rearmost of the 2 stars after this, in advance, in the northern rim	8(240)	27	52	S	15	20	6
10	The more advanced of these 2 faint stars	8(240)	27	22	S	14	50	6
11	The star quite some distance in advance of this	8(240)	24	32	S	14	40	5(s)
12	The one in advance again of this	8(240)	22	22	S	15	50	5(s)
13	The last one, which is south of the aforementioned star	8(240)	21	52	S	18	30	5
13 stars, 1 of the 4th magnitude, 8 of the 5th magnitude and 4 of the 6th magnitude.								



Folio 419

Table for the Constellation Piscis Austrinus (*al-Ḥūt al-Janūbī*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star in the mouth, which is the same as the beginning of the water [Aqr 42]	10(300)	18	22	S	20	20	4
2	The most advanced of the 3 stars on the southern rim of the head	10(300)	16	52	S	22	15	4
3	The middle one	10(300)	18	12	S	22	30	4
4	The rearmost of the three	10(300)	17	2	S	16	15	4
5	The star on the belly	10(300)	7	52	S	19	30	5
6	The star on the southernmost spine on the back	10(300)	13	52	S	15	10	6(s)
7	The rearmost of the 2 stars in the belly	10(300)	11	32	S	14	40	5
8	The more advanced of them	10(300)	7	52	S	15	5	5
9	The rearmost of the 3 stars on the northern spine	10(300)	4	32	S	16	30	5(k)
10	The middle one	10(300)	3	42	S	18	10	4
11	The most advanced of the three on the tip of the tail	10(300)	8	42	S	22	15	3(s)
11 stars, 1 of the 3rd magnitude, 5 of the 4th magnitude, 4 of the 5th magnitude and 1 of the 6th magnitude.								

Note: the last table in manuscript Marsh144 is not complete. I used the data in the Paris manuscript Arab5036.

5.1 Extant Manuscripts of al-Ṣūfī's Book

Al-Ṣūfī's '*Book of the Fixed Stars*' dating from around A.D. 964, is one of the most important medieval Arabic treatises on astronomy. This major work contains an extensive star catalogue, which lists star co-ordinates and magnitude estimates, as well as detailed star charts. Other topics include descriptions of nebulae and Arabic folk astronomy. As I mentioned before, al-Ṣūfī's work was first translated into Persian by al-Ṭūsī. It was also translated into Spanish in the 13th century during the reign of King Alfonso X.

The introductory chapter of al-Ṣūfī's work was first translated into French by J.J.A. Caussin de Parceval in 1831. However in 1874 it was entirely translated into French again by Hans Karl Frederik Schjellerup, whose work became the main reference used by most modern astronomical historians. In 1956 al-Ṣūfī's Book of the fixed stars was printed in its original Arabic language in Hyderabad (India) by Dārat al-Ma'aref al-'Uthmānīa. It was later re-published in Beirut (Lebanon) from the Hyderabad copy by Dār al-Āfāq al-Jadīdah in 1981. At present no English translation of this important treatise exists. In order to remedy this omission, I have made this detailed study of al-Ṣūfī's work, including the preparation of an English translation. However, before I started I had to identify the extant manuscripts of the '*Book of the Fixed Stars*'. Then I had to identify the criteria with which to choose the manuscripts which were used as the bases for the translation and discussions.

5.1.1 List of Extant Manuscripts of al-Ṣūfī's Book

It is a measure of the popularity of this book that many manuscripts are still preserved in libraries throughout the world Figure 17 . However, tracking down several of these manuscripts involved extensive travel worldwide and much library research. The reaction of some librarians or museums has not always been positive or helpful; however, in the end I managed to locate as many as 35 manuscripts and acquired copies of the major ones which are needed for this study. The list below shows the manuscripts of al-Ṣūfī's work which I found from the various references and library catalogs, some of which I managed to study personally. They are grouped by country or location of the library where they are being kept. However, other manuscripts might still be held in other libraries or in private collections. Some manuscripts have also been recently digitized for public viewing or research. Therefore I have included the website locations where these manuscripts can be located.

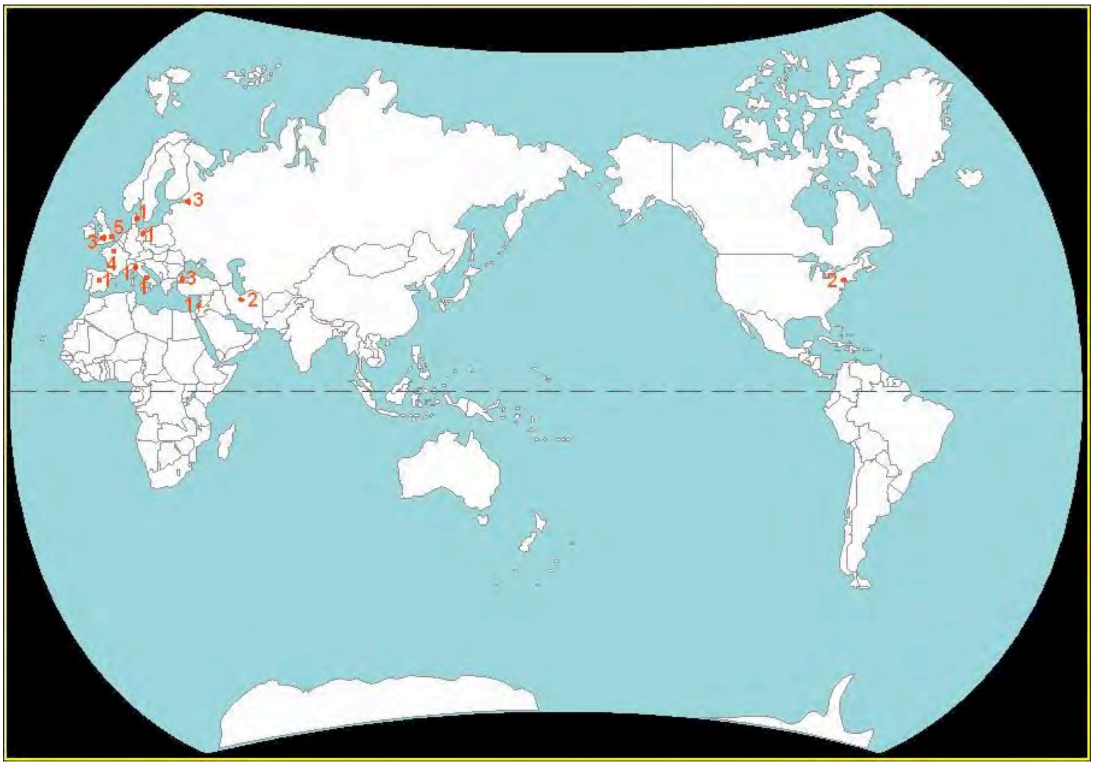


Figure 17 location of manuscripts

1. Oxford, Bodleian Library, MS Marsh 144, dated A.H. 400 / A.D. 1009.

Size: 265 x 180 mm; 419 pages; Layout: written in 15 lines.

2. Oxford, Bodleian Library, MS Pocock 257, dated A.H. 706 / A.D. 1306.

3. Oxford, Bodleian Library, MS Huntingdon 212, dated A.H. 769 / A.D. 1367.

4. Istanbul. Topkapi Sarayi, MSS 3493, dated A.H. 525 / A.D. 1131

5. Istanbul. Topkapi Sarayi, MSS 2595, date unknown.

6. Istanbul. Topkapi Sarayi, MSS 2642, date unknown.

7. Istanbul. Sulaymania Library, Ms number unknown, dated A.H. 529 / A.D. 1135.

A facsimile copy of this manuscript is found in Beirut (American University of Beirut) (MS 520:S94sa) which is taken from a copy from another facsimile copy found at the University of Damascus in Syria.

8. Berlin, Ahlwardt 5658-5660, dated A.H. 620 / A.D.1233.

9. Vatican, Rossi 1033, dated A.H. 621 / A.D. 1224.

10. Paris Bibliotheque Nationale de France, MS Arabe 5036, dated A.H. 833 / A.D. 1430. http://gallica.bnf.fr/ark:/12148/btv1b60006156

11. Paris Bibliotheque Nationale de France, MS Arabe 2488, date unknown.

12. Paris Bibliotheque Nationale de France, MS Arabe 2489, date unknown.

13. Paris Bibliotheque Nationale de France, MS Arabe 2490, date unknown.

14. Copenhagen, Royal Library, MS 83, dated A.H. 1010 / A.D. 1601.
This manuscript was the one used by Schjellerup in his French translation in 1874.

15. St Petersburg, Bibliotheque Imperiale de St Petersburg, MS 191 dated A.H. 1015 / A.D. 1606. This manuscript was the second one used by Schjellerup in his French translation in 1874.

16. St Petersburg, Institute des Langues Oriental, MS 185, dated A.H. 405 / A.D. 1015.
Note: the date of this manuscript is doubtful because according to Schjellerup this manuscript was written in *Ta'līq* style which was not used as early as the 11th century; therefore this manuscript could date to the 15th or 16th century A.D. (Kunitzsch, 1986).

17. St Petersburg, Bibliotheque Imperiale de St Petersburg, MS 190 dated 15th or 16th century A.D.

18. Beirut, American University of Beirut, MS 520:S94 sA, dated A.H. 1122 / A.D. 1711. Size: 215 x 160 mm; 110 pages; Layout: written in 27 lines; *Naskhī* style.

19. New York, The Metropolitan Museum of Art, no 13.160.10, dated 14th century A.D.

20. New York, The Metropolitan Museum of Art, no 1975.192.2, dated 18th century A.D.

21. London, British Library, OR 5323, dated 14th century A.D.

22. London, British Library, ADD 7488, dated 17th century A.D.

23. London, British Library, OR 1407 dated A.H. 1074 / A.D. 1663.

24. London, British Library, IO ISL 621, dated 17th century A.D.

25. London, British Library, IO ISL 2389, dated 18th century A.D.

26. Madrid, library Escurial, MS No 915, dated A.H. 1173 / A.D. 1760.

27. Bologna, les Manuscript Orientaux Collection Marsigli, MS 422, date unknown.

28. Tehran, Majles library, MS 197, date unknown.

29. Tehran, Majles library, MS 196, date unknown.

30. Tunis, Bibliotheque Nationale de Tunisie, MS 8093, dated A.H. 1030 / A.D. 1621.
Size: 225 x 140 mm; 190 pages; Layout: written in 17 lines.

31. Hyderabad, Asafiya library, Ms number unknown, date unknown.

32. Washington, Library of congress, Ms Number unknown, dated A.H. 1142/A.D. 1730.
Size: 250 x 150 mm; 176 pages; Layout: written in 19 lines. This copy is based on Ulugh Beg's copy made in A.D. 1430 which is found at The Bibliothèque Nationale de France in Paris (MS5036). http://www.wdl.org/en/item/2484

33. Cairo, the Egyptian Dar books, Ms Number unknown, dated A.H. 1043 / A.D. 1633.

34. Princeton, Princeton University Librar**y,** Garrett no. 2259Y, dated A.H. 1015 / A.D. 1607.
http://diglib.princeton.edu/view?_xq=pageturner&_index=1&_inset=1&_start=1&_doc=/mets/islamic2259y.mets.xml

35. Doha, The Museum of Islamic Art in Doha, Ms # M1-02-98-90, dated A.H. 519 / A.D. 1125; this manuscript was acquired by the Museum of Islamic Art in Doha in 1998 from the Sotheby's London auction house.

There are also other manuscripts which fall under the title of 'Sufi Latinus' corpus. There are 8 extant copies of these Latin manuscripts which were based on al-Ṣūfī's '*Book of* *the Fixed Stars*'. According to Kunitzsch (1965; 1986) the longitude values and the style of drawing are no doubt derived from the Arabic al-Ṣūfī manuscripts. In the title of one of those manuscripts which is located at the Bibliotheque Nationale de France in Paris we find the name of the author as 'Ebennesophy'. This is one of the first examples whereby al-Ṣūfī was referred to as Ibn al-Ṣūfī. I have not included any of these manuscripts in the above list since I do not believe that the 'Sufi Latinus' corpus represent a genuine or an accurate picture on al-Ṣūfī's work which we can rely on. These manuscripts are:

- Paris, Arsenal 1036.
- Gotha, Forschungsbibliothek, MS M II 141, dated A.D. 1428.
- Prag, Strahov Library, MS D.A. II, 13.
- Berlin, Kupferstichkabinett, MS Hamilton 556.
- Munich, Clm 826.
- Catania, MS Catin 85.
- Vienna, MS 5318.
- Kues, Cusanus-Stift, MS 207.

Finally, I would just like to make a note here on the main sources which modern scholars and historians have been using in their studies of al-Ṣūfī's work and other similar topics. The first is the French translation by Schjellerup which was published in 1874. This translation was produced based on the Copenhagen Manuscript MS83 dated A.D. 1601. However, since Schjellerup used a rather late manuscript in his translation I believe that his work might lack the reliability needed to reflect the potential of al-Ṣūfī's work. The other source is the Hyderabad publication of al-Ṣūfī's '*Book of the Fixed Stars'* which was printed in Arabic in 1956. This production was edited by Muḥammad Nizām al-Dīn based on five manuscripts. The first was the Istanbul MSS 3493, the second was the Vatican Rossi 1033, the third was the Berlin 5658-5660, the fourth was the Paris MS Arabe 5036 and the last was the Hyderabad copy, for which there is no manuscript number and date. This Hyderabad copy was later re-published in Beirut by Dār al-Āfāq al-Jadīdah in 1981. Even though this work was based on several manuscripts, the oldest known manuscript - which is the Marsh144 copy - was not utilized. According to Kunitzsch (1986) and the investigation which I made myself, the Hyderabad copy contains many errors which do not make it very reliable. However, it is the only clearly-printed Arabic copy of al-Ṣūfī's work readily available to the public and is found in many libraries worldwide. In a later section of this discussion (Chapter 5.12) I have identified some of the differences in coordinates and magnitude values found between these two sources and the main manuscripts which I used as the bases for this work. This exercise was made for one constellation only in order to show some of the mistakes present in these sources and to show the importance of producing a reliable text of al-Ṣūfī’s work from the oldest and best-kept manuscripts available to us.

5.1.2 Criteria for Identifying the Book for Translation

Unfortunately not many manuscripts can be used for this study. I have cited several criteria which I used to choose the most suitable manuscripts as the bases for translation. I will try to give examples of these criteria using several manuscripts which I found at the British Library in London.

- Dating of the Manuscript

The first and the most important criterion for choosing the manuscript was the date of the manuscript. The date in this context is the date at which the manuscript was copied or re-written. All these manuscripts were written by hand by copyist or scribes from an original which was probably written by al-Ṣūfī himself. Unfortunately the original copy of al-Ṣūfī’s manuscript is no longer extant. In many of these manuscripts the date of the copy was not mentioned. Therefore, it was sometimes a little difficult to put an exact date on a manuscript copy. However, dating can be approximated based on paleographic techniques and calligraphy types. I have indicated in the list below all those manuscripts for which the date is not known and these cannot be used for this translation exercise. However, other manuscripts carry a definite date which was usually written at the end of the manuscript, such as the example of the British library manuscript number OR1407. On the last page of this manuscript we can clearly see that it is dated A.H. 1074 which is equivalent to A.D. 1663 (Figure 18). The criterion for the date which I selected for choosing the best manuscript is that it should not be older than A.H. 500, which is almost 100 years after al-Ṣūfī’s death. The younger the manuscript the more likely the mistakes of the copyist will grow.


Figure 18


figure 19

- Legibility of Handwriting

In addition to questions of date, the legibility of handwriting was another issue which I considered in identifying a manuscript for study. The handwriting of some of these manuscripts was not very clear. This reflected the style or the interest of the copyist. For example, the copyist of British Library manuscript number OR1407 again was not only very neat, but took a real interest in the substance of what he was copying. This scribe, for instance, compiled an index of the constellations at the beginning of the manuscript which was not originally a part of al-Ṣūfī's work (Figure 19). Unfortunately this manuscript was not among the manuscripts used in this study because it is dated to A.H. 1074 which is more than 600 years after al-Ṣūfī's death.

- Complete Manuscript

Another criterion for choosing a manuscript was whether it was complete. I have found several manuscripts of the '*Book of the Fixed Stars*' which were deficient, some with many diagrams, star charts or tables incomplete or even missing. Such an example is manuscript IO ISL 621 in the British Library which dates to the 17th century (Figure 20). As we can see, the tables in this manuscript were not completed. Even though the images of the constellations and stars were drawn in gold (Figure 21), the stars were not numbered and many stars were missing. Several constellation tables were also not complete with the last two constellations missing.

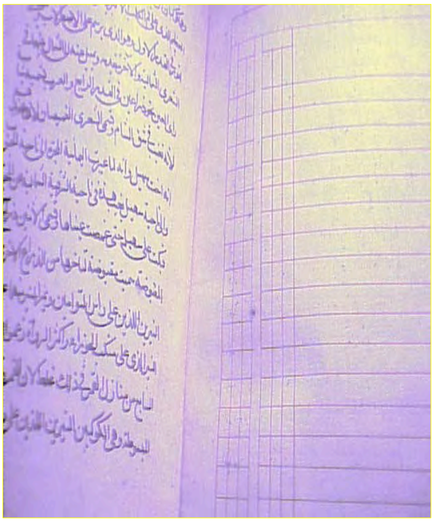


Figure 20

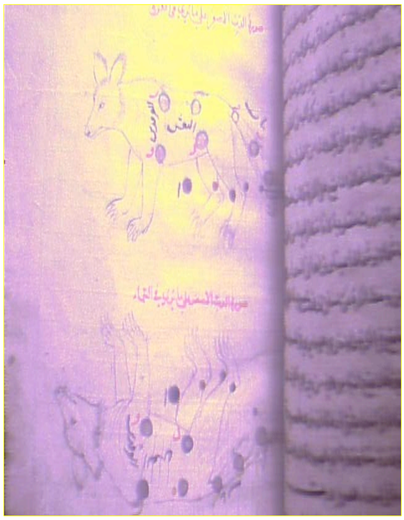


Figure 21

- Obvious Mistakes

The last of the criteria was the obvious mistakes which I found in some of these manuscripts. In the Manuscript ADD 7488 in the British Library which was dated to the 17th century we have an example of an obvious mistake, with ‘Abd al-‘Azīz rather than ‘Abd al-Raḥmān cited as part of al-Ṣūfī's name. This particular manuscript is also incomplete. The last constellation listed is Argo Navis. The last eight constellations, from Hydra to Piscis Austrinus, are missing. Therefore, such a manuscript could not be a suitable candidate in our work on al-Ṣūfī’s book.

- Table 3: The Manuscripts and Identification Criteria.

Manuscript	Copy Date of Manuscript	Legibility	Completeness & Mistakes	Criteria Description
Oxford, MS Marsh 144	A.H. 400	Clear hand writing	Incomplete manuscript	Before A.H. 500 however the last chapter is in-complete.
Oxford, Ms Pocock 257	A.H. 706	Clear hand writing	Complete manuscript	After A.H. 500
Oxford, Ms Huntingdon 212	A.H. 769	Clear hand writing	Complete manuscript	After A.H. 500
Istanbul, MSS 3493	A.H. 525	Clear hand writing	Complete manuscript	After A.H. 500
Istanbul, MSS 2595	Unknown	Clear hand writing	Complete manuscript	Unknown date
Istanbul, MSS 2642	Unknown	Clear hand writing	Complete manuscript	Unknown date
Istanbul Ms number	A.H. 529	Clear hand	Complete	After A.H. 500

Unknown		writing	manuscript	
Berlin, 5658-5660,	A.H. 620	Clear hand writing	Complete manuscript	After A.H. 500
Vatican, Rossi 1033	A.H. 621	Clear hand writing	Complete manuscript	After A.H. 500
Paris, MS Arabe 5036,	A.H. 833	Very clear hand writing	Complete manuscript	After A.H. 500 a very well written copy
Paris, MS Arabe 2488	Unknown	Clear hand writing	Complete manuscript	Unknown date
Paris, MS Arabe 2489	Unknown	Clear hand writing	Complete manuscript	Unknown date
Paris, MS Arabe 2490	Unknown	Clear hand writing	Complete manuscript	Unknown date
Copenhagen, MS 83	A.H. 1010	Clear hand writing	Complete manuscript	After A.H. 500
St Petersburg, MS 191	A.H. 1015	Clear hand writing	Complete manuscript	After A.H. 500
St Petersburg, MS 185	A.H. 405 Date uncertain	Clear hand writing	Complete manuscript	Date uncertain should be 15th century A.D.
St Petersburg, MS 190	15th century A.D.	Clear hand writing	Complete manuscript	After A.H. 500
Beirut, MS 520:S94sA	A.H. 1122	Clear hand writing	Complete manuscript	After A.H. 500
New York, 13.160.10	14th century A.D.	Clear hand writing	In-complete manuscript	After A.H. 500
New York, 1975.192.2	18th century A.D.	Clear hand writing	Complete manuscript	After A.H. 500
London, ADD 7488	17th century A.D.	Clear hand writing	Incomplete manuscript with mistakes	After A.H. 500
London, OR 5323	14th century A.D.	Clear hand writing	Complete manuscript	After A.H. 500
London, OR 1407	A.H. 1074	Very clear hand writing and tables	Complete manuscript	After A.H. 500
London, IO ISL 621	17th century A.D.	Clear hand writing	Incomplete manuscript	After A.H. 500
London, IO ISL 2389	18th century A.D.	Clear hand writing	Incomplete manuscript	After A.H. 500
Madrid, MS No 915	A.H. 1173	Clear hand writing	Complete manuscript	After A.H. 500
Bologna, MS 422	Unknown	Clear hand writing	Complete manuscript	Unknown date
Tehran, MS 197	Unknown	Clear hand writing	Complete manuscript	Unknown date
Tehran, MS 196	Unknown	Clear hand writing	Complete manuscript	Unknown date
Tunis, MS 8093	A.H. 1030	Clear hand writing	Complete manuscript	After A.H. 500
Hyderabad, Ms # unknown	Unknown	Clear hand writing	Complete manuscript	Unknown date

Washington, Ms # unknown	A.H. 1142	Clear hand writing	Complete manuscript	After A.H. 500
Cairo, Ms # unknown	A.H. 1043	Clear hand writing	Complete manuscript	After A.H. 500
Princeton, Islamic Manuscripts, Garrett no. 2259Y, dated	A.H. 1015/ A.D. 1607	Clear hand writing	Incomplete manuscript, no tables, only single illustration per constellations	After A.H. 500
Doha, The Museum of Islamic Art in Doha, dated. Ms # M1-02-98-90	A.H. 519 / A.D. 1125	Clear hand writing	Complete manuscript	After A.H. 500

5.1.3 The Main Manuscripts Identified for Translation and Discussion.

The two main manuscripts which I have identified to be the bases of the translation and discussion are manuscript ‘Marsh144 and manuscript ‘MS5036’. However, I have also found some slight differences in coordinates and magnitude values between these two manuscripts. In a later section of these discussions I have identified some of these differences, which were probably due to scribal error at the time the manuscripts were copied. As we said earlier, all these manuscripts were written by hand over and over again and were handed down from one generation to another. So there must have been hundreds of these copies circulating at any one time. Unfortunately we do not have the original manuscript which was written by the author himself but we have the next best thing which is the copy by the author’s sons. However, I believe that the values in the Marsh144 manuscript are probably more accurate since it is an older manuscript; therefore the values which I indicated in the translation of the main text are based on the Marsh144 figures.

- The Marsh144 Manuscript

The Marsh144 manuscript is the earliest-known manuscript of the ‘*Book of the Fixed Stars*’. It is dated A.H. 400 / A.D.1009 only 23 years after al-Ṣūfī's death. According to the inscription on the last page of this manuscript (Figure 22) this copy was copied and illustrated by al-Ḥusaīn Ibn ‘Abd al-Raḥmān Ibn ‘Umar Ibn Muḥammad. The Marsh144 manuscript was actually written by al-Ḥusaīn who was the eldest son of al-Ṣūfī. It is now located at the Bodleian Library in Oxford. In 1959 a study of the Islamic constellation images was made by Emmy Wellesz based on this manuscript. The manuscript is 419 pages of the size 265 by 180 mm written in *Nasta'lik* style with 15 lines on each page. Black ink was used to draw all the figures as well as the tables and writing. The stars drawn in red and labeled in black, in both images, are part of the constellation. The stars drawn in black and labeled in red are outside the constellation. The stars drawn in black and not labeled are those not mentioned by Ptolemy.

According to the Bodleian Library records it was purchased by 'Narcissus Marsh' at the Jacob Golius's Library in Leiden in 1696. On page 419 of this manuscript we find the inscription of the previous owner by the name of 'Christianus Ravius' who purchased this copy in 1644. However from page 405 onward the manuscript shows more or less drastic repairs with the last page of this manuscript showing an incomplete table. According to the Latin inscription found at the margin on the last page 'Christianus Ravius' wrote that he supplied the missing parts of the text after having compared it with a more recent copy of the same work. These missing pages were probably the first eleven folios of this manuscript. This can be seen from the difference in handwriting between these folios compared to the remaining text. These first eleven folios also exhibit many mistakes as well as correction which were made by hand. The folios 252 to 269 have also been incorrectly arranged and should have been inserted between the folio 211 and 212. However, even with these shortcomings this manuscript is still considered the oldest and most reliable copy available of al-Ṣūfī's book. Therefore I have chosen this manuscript to be the basis for this study and I managed to acquire a facsimile copy of this work.

Figure 22 The Last Page of Marsh144 Manuscript

- The MS5036 Manuscript

The MS5036 manuscript is found at the National Library in Paris. It is dated A.H. 833 / A.D. 1430. The final page of his manuscript is shown in Figure 11. This copy was written for King Ulugh Bēg as is mentioned at the last page of this manuscript. As I said earlier, the text next to the last table of this manuscript states that the pictures were drawn according to the instructions of Ibn al-Ṣūfī and the data were taken from the copy of Naṣīr al-Dīn al-Ṭūsī. This is a very well-written manuscript with clear tables and pictures of the constellations. The stars which are part of the main constellation picture were drawn in gold while the stars drawn in red are outside the constellation. The manuscript contains 494 pages of the size 285 by 205 mm also written in *Nasta'lik* style with 13 lines on each page. Even though this manuscript was written much later, I needed another well-written but reliable copy to compare with and complete the last missing page of the Marsh144 manuscript. Since this copy was written for Ulugh Bēg from al-Ṭūsī's copy I believe that it is a good reliable copy of al-Ṣūfī's work which I could utilize. Therefore I have chosen this copy and I included the text of this manuscript whenever I needed to complement the work.

5.2 The Structure of al-Ṣūfī’s Book and Star Catalog

The original Arabic name of al-Ṣūfī’s book was ‘*Ṣuwar al-Kawākib al-Thamāniyah wa-al-Ārba'een*’ which is simply translated as ‘*The 48 Constellations*’. However, it was later known by other names, the most famous of which are: ‘*Kitāb al-Kawākib al-Thābitah*’ or the ‘*The Book of the Fixed Stars*’ and ‘*Kitāb al-Kawākib al-Thābitah Muṣawaran*’ or the ‘*The Illustrated Book of the Fixed Stars*’. This book was also known by another name which was: ‘*Kitāb Ṣuwar al-Samawīyah Muṣawaran*’ or ‘*The Illustrated Book of the Heavenly Signs*’. I will begin this study of al-Ṣūfī’s work with the description of the structure and layout of the ‘*Book of the Fixed Stars*’. Al-Ṣūfī’s original Arabic text contained 55 astronomical tables as well as star charts of 48 constellations. Al-Ṣūfī commented in detail on every constellation before every section of those star charts. These tables and charts were written in the same order using the same structure and layout as in the *Almagest*. Al-Ṣūfī’s book is divided into four main sections:

1. The Introductory Chapter

Al-Ṣūfī’s introductory chapter is a very important part of his work. In it he explained the reasons for writing his book. He also included his strong criticisms of other works, especially those of al-Battānī and al-Daīnawari. He explained the method he used in writing his book and the technique he used for calculating the precession value. Al-Ṣūfī also identified the 48 constellations which, as he mentioned, were taken from Ptolemy’s *Almagest*. He also mentioned that some ancient astronomers counted the number of stars in each constellation to be 917 stars that are included in the main constellations and 118 stars outside of the constellations. He then mentioned that other people also mistook the number of the stars in the sky to be 1025 stars only and this is wrong also because as he explained, there are many other stars of the 5th and 6th magnitude. He finally summarized the total number of brightly-observed stars to be 1022 except the three stars that are part of the Asterism ‘*al-Ḍafira*’. He also explained how the tables were compiled and the reason and method for using the dual constellations charts and images. (See translation and comments on al-Ṣūfī’s introduction chapter)

2. The 21 Chapters of the Northern Constellations (Table 4):

#	Constellation name	# stars in	#stars out	Arabic names according to al-Ṣūfī
1	Ursa Minor	7	1	*al-Dub al-Aṣghar*

2	Ursa Major	27	8	*al-Dub al-Akbar*
3	Draco	31	-	*al-Tinnīn*
4	Cepheus	11	2	*Qīqāwūs; al-Multaheb*
5	Bootes	22	1	*al-‘Awwā; al-Sayyāḥ ; al-Naqqār; Ḥāris al-Shamāl*
6	Corona Borealis	8	-	*al-Iklīl al-Shamālī; al-Fakka*
7	Hercules	28	1	*al-Jāthī ‘ala Rukbateh; al-Rāqeṣ*
8	Lyra	10	-	*al-Silyāq; al-Wazza; al-Subeḥ; al-Ma’refa; al-Sulaḥfāt*
9	Cygnus	17	2	*al-Ṭā’er ; al-Dajāja*
10	Cassiopeia	13	-	*Dhāt al-Kursīy*
11	Perseus	26	3	*Barshāūsh ; Ḥāmel Ra’s al-Ghūl*
12	Auriga	13	-	*Mumsek al-‘Inān; al-‘Inān; Mumsek al-A‘ina*
13	Ophiuchus	24	5	*al-Ḥawwā’*
14	Serpens	18	-	*al-Ḥayyā*
15	Sagitta	5	-	*al-Sahem*
16	Aquila	9	6	*al-‘Uqāb; al-Nasr al-Ṭā’er*
17	Delphinus	10	-	*al-Dalfīn*
18	Equuleus	4	-	*Quṭ‘at al-Faras*
19	Pegasus	20	-	*al-Faras al-A’ẓam*
20	Andromeda	23	-	*al-Mara’ al-Musalsala*
21	Triangulum	4	-	*al-Muthallath*

The total number of stars in the northern constellations is 330 which form the main body of the northern constellations and 29 stars outside of the constellations making a total of 359 stars. However, in his introductory chapter al-Ṣūfī mentioned that the total numbers of stars was 331 that are part of the northern constellations and 29 that are outside of the constellations totaling 360. This is because Ptolemy assigned 14 stars to the constellation Auriga whereas al-Ṣūfī only found 13; the last was not seen by him.

3. The Twelve Chapters of the Constellations of the Zodiac (table 5):

#	Constellation name	# stars in	#stars out	Arabic names according to al-Ṣūfī
1	Aries	13	5	*al-Ḥamal*
2	Taurus	32	11	*al-Thawr*
3	Gemini	18	7	*al-Tawāmān*
4	Cancer	9	4	*al-Saraṭān*
5	Leo	27	8	*al-Asad*
6	Virgo	26	6	*al-‘Adhrā’; al-Sunbula*
7	Libra	8	9	*al-Zubānayn ; al-Mīzān*
8	Scorpio	21	3	*al-‘Aqrab*
9	Sagittarius	31	-	*al-Rāmī; al-Qaws*
10	Capricorn	28	-	*al-Jadī*
11	Aquarius	42	3	*Sākib al-Mā’ ; al-Dalw*
12	Pisces	34	4	*al-Samakatān ; al-Ḥūt*

The total number of stars in the Zodiac constellations is 289 which form the main body of the constellation and 60 stars outside of the constellation, with a total of 349 stars. However, in his introductory chapter al-Ṣūfī mentioned that the total numbers of stars was 289 that are part of the Zodiac constellations and 57 outside of the constellations, totaling 346 except for the asterism called '*al-Ḍafira'* which is a 3-star group.

4. The Southern Constellations which are 15 Constellations Chapters (table 6):

#	Constellation name	# stars in	#stars out	Arabic names according to al-Ṣūfī
1	Cetus	22		*Qītus*
2	Orion	38		*al-Jabbār; al-Jauzā'*
3	Eridanus	34		*al-Nahr*
4	Lepus	12		*al-Arnab*
5	Canis Major	18	11	*al-Kalb al-Akbar*
6	Canis Minor	2		*al-Kalb al-Mutaqadem; al-Kalb al-Aṣghar*
7	Argo Navis	45		*al-Safīna*
8	Hydra	25	2	*al-Shuja'*
9	Crater	7		*al-Bāṭīya*
10	Corvus	7		*al-Ghurāb*
11	Centaurus	36		*Qanṭurūs*
12	Lupus	18		*al-Sab'*
13	Ara	7		*al-Jamra; al-Majmara*
14	Corona Australis	13		*al-Iklīl al-Janūbī*
15	Piscis Austrinus	11		*al-Ḥūt al-Janūbī*

The total number of stars in the southern constellations is 295 which form the main body of the constellation and 13 outside of the constellation, with a total of 308 stars. However, in his introductory chapter al-Ṣūfī mentioned that the total numbers of stars was 297 that are part of the northern constellations and 19 outside of the constellations totaling 316 stars. This is because Ptolemy assigned 37 stars to the constellation Centaurus and 19 stars to the constellation Lupus, whereas al-Ṣūfī found one less star in each of these two constellations. The other difference is that Ptolemy added 6 stars to the last constellation Piscis Austrinus whereas al-Ṣūfī did not include these in his catalog nor does he mention them in the comments on this constellation in his book.

Each constellation chapter is in turn divided into three parts. The first part is a detailed written commentary describing the position of the stars, their numbers, magnitudes as well as many other details. Al-Ṣūfī also tried to identify the stars or group of stars according to the old Arabic tradition, by giving their old Arabic names and what the Arabs said about them. The Arabic text in Figure 23 is from a copy of a manuscript which was written by Ulugh Bēg in the 15th century. As we can see it is a very well-written and clear manuscript. It is one of the manuscripts that I used in the translation.

The second part of the constellation chapter is a table showing the coordinates and magnitude values for every constellation (see Figure 24). The stars in every constellation were divided into two groups. The first groups of stars were those that form the main image of the constellation. The other groups were the stars outside the image. Al-Ṣūfī used ecliptical coordinates**,** as did Ptolemy before him.

The last parts for each constellation chapter are the charts (see Figure 25). These were the dual charts depicting the stars as they appear in the sky and as they were drawn on a globe.

Figure 23 written commentary

Figure 24 Tables

Figure 25 the charts

5.2.1 Method Used in Translating '*The Book of the Fixed Stars*'

The main effort to search for the hidden treasures in al-Ṣūfī's book started with the translation of this work from Arabic to English, especially the constellation commentaries. For every constellation al-Ṣūfī wrote a commentary which describes in detail the number of stars, their location and their magnitudes. Therefore, the information regarding the magnitude estimate in particular can be more reliably taken from the text than from the tables which might not be correctly copied.

The layout of the translation was as depicted in Figure 26 which shows the table or the star catalog for the constellation Ursa Major. Next to it is the corresponding English translation. At the top of this table al-Ṣūfī noted that he added 12 degrees 42 minutes to

Ptolemy’s longitude to allow for precession. The first column gives the number of the star in the constellation. The second gives the description or name of the star. This sometimes included the star color, Arabic name and explanation on the position of the star in the constellation. The third group of columns gives the ecliptical longitude coordinates. It was also customary to divide the ecliptic into twelve 30 degrees divisions. Therefore when describing the longitude, al-Ṣūfī first wrote the number of that division then the remaining degrees and minutes in order to depict the complete longitude value. The fourth column gives the latitude direction of the star relative to the ecliptic. The fifth group of columns gives the latitude coordinates. And the last column gives the apparent magnitude estimates as the author found them.

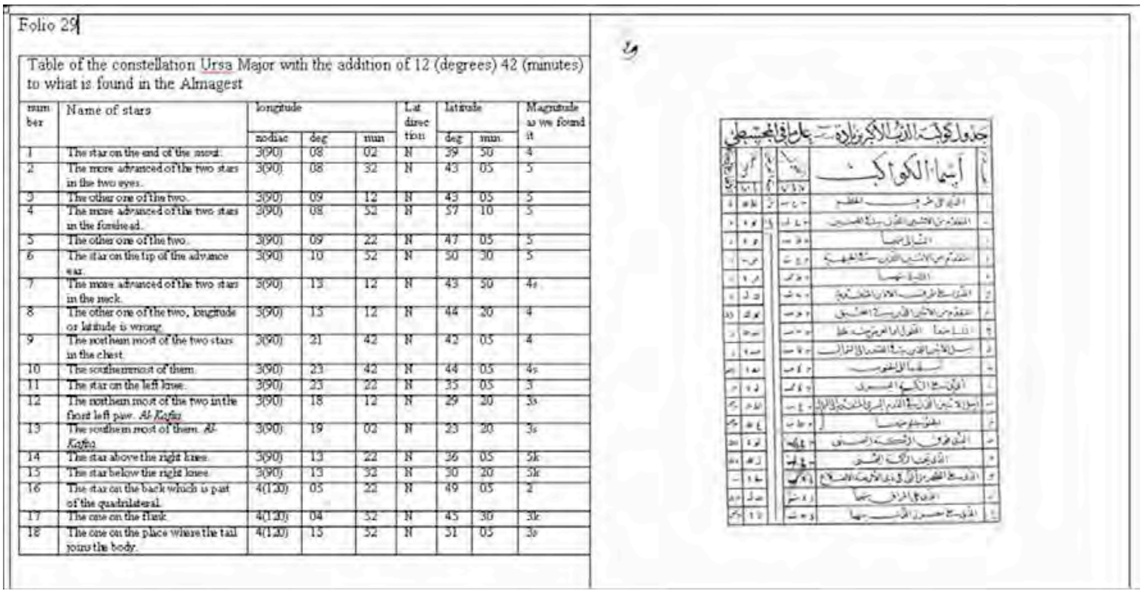

Folio 29

Table of the constellation Ursa Major with the addition of 12 (degrees) 42 (minutes) to what is found in the Almagest

number	Name of stars	longitude			Lat direction	latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star on the end of the snout.	3(90)	08	02	N	39	50	4
2	The more advanced of the two stars in the two eyes.	3(90)	08	32	N	43	05	5
3	The other one of the two.	3(90)	09	12	N	43	05	5
4	The more advanced of the two stars in the forehead.	3(90)	08	52	N	57	10	5
5	The other one of the two.	3(90)	09	22	N	47	05	5
6	The star on the tip of the advance ear.	3(90)	10	52	N	50	30	5
7	The more advanced of the two stars in the neck.	3(90)	13	12	N	43	50	4s
8	The other one of the two, longitude or latitude is wrong	3(90)	15	12	N	44	20	4
9	The northern most of the two stars in the chest.	3(90)	21	42	N	42	05	4
10	The southernmost of them.	3(90)	23	42	N	44	05	4s
11	The star on the left knee.	3(90)	23	22	N	35	05	3
12	The northern most of the two in the front left paw. *Al-Kafza*	3(90)	18	12	N	29	20	3s
13	The southern most of them. *Al-Kafza*	3(90)	19	02	N	23	20	3s
14	The star above the right knee.	3(90)	13	22	N	36	05	5k
15	The star below the right knee.	3(90)	13	32	N	30	20	5k
16	The star on the back which is part of the quadrilateral.	4(120)	05	22	N	49	05	2
17	The one on the flank.	4(120)	04	32	N	45	30	3k
18	The one on the place where the tail joins the body.	4(120)	15	32	N	51	05	3s

Figure 26 The Layout of the Translation

5.3 Maps in al-Ṣūfī's Book

Cartography or mapmaking has been an integral part of the human development for thousands of years. There is some evidence that suggest that the figurative paintings which were produced in the Lascaux Caves more than 12,000 years ago might have some reference to the phases of the Moon and the animal figures depicted in these caves might also suggest some reference to seasonality changes (Krupp, 1997: 122). Almost all ancient cultures such as the Babylonians, Greeks and Chinese created and used maps in order to help them explain and navigate their way through out the world. The first known maps were those of the heavens. Stellar cartography or 'Uranography' is the science of mapping or projecting representations of stars and other celestial bodies on to flat surfaces such as paper or stone or onto spherical objects. The art or science of Uranography started by observation of the sky, then by measuring the position of the stellar objects in order to produced star tables and maps or charts for use by astronomers and astrologers. A variety of instruments and techniques was developed to help produce these tables and charts such as angular measurements, light or magnitude determination methods, quadrants, astrolabes, globes and others.

The earliest ancient Greek scientist who is believed to have constructed a map of the world is Anaximander of Miletus (B.C. 611-546). One of the first Greek philosophers to draw the stars on a globe was Eudoxus of Cnidus (B.C. 408- 355). He was considered the first to represent the sky from outside looking in rather than as seen by an observer on the Earth (Harley & Woodward, 1987). In classical antiquity, maps were drawn by Hecataeus, Herodotus, Eratosthenes and Ptolemy using astronomical and mathematical techniques. The oldest available representation of the celestial sphere is the Farnese Atlas which is a 2nd century Roman marble copy of a statue of Atlas kneeling with a globe on his shoulders. The globe depicts the night sky as seen from outside the celestial sphere showing 41 out of the 48 classical Greek constellations as mentioned by Ptolemy. Chinese mapping of the stars began at much the same time as Greek celestial cartography. However, in general this did not make a significant contribution to the development of Islamic astronomy.

In the Middle Ages, Arab and Islamic scholars continued to produce stellar maps using methods which they found in Greek sources such as Ptolemy's *Almagest* and *Geography*. Astronomers and geographers working under Caliph al-Ma'mūn in the 9th century re-measured the distance on the Earth that corresponds to one degree of the celestial meridian in order to help them calculate the circumference of the Earth. al-Ma'mūn also patronized the production of a large map of the world, which has not survived. Historical records point to many important Arab and Islamic astronomers who worked on this subject and produced works resembling the Greek classical globes such as the Farnese Atlas and illustrated astronomical maps. The works of these scholars must have been known during the Middle Ages because al-Ṣūfī mentioned in his book that he saw a book by ‘Uṭārid with celestial maps and a celestial globe by al-Ḥarrānī which he both criticized because of the errors he found in them. Unfortunately none of these works is extant today. The earliest surviving celestial map in Islamic culture is to be found in an 8th century Umayyad palace called *Qaser al-Ūmāra’*. This palace contains a room with a dome on to which a painted fresco of the celestial heaven is drawn on the ceiling. The design of this fresco was drawn as if you are looking down on a globe and not as you would be looking to the sky. The constellations of *Qaser al-Ūmāra’* were based on classical or early medieval western Byzantine style.

5.3.1 The Characteristics and Development of al-Ṣūfī’s Constellations Images

The Marsh144 manuscript by al-Ṣūfī is one of the oldest illustrated Islamic manuscripts which we know of today. One of al-Ṣūfī's innovations in charting the stars was the production of dual illustrations of each of Ptolemy’s constellations. One illustration was as portrayed on a celestial globe. The other illustration as viewed directly in the night sky. At the end of the chapter on the constellation Ursa Minor, al-Ṣūfī explains why he produced two different sets of pictures and outlined the method of using these maps as follows:

> “For every constellation we have drawn two pictures: one as it is projected on the globe and the other as it is seen in the heavens. Hence we have covered both of the different cases, so there is no confusion for anyone who sees that what is viewed on the globe is different from what is in the heavens. When we want to see the constellation as it (really) is we lift the book over our heads and we look at the second picture (in the book). From beneath (the book) we are viewing (the constellation) as it is seen in the heavens.”

Figure 27 is a picture of the constellation Equuleus from the manuscript Marsh144. The right figure shows the constellation as seen on a celestial globe. The left figure shows the constellation as it is seen in the sky. Figure 28 is a picture of the constellation Cancer from the Paris manuscript MS5063. In this latter illustration, the upper figure shows the constellation Cancer as seen on the celestial globe. The lower figure shows the constellation as it is seen in the sky. In this Figure the stars drawn in gold are considered part of the constellation picture while the stars drawn in red are bright enough to be noticed but are outside the constellation.

Figure 27

Figure 28

It is interesting to note that all the Arab and Islamic astronomers including al-Ṣūfī were inconsistent and incorrect in their depiction of the constellations. Ptolemy’s original description of the constellations was based on an interior point of view; therefore Ptolemy described the figures of the constellation as if the observer would see the constellation figure from a central position looking up. However when the constellations are projected on a celestial globe then the exterior observer should be seeing the reverse of the constellation figures looking down on the globe. However in all Arab and Islamic globes the constellation figures are all drawn in front view therefore the images are mirrored in order to depict them looking towards the observer. It is unknown why the Arabs used such a system for drawing the constellations on the globes. Most probably they wanted to avoid depicting the figures whereby they are represented from the rear.

Since al-Ṣūfī’s work was based on Ptolemy’s *Almagest* therefore most of the rendering of the constellation figures resemble classical style similar to the Farnese globe constellations. However some of the figures have undergone a process of ‘orientalization’ which probably began before al-Ṣūfī started to write his work. This process was the result of misunderstanding some of the Greek mythology figures as well as copyist errors in some of the versions of the *Almagest*. The other diversion from classical style constellations was also due to influence of the *Anwā’* tradition in which al-Ṣūfī was very much interested. An example of such addition is to be found in the constellation Andromeda. Al-Ṣūfī makes three illustrations for this constellation. The first is the figure of Andromeda with her arms stretched out. The second is the figure of Andromeda with a fish covering her legs (Figure 29). The third illustration is with two fishes covering her body (Figure 30). Another example of this *Anwā'* tradition is the illustration of a full horse figure which is to be found between the constellation Equuleus and Pegasus (Figure 31). All these iconographies were not part of the original classical Greek tradition (Wellesz, 1965).

Figure 29

Figure 30

Figures 31

The constellation figures of manuscript Marsh144 especially the facial outlines were drawn according to style of the 9th century Abbasid period. They were rendered in a flat two-dimensional style. Their faces were drawn almost in profile while their bodies in full view usually with their arms stretched out. The turbans were depicted from a later 10th century style, an example of which can be found in the decorative pottery of that era. In later manuscripts of al-Ṣūfī's book the turbans as well as garments were also altered to reflect the dressing style of the era when these manuscripts were copied. However it is interesting to note here that the drawings of the jewelry, the garments and some of the constellations in the Marsh144 manuscript were also influenced by a much earlier period in history, as is found in the Art of the Sassanid era. An example of such Sassanid influence can be found in the illustration of the flying wings of Pegasus (Figure 32) which resembles Simurgh the Sassanian mythical flying creature (Figure 33).

Figure 32 Figure 33

By the time we reach the manuscript MS5063 we see that some of the illustrations have undergone an iconographical change which reflects the time that this manuscript was produced. This is evident in the illustration of constellation Cetus; when this is compared to the Marsh144 manuscript (Figure 34) we find a strong Chinese influence in the iconography of the beast which now resembles a Chinese dragon (Figure 35).

Figure 34 Figure 35

Another interesting constellation to note is the constellation Lyra or Lyre meaning the Harp. Al-Ṣūfī gave several names for this constellation: *al-Silyāq; al-Wazza; al-Ṣubh; al-Ma'arefa* and *al-Sulaḥfāt*. The word *al-Silyāq* was also written as al-*Shilyāq*; however, Kunitzsch corrected this name to *Salbāq* which was a kind of harp used by ancient Arabs (Kunitzsch & Smart, 2006: 44). The Marsh144 manuscript indeed depicts this constellation as a type of harp (Figure 36). However in many other eastern manuscripts Lyra was illustrated as a *Sulaḥfāt* or tortoise. Al-Ṣūfī mentioned that he saw this constellation drawn on some celestial globes as a *Sulaḥfāt*. An example of this is seen in the manuscript MS5063 (Figure 37). The other name given to this constellation which was probably based on the *Anwā'* tradition was *al-Wazza* meaning the Goose. This depiction was used in later western illustrations while adding the image of the harp superimposed on the image of the goose. Such an illustration can be found in Andreas Cellarius' *Harmonia Macrocosmica* which is a stellar catalogue published in 1660 and in Johann Hevelius' *Uranographia* printed in 1690 (Figure 38).

Figure 36

Figure 37

Figures 38

5.3.2 Accuracy of the Maps

An important issue concerns the accuracy of these maps. Were they really used as they were intended by al-Ṣūfī? It is apparent that as an observational astronomer and an instrument-maker al-Ṣūfī was very much concerned with the accuracy of the data he had and the way the maps should be used when observing the heavens or when constructing a celestial globe. Since the Marsh144 manuscript was written by the al-Ṣūfī's son therefore it might have been copied as close to the original as possible with regards to the illustrations and images of the constellation provided the son was as good as the father. However, these star maps might be considered an accurate depiction of the heavens according to al-Ṣūfī. Therefore it might also be safe to assume that these star charts were used to help the observer locate the main celestial bodies in the sky with ease and accuracy. As for the other manuscript MS5063, which was written for Ulugh Bēg who was also an important astronomer, his copy might have also been accurately produced and illustrated under the guidance of Ulugh Bēg himself for this purpose.

Therefore in order to investigate this question I have reproduced two star charts from al-Ṣūfī's manuscripts Marsh144 and MS5063 and a projection upon a modern chart showing the location of these stars in the constellation was then made. As can be seen from the projection of the chart from the manuscript Marsh144 for the constellation Orion (Figure 39) the chart is somewhat accurate and it could have been used as al-Ṣūfī intended it to be used.

The other projection of the chart is from the manuscript MS5063 for the constellation Ursa Minor (Figure 40). This chart can also be considered as a fairly accurate presentation of the constellation.

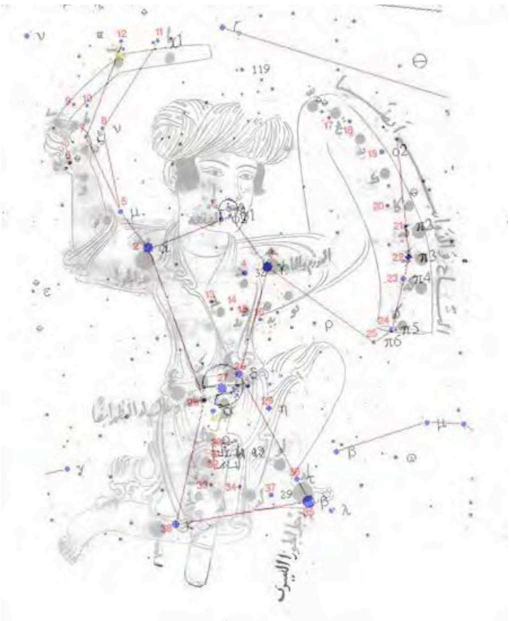


Figure 39 Projection of the Chart Manuscript Marsh144 for the Constellation Orion

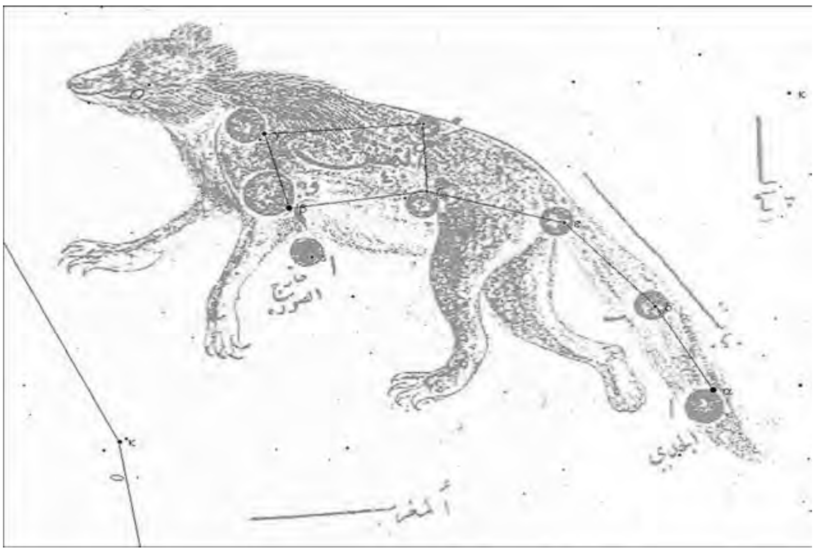


Figure 40 Projection of the Chart Manuscript MS5063 for the Constellation Ursa Minor

5.4 Al-Ṣūfī's Data Analysis and 3-step Magnitude System

As discussed above, al-Ṣūfī's star catalog was based on Ptolemy's classical work the Mathematike Syntaxis which was later called the *Almagest* by the Arabs. In his introductory chapter al-Ṣūfī corrected several observational errors in the works of his predecessors, like the famous Arab astronomer al-Battānī. He also exposed many of the faulty observations found in the various versions of the *Almagest*. However his major endeavor was to carefully define the boundaries of each constellation, and record the magnitudes and positions of stars using new and independent observations he made himself. For the epoch of his catalog al-Ṣūfī adopted the beginning of the year 1276 of the era of Alexander (*Thū al-Qarnaīn*) which corresponds to the year A.D. 964 (Kunitzsch, 1986). Al-Ṣūfī updated Ptolemy's stellar longitudes from A.D. 125 to A.D. 964 by adjusting for precession. However al-Ṣūfī mentioned that "Ptolemy used the observations of Menelaus' who made his observations in the year 845 of the year of Nabūkhat Nassar. Al-Ṣūfī also mentioned that: "The time difference between the observations of Menelaus and the date of Ptolemy is 41 years". He concluded that Ptolemy added 25 minutes to Menelaus' longitude values to account for precession. However it is still unknown why al-Ṣūfī refers to this fact because at this time there is no evidence or available text that mentions that Ptolemy used Menelaus observations other than al-Ṣūfī's claim (Grasshoff, 1990: 21).

At the end of al-Ṣūfī's introductory chapter he described in detail the method he used in constructing his catalog especially in calculating precession. For his epoch of A.D. 964 he applied the most accurate Arabic precession constant at that time of 1 deg in 66 years rather than the correct value of 1 deg in 71.2 years, thereby adding 12 degrees 42 minutes on Ptolemy's longitude value to allow for precession. Over the 839 years between the tables of Ptolemy and al-Ṣūfī, precession would actually amount to 11 deg 47 min. Hence by using 12 deg 42 min, al-Ṣūfī over-corrected Ptolemy's stellar longitudes by 55 min. Therefore, it would be unreasonable to compare the accuracy of al-Sufi's data with those of Ptolemy's because of this overcorrection which renders al-Ṣūfī's coordinates to be slightly more accurate then Ptolemy's. Al-Ṣūfī could not have been aware of this over-correction because his calculations were based on the *Almagest* and thus he did not discover the systematic error in Ptolemy's longitude even though Arabic and Islamic astronomers recognized earlier on that Ptolemy's value of precession was false. As for the ecliptic latitudes, al-Ṣūfī also explained in his introductory chapter that: "…since they (the stars) rotate around the poles of the ecliptic therefore they do not ever change".

The study and analysis of al-Ṣūfī's stellar data can be divided into two parts. The first is the study of the ecliptical longitude and latitude coordinates which where included in the stellar catalog. The second is the analysis of magnitude values which are found in both the chapters on the constellations as well as in the stellar catalog. As I mentioned earlier the study or analysis of the coordinate values is closely related to the study of the *Almagest*. Al-Ṣūfī relied heavily on Ptolemy's values where-by he merely adopted these coordinates which he found in the *Almagest* while adding 12 degrees 42 minutes on Ptolemy's longitude values to allow for precession. However, in many instances al-Ṣūfī mentioned that the coordinates of Ptolemy are incorrect. For example in the constellation Ursa Minor al-Ṣūfī states:

> "In some of (Ptolemy's) stars both the latitude and longitude are incorrect. This is because if they are marked on a (celestial) globe according to (Ptolemy's) table of latitude and longitude, especially (the stars of) *al-Na'esh*, we notice that the image (of the constellation) in the heavens does not correspond with what is (seen) on the globe"

Such a statement was repeated many times throughout the book, however it is again a surprise that our author did not follow up on these comments and correct what he thought to be Ptolemy's errors. This again might have been out of respect and in order to keep with the data which was found in the *Almagest*. The study of Ptolemy's coordinates was extensively covered in many research papers and books by prominent scholars such as Knobel, Peters, Newton, Toomer, Kunitsch and Grasshoff. Therefore the major analysis which I made for this study was to compare al-Ṣūfī's star magnitudes with modern values and with those found in the *Almagest*. I have tabulated the magnitude values of al-Ṣūfī and Ptolemy, together with the modern star magnitudes (table to be found in Appendix-A). Ptolemy's magnitude values and the star identification have been taken from G.J Toomer's book while the modern magnitude values were taken from the *Bright Star Catalogue*.

At first glance it would seem that about 50% of al-Ṣūfī's magnitude values were identical with those of Ptolemy's. The results showed that the magnitude values of 520 stars out of the total 1022 stars were identical between al-Ṣūfī and Ptolemy. Therefore one might wonder whether al-Ṣūfī only re-estimated the magnitudes of about half of the stars observed by Ptolemy. However, upon detailed comparison I found that out of these 520 stars only 206 stars have difference in values from the modern visual magnitude by more than 0.5 magnitude and only 56 stars where the difference in values from the visual magnitude is more than 1 magnitude. The results also showed that out of these 56 stars 22 stars have magnitudes of 5 or 6. This can also be understood because it is difficult to visually estimate some of these faint stars. Therefore a level of accuracy of 0.5 magnitudes is more than can be expected of eye estimation, either by al-Ṣūfī or Ptolemy for these stars. This conclusion is confirmed by the calculation of the standard error. Consequently I do not believe that al-Ṣūfī could have been more accurate in these stars by more than the 0.5 magnitudes. Another study conducted by Tomoko Fujiwara and Hitoshi Yamaoka (2005) on the magnitude estimates of old star catalogs also confirm the above result. Fujiwara and Yamaoka found that the 1st and the 6th magnitude stars in the old star catalogs should not be used in determining the current magnitude system because they exhibited a Malmquist bias where as all other stars magnitude in the old catalogs fit a logarithmic scale consistent with the light ratio of R = 2.512. However all this does not prove that al-Ṣūfī did or did not himself re-estimate all stars again.

Al-Ṣūfī and Ptolemy both added intermediate values to the magnitude class system for some stars. Ptolemy mentioned the words 'more-bright' and 'less-bright' for certain stars. However al-Ṣūfī expressed these intermediate magnitude values by the words '*Aṣghareh*' which means 'less' or '*Akbareh*' which means 'greater' and '*A'ẓameh*' which means 'much-greater'. Most scholars who studied al-Ṣūfī's work used the translation of Schjellerup (1874), who did not differentiate between the two words '*Akbareh*' and '*A'ẓameh*'. In Schjellerup's translation the magnitude was written as a middle value; for example 4-5 (between 4 and 5 magnitude). In their work on Ptolemy, Knobel & Peters (1915) and later Toomer (1998) as well as Grasshoff (1990) also relied upon Schjellerup's translation of al-Ṣūfī's data. They expressed Ptolemy's magnitudes by the words 'greater' and 'less'. They expressed these magnitudes on a 2-step system. By the 20th century this 2-step intermediate magnitude was numerically interpreted by a constant difference of (0.33) magnitude especially by Grasshoff. However, when we look at al-Ṣūfī's text in detail it is evident that he made a clear distinction between three intermediate magnitudes. I believe that al-Ṣūfī used what I have termed a 3-step intermediate magnitude system, which was more accurate than Ptolemy 2-step intermediate system. I think that with this system al-Ṣūfī managed to express all magnitude values by a constant difference of 0.25. For example the magnitude of the star 19 Ursa Major was expressed by al-Ṣūfī as "much greater than 3rd magnitude". This can be interpreted on the 3 step scale as (3 minus 0.5) which is equal to 2.5 magnitudes. The modern star magnitude is 2.44 which is a fairly close value. However if we are to interpret this on a 2-step scale as in Ptolemy then we get the magnitude value of 2.7. However it is unclear why al-Ṣūfī did not make this distinction in the tables when he clearly expressed this difference in the constellation chapters and comments.

One of the main topics of this study was to research this 3-step intermediate magnitude system which would shed new light on the accuracy and independence of al-Ṣūfī's work. Therefore in this part of the study I have made a complete analysis on al-Ṣūfī's magnitude values where the magnitude values were numerically interpreted by a constant difference of 0.25 magnitudes: that is +0.25 for 'less', -0.25 for 'greater' and -0.5 for 'much-greater'. Ptolemy's 2-step intermediate magnitude difference was interpreted by a constant of (0.3) magnitude. However, in order to analyze this topic further, all the data and information from al-Ṣūfī's book were collected in a table (see Appendix 8.1). The first three columns of this table show the number and the number sequence of the stars and constellations. The 4th to the 9th columns are the coordinated values according to al-Ṣūfī's tables. The 10th column shows the magnitudes of the stars according to al-Ṣūfī. I used the letters (s) for 'less', (k) for 'greater' and (m) for 'much-greater'. The 11th column shows the magnitudes after adjustment for the 3-step system and the 12th column for the 2-step system. This was done by adding the values +0.25 for 'less', -0.25 for 'greater' and -0.5 for 'much-greater' for the 3-step system while I added the values +0.3 or -0.3 for the 2-step system. The 13th column shows the magnitude according to Ptolemy. Here I used the magnitude which al-Ṣūfī attributed to Ptolemy. The 14th column shows Ptolemy's magnitudes after adjustment for the 2-step system. The 15th and 16th columns show the modern visual magnitude and the HR number for each star. Then I conducted an accuracy analysis for the magnitudes of al-Ṣūfī and Ptolemy by calculating the difference (Δ) between those values and the visual magnitudes in order to see if al-Ṣūfī had in mind a two-step or three-step magnitude systems. The statistical results of this analysis are summarized in (Table 7) which shows the Mean and the Standard Deviation for all 1022 stars combined:

Table 7 Statistical Data.

	Mean	standard deviation
al-Ṣūfī 3-step	-0.06	0.59
al-Ṣūfī 2-step	-0.09	0.59
Ptolemy	+0.07	0.71

From the above values it seems that the mean for the 3-step system is slightly better but barely statistically significant. The standard deviation is the same whether we apply the 3 or 2 step system whereas it is higher with Ptolemy. The dispersion in al-Ṣūfī's data is thus significantly less than in Ptolemy. The statistical results for al-Ṣūfī values according to the above table are not entirely conclusive between the 2-step and the 3-step systems. However, I still believe that al-Ṣūfī intended to use the 3-step system. The main reason for this assumption is the way al-Ṣūfī expressed or described the values of the stellar magnitudes in his book. For example, if we look at magnitude values in the constellation Gemini, it is clear that al-Ṣūfī was referring to three separate intermediate magnitudes (Table 8).

Table 8 al-Ṣūfī magnitudes for Constellation Gemini.

1	GEMINI	2
2	GEMINI	2
3	GEMINI	4(m)
4	GEMINI	4
5	GEMINI	4
6	GEMINI	4
7	GEMINI	4(k)
8	GEMINI	5(s)
9	GEMINI	5
10	GEMINI	3(s)
11	GEMINI	3
12	GEMINI	4(m)
13	GEMINI	3(s)
14	GEMINI	4(k)
15	GEMINI	4(k)
16	GEMINI	3(s)
17	GEMINI	3
18	GEMINI	4
19	GEMINI	4(s)
20	GEMINI	4(s)
21	GEMINI	5(s)
22	GEMINI	5(s)
23	GEMINI	5(s)
24	GEMINI	5(s)
25	GEMINI	4(s)

From the various magnitude values which we can see in the constellation Gemini, al-Ṣūfī made the distinction between (m) and (k) and he was not really concerned with word repetition or correct sentence structure. The above example shows that he expressed 4(m) and 4(k) consecutively then 4(k) twice. He also mentioned several (s) successively. These word repetitions for the various terms are to be found in many places through out the work. For example in the constellation Taurus, al-Ṣūfī wrote:

> “The third (star) is south of the second, close to it, and is much greater than 4^{th} magnitude, but it was mentioned by Ptolemy as 4^{th} magnitude exactly. The fourth (star) is the southernmost star of the four, south and close to the third, and is much greater then 4^{th} magnitude, but it was mentioned by Ptolemy as 4^{th} magnitude exactly”.

Here also the term *A'ẓameh* (much-greater) was used repeatedly in order to give the exact value which was intended. Therefore the assumption of word repetition is not valid in this case. Al-Ṣūfī also used the word *Aṣghareh* (s) throughout his entire work and he repeated it many times consecutively in many locations through out his book. Therefore, if al-Ṣūfī was concerned with correct grammatical structure, why did he not use other words for the term 'less' (s) *Aṣghareh* even though there are many other words in Arabic vocabulary which could have been used for this case?

However, the question arises is why did al-Ṣūfī not include these distinctions in his tables of the constellations? One answer to this question might be that the original tables which were written by al-Ṣūfī possibly included these values, but they might have been omitted when the work was copied even by al-Ṣūfī's son. However, the other reason which is much more reasonable is that al-Ṣūfī did not deviate too much from the format of Ptolemy's catalogue out of respect for this standard reference work since he asserted that he is compiling the tables according to the Ptolemy's *Almagest*.

5.5 Stars Mentioned by al-Ṣūfī and not in the Almagest

In his written comments on the constellations, al-Ṣūfī mentioned some additional stars that were not included in Ptolemy’s star catalog. However, it is surprising that al-Ṣūfī did not include these stars in his tables even though he identified many of them in detail and described their magnitudes and he even estimated their locations. One reason why al-Ṣūfī did not include these additional stars might have been out of respect for Ptolemy's catalogue which had long been a standard reference work in this field. In his introductory chapter al-Ṣūfī’s clearly stated that the tables he produced were made according to Ptolemy’s work; therefore he might have been inclined to follow the classical tradition to which he and all other scholars before him were used.

It is also surprising that there are very few Arabic or Islamic historical sources that mention these additional stars. However the major text which makes reference to these stars is the *Alfonsine IIII Libros de la Ochaua Espera* (*Four Books of the Eight Spheres*) which was also called *Libros de las Estrellas Fixas* (*Books on the Fixed Stars*). These works were produced in Toledo in A.D. 1256 but were based on the al-Ṣūfī’s *Book of the Fixed Stars*. Book four of these *Alfonsine* texts was a statistical summary which included the number of stars in each constellation as well as Arabic names of stars according to Arabic folk astronomy (Samso et al., 1988). This book also included a general list of 84 stars taken from al-Ṣūfī’s work which were not mentioned by Ptolemy.

In this part of the study I have identified a total number of 134 of these additional stars; 65 were located in the Northern constellations, 41 in the Zodiac constellations and 28 in the Southern constellations. Al-Ṣūfī mentioned these stars in his constellation commentaries but not in the tables and he clearly said that these stars were not mentioned by Ptolemy. In many instances al-Ṣūfī mentions that in several areas of the sky there are many stars but he fails to mention a definite number because of their large numbers. For example in the comments on the constellation Ursa Major al-Ṣūfī wrote that: “Throughout (the main image of the) constellation and outside of it, there are many stars of the 5^{th} and 6^{th} magnitudes. Additionally there is an infinite number of dim (stars) which are outside of the 6^{th} magnitude (classification).”

Therefore I have tried to identify in the below tables all the major stars that were mentioned by al-Ṣūfī. I have also tried to identify these stars by their HR number and I have included the magnitude that al-Ṣūfī assigns together with the modern magnitude for these stars. In the star number column, I continued with the sequence of the star number as per al-Ṣūfī in order to include these numbers in the star charts.

Table 9: Northern Stars mentioned by al-Ṣūfī but not by Ptolemy.

Number	Star number (as per al-Ṣūfī)	Star/s (HR)	Al-Ṣūfī Magnitude	Modern Magnitude	Explanations and Comments
1	36 Ursa Major	5062	Not mentioned	4.01	This is the star named Alcor. The Arabic name is *al-Suhā*. This star was not mentioned in Ptolemy; therefore it was not presented in al-Ṣūfī's chart. However al-Ṣūfī mentioned this star in his written explanation of this constellation. This is a very famous star in Arabic tradition, as al-Ṣūfī explained that this star was used to test eyesight.
2	37 Ursa Major	4518	4	3.71	Al-Ṣūfī mentioned this star in his written explanation of this constellation and he mentioned that it was not included in Ptolemy.
3-7	38 Ursa Major 39 Ursa Major 40 Ursa Major 41 Ursa Major 42 Ursa Major	4392 4248 4277 4288 4380	Al-Ṣūfī mentioned that these are of magnitude 5 or 6	4.99 4.71 5.05 5.08 4.78	Al-Ṣūfī mentioned in the written explanation that there is a group of stars that together with the twenty-second star form a circle. These stars were not mentioned by Ptolemy. These stars are all part of Ursa Major.
8	43 Ursa Major	4728	5.25	5.02	Al-Ṣūfī mentioned that this star is between the second of the two (stars) outside of the constellation, close to *Kabd al-Asad* and (the star) on the knee-bend. It is less than the 5th magnitude. It is much closer to the second (star) that is outside of constellation. This star is now included in constellation CVn.
9	44 Ursa Major	3648		5.13	Al-Ṣūfī explained that this star together with the seventh and eighth form a triangle and which form together with the ninth and the tenth another open angle (obtuse) triangle.
10-11	45 Ursa Major 46 Ursa Major	5023 5112	6 6	5.15 4.7	Al-Ṣūfī explained these two stars (5023 & 5112) are one *dhirā‘* (2 deg 20 min) distance

					from each other. The actual distance between these two stars is approximately 2 deg 26 min.
12	32 Draco	6618	6	5.75	Al-Ṣūfī mentioned that in the middle of the 4 stars which are the second , third, fourth, and fifth there is a very faint star which was not mentioned by Ptolemy and which the Arabs call *al-Ruba'*.
13	14 Cepheus	8591	6	5.50	The Arabs call this star *Kalb al-Rā'ī* (shepherd's dog). Al-Ṣūfī mentioned that this is a faint star located between the left and right leg but closer to the left leg.
14-17	15,17,18,19 Cepheus	7701 7633 7740 7955	Not mentioned	5.39 4.96 4.30 4.51	Al-Ṣūfī mentioned that the fifth and sixth stars together with other stars form a circle of stars between the constellations of Draco and Cygnus. This circle of stars was called *al-Qidr*. In the image al-Ṣūfī drew four of these stars with the fifth and sixth which form the circle.
18-21	20,21,22,23 Cepheus	8317 8468 8615 8819	6(k) or 5(s)	4.56 4.79 5.08 4.41	Al-Ṣūfī mentioned that there is a line of stars between the second and third stars whose magnitude is either greater than 6^{th} magnitude or less than 5^{th} magnitude. I have tried to identify only a few of these stars. Al-Ṣūfī also mentioned that there are many 5^{th} and 6^{th} magnitude stars on the body and between the legs however these cannot be identified accurately since their location is a little vague.
22-24	24,25,26 Bootes	5502 5544 5575	5 5 6	4.6 4.55 5.71	These stars are above the nineteenth star which is on the right heel and they form a triangle.
25-28	27,28,29,30 Bootes	5370 5365 5330 5159	5 5 5 4	4.86 5.41 5.29 5.36	Al-Ṣūfī mentioned that there is a line of stars between the constellation Bootes and Virgo; however he identified the magnitudes of 4 stars: 3 of the 5^{th} magnitude and 1 of the 4^{th} magnitude.
29	31 Hercules	6159	6	4.84	
30-31	32,33 Hercules	6355 6337	6 6	4.91 4.98	

32-36	34,35 Hercules	6781 6685 6644 6571 6480	5(s) or 6 5(s) or 6 5(s) or 6 5(s) or 6 6(m)	5.86 5.46 5.12 5.77 5.74	
37	36 Hercules	6677	6	5.16	
	37,38 Hercules	6793 6872	Not mentioned	5.48 4.33	Al-Ṣūfī mentioned that there are many 6th magnitude stars between the eighteenth star of Hercules and the constellation Lyra which were not mentioned by Ptolemy. He also mentioned that there are many 6th magnitude stars between the twenty-fifth star of Hercules and the constellation Draco and one particular star of the 5th magnitude which is closer to the tip of the tongue of Draco; however it was not possible to identify this star with an acceptable degree of accuracy.
38	11 Lyra	7262	5	5.28	
39	20 Cygnus	8146	5	4.43	Al-Ṣūfī mentioned that this star is between the two stars outside of the constellation (the eighteenth and the nineteenth) and the twelfth star.
40-43	21,22,23,24 Cygnus	7834 7942 7866 7806	4(s) 4(s) 6 5	4.01 4.22 4.61 4.43	Al-Ṣūfī also mentioned that between these stars and the constellation Sagitta are many stars of the 6th magnitude which were not mentioned by Ptolemy.
					Al-Ṣūfī also mentioned that between the twelfth star and the constellation Delphinus are many stars of the 6th magnitude which were not mentioned by Ptolemy.
44	25 Cygnus	7405	5	4.44	Al-Ṣūfī mentioned that this star should have been on the beak and that it is brighter than the star on the head (second star which he mentioned to be 6 magnitude).
45-47	14, 15,16 Cassiopia	580 575 548	4 4 6	3.98 4.54 4.99	Al-Ṣūfī mentioned that there are three stars north of the seventh stars; two of the 4th magnitude and one of the 6th magnitudes. He also mentioned that next to these stars are many 6th magnitude stars which were not mentioned by Ptolemy.

48	14 Auriga	1995	5	4.52	This forms a double star with the fifth star. Al-Ṣūfī did not mention its magnitude, however he mentioned that the fifth star was of the 5th magnitude while Ptolemy mentioned it to be 4th magnitude. Al-Ṣūfī might have made a mistake here and switched between the two.
49	30 Ophiuchus	6493	5(m)	4.54	
50	31 Ophiuchus	6243	5	4.65	
51	32 Ophiuchus	6770	5 or 6	4.64	The double star with the twenty-ninth star of Ophiuchus. Al-Ṣūfī mentioned that it is a small or faint star.
52	33 Ophiuchus	6093	6	4.83	
53	34 Ophiuchus	6524	6	5.59	
54	19 Serpens	5843	5	5.33	
55	20 Serpens	5895	5 or 6	5.11	The double star with the eleventh star of the Serpens. Al-Ṣūfī mentioned that it is a small or faint star.
56	16 Aquila	Cr 399			Al-Ṣūfī identified this Nebula between the ninth star of Aquila and the constellation Sagitta. It is the open cluster Cr 399 which is also called Brocchi's cluster. He mentioned that this nebula contains stars of the 4th, 5th and 6th magnitude but most are of the 5th magnitude.
57	17 Aquila	7437	6	5.00	Al-Ṣūfī mentioned that this star is between the nebula and the constellation Sagitta.
58	18 Aquila	7193	4(s)	4.02	
59	19 Aquila	7149	6	4.83	
60	20 Aquila	7063	5	4.22	
61	21 Aquila	7032	5	4.90	
62	22 Aquila	7020	5	4.72	
63	23 Aquila	6973	4(m)	3.85	
64	24 Aquila	7007	6	5.84	
65	5 Triangulum	655	6	5.28	Double star with the fourth star of Triangulum.

Table 10: Zodiac Stars mentioned by al-Ṣūfī but not by Ptolemy.

Number	Star number (as per al-Ṣūfī)	Star/s (HR)	Al-Ṣūfī Magnitude	Modern Magnitude	Explanations and Comments
1	19 Aries	1005	4	5.28	Al-Ṣūfī did not exactly specify a magnitude; however, he mentioned that this star is

					similar to the tenth star which he stated as 4th magnitude.
2-3	20 Aries 21 Aries	569 623	4(s)=4.25 5(s)=5.25	4.79 4.98	Al-Ṣūfī mentions that these two stars are similar in magnitude to the two stars on the muzzle, which are 4(s) and 5(s).
4	22 Aries	613	6	5.03	Al-Ṣūfī mentioned that this star is close to the star al-*Nāṭiḥ* (which is the fourteenth star of Aries).
5	44 Taurus	1153	6	5.35	
6	45 Taurus	1159	6	5.91	
7	46 Taurus	1268	5	5.20	
8	47 Taurus	1990	5(s)=5.25	5.49	
9	48 Taurus	1253	6	5.33	
10	49 Taurus	1381	6	5.12	
11	50 Taurus	1389	6(m)=5.5	4.29	
12	51 Taurus	1427	5(s)=5.25	4.78	
13	52 Taurus	1394	6	4.49	
14	53 Taurus	1356	6	5.26	
15	54 Taurus	1149	Not mentioned	3.87	Additional stars of the Pleiades.
16	55 Taurus	1165	Not mentioned	2.87	Additional stars of the Pleiades.
17	56 Taurus	1142	Not mentioned	3.70	Additional stars of the Pleiades.
18	26 Gemini	2852	5	4.18	
19	27 Gemini	2973	5	4.28	
20-22	28 Gemini 29 Gemini 30 Gemini	2456 2503 2506	5 5 5	4.66 4.77 4.47	Al-Ṣūfī mentioned that these three stars form an arc which is between the constellation Orion and the asterism *al-Han'a* (the 6th lunar mansion)
23	33 Virgo	5044	Not mentioned	5.37	Double star with HR 5019.
24	34 Virgo	4824	6	6.19	Next to the eleventh star HR4828.
25	18 Libra	5824	6	4.96	
26	25 Scorpio	6143	6	4.23	
27	26 Scorpio	6166	6	4.16	
28	27 Scorpio	6081	5(s)=5.25	4.55	
29	28 Scorpio	6141	5(s)=5.25	4.79	
30	29 Scorpio	5885	6	4.64	
31	30 Scorpio	5904	6	4.59	
32	32 Sagittarius	7120	Not mentioned	5.00	Double star with 8 Sagittarius HR7116.
33	33 Sagittarius	7337	Not mentioned	4.01	Double star with 23 Sagittarius (HR7343).
34	34 Sagittarius	-	3	-	Al-Ṣūfī mentioned that there is a 3rd magnitude star between 23 Sagittarius and the constellation Piscis Australis; however the location was not precise enough

					to locate this star.
35	46 Aquarius	7845	5	5.65	
36	47 Aquarius	8496	6	5.34	
37	48 Aquarius	8590	Not mentioned	5.89	Al-Ṣūfī mentioned that this star is between 12 Aquarius and 23 Aquarius
38	49 Aquarius	8890	6	5.20	Al-Ṣūfī mentioned that this star is north of 30 Aquarius
39	50 Aquarius	8987	6	5.28	Double star with 31 Aquarius (HR8968)
40	39 Pisces	389	5	5.23	
41	39 Pisces	274	5	5.42	

Table 11: Southern Stars mentioned by al-Ṣūfī but not by Ptolemy.

Number	Star number (as per al-Ṣūfī)	Star/s (HR)	al-Ṣūfī Magnitude	Modern Magnitude	Explanations and Comments
1	23 Cetus	775	5	6.21	Between 3 and 5 Cetus.
2	24 Cetus	531	5	4.67	Close to 14 Cetus.
3	25 Cetus	583	5	5.41	South of 13 Cetus.
4	26 Cetus	329	6	5.82	Double star with 16 Cetus (HR 334).
5	39 Orion	2130		5.14	Double star with 12 Orion (HR 2135).
6	40 Orion	1931	4	3.81	
7	35 Eridanus	917	5	5.32	Double star with 15 Eridanus (HR925).
8	36 Eridanus	994	4	4.88	Double star with 21 Eridanus (HR1003).
9	37 Eridanus	794	4	4.11	
10	38 Eridanus	789	5	4.75	
11	39 Eridanus	1008	4	4.27	
12	40 Eridanus	963	3(s)=3.25	3.87	
13	46 Argo	3307	3(s)=3.25	1.86	
14	47 Argo	2787	Not mentioned	4.66	Double star with 12 Argo (HR2773).
15	48 Argo	3037	Not mentioned	5.23	Double star with 34 Argo (HR3055).
16	49 Argo	NGC2669 IC 2391			Al-Ṣūfī mentioned that next to 37 Argo is a nebula. He is probably referring to NGC2669.
17	28 Hydra	3492	5	4.36	Double star with 3 Hydra (HR3482).
18	29 Hydra	3709	5	4.80	
19	30 Hydra	3706	5	4.79	
20	31 Hydra	3636	6	5.77	
21	38 Centaurus	4933		4.27	Double star with 22 Centaurus.
22	20 Lupus	5457	6	6.07	Close to 2 Lupus.
23	21 Lupus	5494	6	5.74	Close to 2 Lupus.
24	8 Ara	6897	4	3.51	Double star with HR6934.
25	9 Ara	6934	6	4.96	

26	10 Ara	6905	5	4.13	
27	14 Corona Australis	6938	5	5.07	
28	12 Piscis Austrinus	8447	Not mentioned	4.92	Double star with 6 Piscis Austrinus (HR8431).

5.6 Color of Stars in al-Ṣūfī's Book

The color of the stars was never an important topic for ancient observers of the sky. There are very few ancient records on this subject or in ancient star catalogs. 'Red' was the color that attracted the most attention whilst the other colors such as 'white' or 'blue' were rarely mentioned. Ptolemy gave the color red to six stars in his catalog. These stars were Aldebaran, Arcturus, Betelgeuse, Pollux, Antares and strangely enough Sirius. One of the first Arab and Islamic authors to mention the color of the stars was al-Farghānī. In his discussion of Ptolemy's book al-Farghānī mentioned only the color of three red stars, Antares, Pollux, and Aldebaran. On the other hand al-Battānī did not attribute any color to any of the stars in his star catalog whereas Ulugh Bēg mentioned the color of four red stars, Antares, Pollux, Betelgeuse and Aldebaran but neglected Arcturus and Alpha Hydrae. The Alfonsine authors do not mention any remarks on the color of stars except the red color of Antares (*Qalb al-'Aqrab*) (Samso&Comes, 1988). By the time we reach the catalog of Tycho Brahe we find that it only mentions the color of Antares: as ruby red.

In the '*Book of the Fixed Stars*' al-Ṣūfī described seven stars with red color in particular. These stars were Aldebaran, Arcturus, Betelgeuse, Pollux, Alpha Hydrae, Algol and Antares. However al-Ṣūfī stays silent about the color of Sirius. He only describes it as a bright star on the mouth called *al-Kalb* (Dog). I have tried to give in the table below (Table 12) a brief summary on each of these eight stars along with what al-Ṣūfī mentioned about them. These stars were sometimes mentioned in the tables and other times in his comments on the constellations:

Table 12: Color of the stars according to al-Ṣūfī.

Number	Modern Star name & (HR) & Color Index	Star Numbers according to al-Ṣūfī	Description according to al-Ṣūfī
1	Aldebaran HR1457 B-V = 1.54	14 Taurus	From the table: The bright star, the reddish one of the letter (Δ) *al-Dāl* on the southern eye and it is *al-Dabarān*. From the comments: The fourteenth is the large bright red (star) on the south edge of the stars that resemble *al-Dāl*. It is located on the south eye and is drawn on *al-Īsterlāb* (the Astrolabe). It is called *al-Dabarān* and '*Ayn al-Thawr* (the eye of Taurus) and is of

			the 1st magnitude.
2	Arcturus HR5340 B-V = 1.23	23 Bootes	From the table: The star between the thighs called *al-Simāk al-Rāmiḥ*. From the comments: As for the one outside the constellation image it is the bright red star between the thighs. It is of the 1st magnitude and it is drawn on the *al-Īsterlāb* (Astrolabe). It is called *al-Simāk al-Rāmiḥ*.
3	Betelgeuse HR2061 B-V = 1.84	2 Orion	From the table: The bright reddish star on the right shoulder. From the comments: The second is the great bright red star located on the right *Mankib* (shoulder). It is less than the 1st magnitude. The distance between it and the three stars on the head is three Thira. It is (one of the stars that are) drawn on an Astrolabe. It is called *Mankib al-Jauzā'* (the shoulder of Orion) and also *Yad al-Jauzā'* (the hand of Orion).
4	Pollux HR2990 B-V = 1.00	2 Gemini	From the table: The reddish star on the head of the rear twin. From the comments: The second (star) follows the first on the head of the rear twin. It is a little south (of the first) with a distance of more than 2 *dhirā'* between them. It is also of the 2nd magnitude.
5	Alpha Hydrae HR3748 B-V = 1.45	12 Hydra	From the table: The bright one of these two close stars called *al-Fard*. From the comments: The twelfth star is the bright red star at the end of the neck and at the beginning of the back. It is of the 2nd magnitude. It is drawn on the *al-Īsterlāb* (Astrolabe). It is called '*Unuk al-Shujā'* (the Neck of Hydra). It is also called *al-Fard*.
6	Algol HR936 B-V= -0.05	12 Perseus	From the table: stars in the Gorgon's head: the bright one. From the comments: The twelfth star is the bright red star less than 2nd magnitude. Ptolemy mentioned it is exactly of the 2nd magnitude. It is on the gorgon's head. It is further than the eleventh star by two *Thira*. It is drawn on the Astrolabe. It is called *Rae's al-Ghūl* (Gorgon's Head).
7	Antares HR6134 B-V = 1.84	8 Scorpio	From the table: The middle one of these which is reddish and called *Qalb al-'Aqrab* (Antares). From the comments: The eighth is the bright red (star) that is close to the seventh.

			It is of the 2nd magnitude. It is (one of the stars that are) drawn on an Astrolabe. It is called *Qalb al-‘Aqrab* (the heart of Scorpio). It is the eighteenth of the lunar mansions.
8	Sirius HR2491 B-V = 0.00	1Canis Major	From the table: The star in the mouth, the brightest, which is called *al-Kalb* (Dog) and *al-Shi’ra al-Yamāniya* and *al-‘Abūr*. From the comments: The first star is the great bright star on the mouth. It is drawn on the Astrolabe. It is called *al-Yamāniya*.

The color index is a numerical expression that determines the color of a stellar object and thus its temperature. These indices are measured by determining the magnitude of an object using different kinds of filters; the U filter which transmits ultraviolet rays, the B filter which transmits blue light, and the V filter visible (green-yellow) light. The difference in magnitudes found with these filters is called the U-B or B-V color index. The smaller the color index, the bluer (or hotter) the object is. Conversely, the larger the color index, the redder (or cooler) the object is. Starting from the least red color (B-V) index of 1.0 for the star Pollux to the high color index of 1.84 for both the stars Betelgeuse and Antares, the above color indices are an obvious evidence for the reliability of the data for most of these stars - except when it comes to the two stars Sirius and Algol. The Sirius problem and consequent debate will be discussed in depth in the section below. As for the color of Algol, it is surprising for an acute observer such as al-Ṣūfī to assign the red color to this star. The star Algol is a short period close binary eclipsing system that changes magnitude from maximum 2.12 to minimum 3.39 in few days and the color index scarcely varies. al-Ṣūfī considered this star to be a bright star with less than 2nd magnitude (2.25) while Ptolemy assigned it the 2nd magnitude. Therefore the nature of the variability of this star is not a reason which explains the error of assigning the red color to this star. The only other explanation is that al-Ṣūfī was mistaken in this regard. A similar mistake was also made by Julius Schmidt who was the Director of Athens Observatory. He also observed Algol to be ‘reddish yellow’ in 1841 (Ceragioli, 1995).

5.6.1 The Debate on Color of the Sirius

A puzzling question in the history of astronomy concerning the star Sirius is whether this star changed color in the last 2000 years. For a long time in the past there used to be confusion on the actual color of Sirius. Ptolemy and many other Greek and Latin astronomers mentioned that the color of Sirius is red. Ptolemy described this star as "…the star in the mouth and is the brightest and is reddish in color." More than 1000 years later al-Ṣūfī stopped from attributing any color to Sirius, even though he mentioned the colors for other stars. It is a very well known fact today that the color of Sirius is bright white. So the question arises why there is such a difference in what the Greeks said about this star and what al-Ṣūfī wrote and what we know as a fact today? Has there been a change in the color of this star in the lat two millennia and why?

The first and most obvious answer to this problem is that Ptolemy might have made an error in assigning the color red to this star. Another answer is that during the course of history there might have been some errors in copying the ancient manuscripts which we know of today especially the *Almagest*. The reason for this is that Ptolemy does not mention the red Sirius in his astrological treatise, the *Tetrabiblos*. Therefore, during the course of history many Arabic, Islamic and Western astronomers might have overlooked this matter for these reasons. However such a description of a major star could not be easily disregarded especially since there were many other ancient Greek and Latin philosophers, poets and astronomers who corroborate Ptolemy by calling Sirius "Reddish" such as Aratus (3th century B.C.), Cicero (1st century B.C.), Horace (1st century B.C.), and Seneca (1st century A.D.). This fact was also enforced by an Assyrian cuneiform tablet which mentioned this star as "…reddish-white like molten copper…" (Rietschi, 1995).

According to Aristotelian philosophy the heavens or the 'Cosmos' was a physically unchanging order. This physical concept was the dominant view to which most scholars, philosophers and astronomers adhered to through out the Middle Ages. Therefore, the idea of Sirius changing color was not considered until the time of Tycho and Kepler. The Sirius debate seriously began in the eighteenth century with the study of variable stars. In 1790 Thomas Baker published a short article in the *Philosophical Transaction of the Royal Society* in favor of Sirius being red. The first physical mechanism for the redness of Sirius was proposed in 1839 by John Herschel. In his study of variable stars he mentioned that a 'cosmic' cloud might be an explanation for this phenomenon. However, in the nineteenth century with the development of the first theories of stellar evolution the idea of a red star changing color was dismissed. This argument was further confirmed by studies of ancient manuscripts especially with the publication in 1874 of Schjellerup's translation of al-Ṣūfī's *Book of the Fixed Star*. In his introduction to this translation Schjellerup discredited the evidence of Sirius being red and he attributed Ptolemy's remarks of a red Sirius to errors in copying and translating the *Almagest*. In 1882 yet another reason was added to this debate by

W.T. Lynn, which was the effect of atmosphere condition on observation. He explained that Sirius is the only bright star which can actually be seen at sunset or sunrise from the horizon and Ptolemy might have been referring to an observation of this star at this time close to the horizon when it could appear to be red due to the effect of the atmosphere.

The counter attack to these arguments did not take a very long time to happen. In 1892 a controversial astronomer by the name of T.J.J. See published a series of articles in the *Astronomy and Astrophysical Journal* in favor of the redness of Sirius. He also disregarded the atmospheric effect, since Ptolemy made his observations from Egypt where the atmosphere is usually clear at night and the fact that Ptolemy could not have made such a mistake on this most important of stars (See, 1927). However, See's historical arrangements were not favorably received by the scientific community-mainly due to See's personality as well as the scientific nature of this subject. By this time most astronomers preferred to endorse the astronomical facts, which have been achieved up to that date. These attacks have been spearheaded by astronomers such as Schiaparelli and Newcomb and continued in a series of articles between See and Schiaparelli until 1930's. This debate later died down with most astronomers favoring the idea of atmospheric effects rather then a star changing color.

In the mid-twentieth century the debate started again with the ever-emerging theories of binary star evolution. By this time Sirius was known to be a binary system composed of Sirius-A which is a 2.25 solar-mass main-sequence star and Sirius-B which is a 1.05 solar-mass white dwarf. Research also indicated that this system is surrounded by dust. Several astronomers tried to explain the redness of Sirius by several astrophysical mechanisms such as mass loss through solar wind, nova ejection, supernova explosions, interstellar dust absorption as well as a thermonuclear runaway (Holberg, 2007). However, none of these astrophysical explanations stood scientific ground and accurately explained the redness of Sirius. When we turn to records of ancient China the color of Sirius is described as white. Early details of this can be found in Edouard Chavannes (1898) translation of Sima Qian historical (*Shiji*) records compiled around B.C. 100 (Rietschi, 1995).

The Sirius debate will probably continue in the future until a reasonably accurate explanation is achieved. The study of variable stars is a fairly young science with abundant data available for only the past 100 years. The study of color change and long term variability of stars can only be made if what has been written about these stars is properly authenticated. The main ancient data which are available to researchers are to be found in the old star catalogs such as those produced by Ptolemy's and al-Ṣūfī's. Therefore, once the stellar identification and comparisons are made, it is possible to identify some of the reasons for change in the magnitudes and star colors. The final results from al-Ṣūfī's data will hopefully be better used in the field of applied historical astronomy such as the changing of star magnitudes, proper motion, or variable star analysis and will hopefully open new doors of investigations in these fields.

5.7 Stars Used on the Astrolabe in al-Ṣūfī's Book

The Astrolabe is an ancient analog calculator capable of working out several different kinds of problems in spherical astronomy. It was used for solving problems relating to the time and position of the Sun and stars in the sky. The astrolabe is thought to be a Greek invention. The stereographic projection was probably known by Hipparchus as early as B.C. 150. The oldest available treatise about stereographic projection and the astrolabe was the *Planispherium*, which was written by Ptolemy (Evans, 1998). However Ptolemy's astrolabe was a simple instrument, which was used as a star finder and not as an observational instrument for measuring the altitude of stars. It did not include many of the features found in later instruments (Webster, Roderick & Marjorie, 1998).

In his *al-Fahras,* al-Nadīm reported that the first person credited with constructing an *Isṭerlāb* (astrolabe) in the Islamic world was the eighth century mathematician and astronomer Muḥammad al-Fazārī. In A.D. 856 al-Faraghānī wrote one of the first detailed descriptions on this instrument (Lorch, 2005). By the 9th century the astrolabe was very much in use in the Arabic and Islamic world. It was later introduced to Europe from Islamic Spain (Andalusia) in the early 12th century. It was also introduced to China from the Islamic world in the 13th century (Webster, Roderick & Marjorie, 1998). Several types of astrolabes in the Arab and Islamic world were made. The most popular type was the planispheric astrolabe, on which the celestial sphere is projected onto the plane of the equator. Other types include the spherical astrolabe, Azarquil (al-Zarqālī) astrolabe and the mariner astrolabe which was a crude instrument used in navigation. The astrolabe was very much developed in the Arab and Islamic world and was extensively used as an astronomical instrument. Most of the astrolabes constructed in that period were made of brass and were about 10-15 cm in diameter. There are more than 600 surviving Arabic and Islamic astrolabes, the oldest are from the 9th and 10th centuries (King, 2005).

An astrolabe consists of a hollow disk (called mater) which holds one or more flat plates (called climates). Each plate is specially made for a specific latitude. They are engraved with a stereographic projection of circular lines which represent the celestial sphere. The disk also holds another frame or net called a spider (also called rete- in Arabic *al-'Ankabūt*) which is free to rotate on top of the flat plates. This frame or spider which acts as a star map is a projection of the ecliptic plane with pointers or indicators pointing to the position of the brightest stars in the sky. The early astrolabes included no more than 20 stars of the 1st and 2nd magnitudes. The earliest extant eastern astrolabe dated A.D. 927 contained only 17 stars, however later astrolabes had more than sixty stars positioned on the rete. The back of the disk (mater) includes a number of trigonometric scales which are used in various astronomical, timekeeping and other applications. The final piece of the astrolabe is a movable rectangular rod (alidade- in Arabic *al-‘Iḍaḍah*) attached to the back face of the instrument. When the astrolabe is held vertically, the alidade can be rotated and a star sighted along its length, so that the star's altitude in degrees can be read from the graduated edge of the astrolabe. To use an astrolabe, you adjust the moveable components to a specific date and time. Once set, the entire sky, both visible and invisible, is represented on the face of the instrument. This allows a great many astronomical problems to be solved in a very visual way. Figure 41 shows the parts of the astrolabe with the spider at the top of the image.

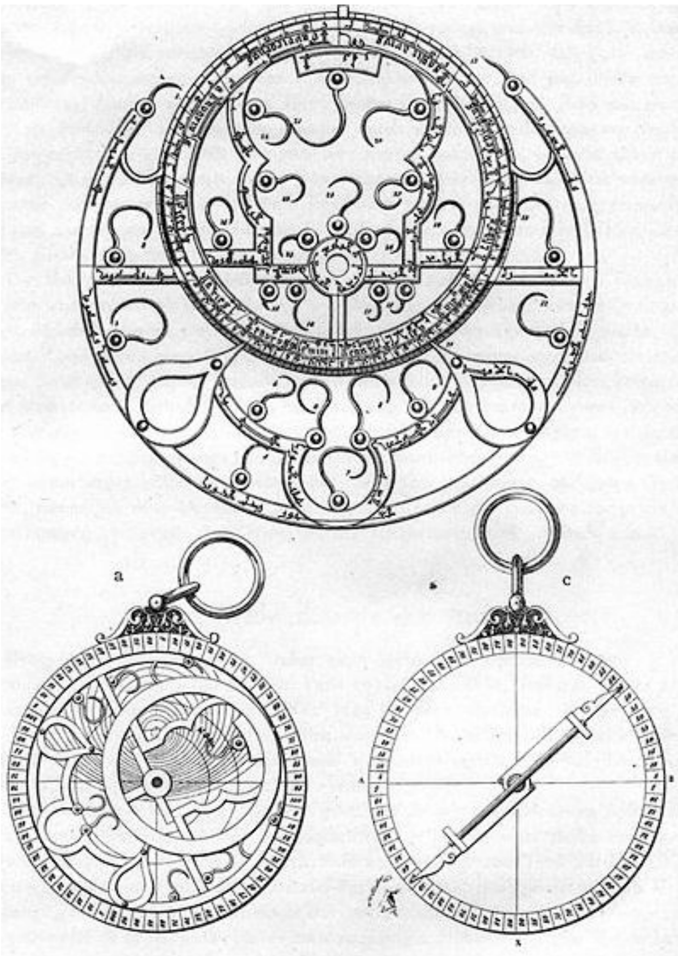


Figure 41

Al-Ṣūfī wrote extensively on the construction and use of the astrolabe (see biography section). In one of his treatises al-Ṣūfī described more than 1000 different uses for an astrolabe in fields such as astronomy, astrology, timekeeping, navigation, construction and surveying. Kunitzsch mentioned that in several of the al-Ṣūfī's works he identified as many as 55 stars which could be used on the astrolabe spider. Al-Ṣūfī's *Book of the Fixed Stars*, which included 44 of these stars, was the best and most accurate of al-Ṣūfī's works (Kunitzsch, 1990). This was one of the main reference to which many later astronomers and instrument makers used to identify the stars of the astrolabe.

However al-Ṣūfī did not make a list of the astrolabe stars but rather the information on these stars were scattered throughout the various sections of al-Ṣūfī's book. Therefore I have tried to identify below (Table 13) all the astrolabe stars found in al-Ṣūfī's book. I also included a brief summary on every one of these stars as they were mentioned by al-Ṣūfī. This summary included all the descriptions both from the tables as well as from the comments in the constellation chapters which mentioned these stars according to al-Ṣūfī. As can be seen from the various comments below, al-Ṣūfī very clearly indicated which stars were to be used on this instrument. He also indicated the various known names and the magnitudes either in the tables or in the comments. Al-Ṣūfī also mentioned 5 stars which were used on the southern astrolabes. Southern astrolabes were probably those instruments which were constructed and used by people living in the Southern Hemisphere.

Table 13: Stars used on the astrolabe in al-Ṣūfī's book.

Num	Modern star name +(HR)	Numbers according to al-Ṣūfī	Magnitude According to al-Ṣūfī	Names and Description according to al-Ṣūfī
1	Arcturus HR5340	23 Bootes	1	*al-Simāk al-Rāmiḥ* From the table: The star between the thighs called *al-Simāk al-Rāmiḥ*. From the comments: As for the one outside the constellation image it is the bright red star between the thighs. It is of the 1st magnitude and it is drawn on the astrolabe. It is called *al-Simāk al-Rāmiḥ*.
2	HR5793	1 Corona Borealis	2	*al-Munīr Min al-Fakka* From the table: The bright star in the crown. From the comments:

				The first star is the bright one of the 2nd magnitude. It is used on the astrolabe and is called *al-Munīr Min al-Fakka*.
3	HR6406	1 Hercules	3(s)= 3.25	*Rae's al-Jāthī* From the table: The star on the head. From the comments: The first star is the one on the head. It is in advance of the bright star on the head of *al-Ḥawwā* (constellation Ophiuchus). It is less than 3rd magnitude. Ptolemy mentioned it is exactly of the 3rd magnitude. It is incorrect to consider the magnitude of this star the same as the star on the head of *al-Ḥawwā*. It is drawn on the astrolabe and called *Rae's al-Jāthī.*
4	Vega HR7001	1 Lyra	1	*al-Nasr al-Wāqi'* From the table: The bright star on the shell called Lyra called *al-Nasr al-Wāqi'*. From the comments: The first one is the famous bright star of the 1st magnitude which is drawn on the astrolabe. It is called *al-Nasr al-Wāqi'*.
5	HR7417	1 Cygnus	3(s)=3.25	*Minqār al-Dajāja* From the table: The star on the beak. From the comments: The first of the constellation *al-Ta'er* (Cygnus) is the bright star on the beak behind the constellation of *al-Nasr al-Wāqi'*. Ptolemy mentioned it is exactly of the 3rd magnitude; however, it is less than 3rd magnitude. It is drawn on the astrolabe and called *Minqār al-Dajāja*.
6	Deneb HR7924	5 Cygnus	2	*Dhanab al-Dajāja* From the table: The bright star in the tail. From the comments: The fifth star is the bright one on the tail. It is of the 2nd magnitude. It is drawn on the astrolabe and is called Dhanab al-Dajāja.
7	HR12	12 Cassiopeia	3	*al-Kaff al-Khaḍīb* *Sinām al-Nāqa* From the table: The star on the middle of the back of the throne

				called *al-Kaff al-Khaḍīb*. From the comments: The twelfth star is the one on the middle of the back of the throne. It is drawn on the astrolabe. It is called *al-Kaff al-Khaḍīb* and *Sinām al-Nāqa*.
8	HR 1017	7 Perseus	2	*Janb Barshāūsh* From the table: The bright star in the right side. From the comments: The seventh is the bright star on the right side next to the sixth star. It is also outside of the galaxy touching its western edge. It almost forms a straight line with the sixth and fourth stars. It is of the 2nd magnitude. It is drawn on the astrolabe and called *Janb barshāūsh*.
9	Algol HR936	12 Perseus	2	*Ra's al-Ghūl* From the table: The stars in the gorgon head: the bright one. From the comments: The twelfth star is the bright red star less than 2nd magnitude. Ptolemy mentioned it is exactly of the 2nd magnitude. It is on the gorgon's head. It is distant from the eleventh star by two Thira. It is drawn on the astrolabe. It is called *Ra's al-Ghūl* (Gorgon's Head).
10	Capella HR1708	3 Auriga	1	*al-'Ayyūq* From the table: The star on the left shoulder called *al-'Ayyūq* From the comments: The third is the very bright star on its left shoulder. It is on the southern edge of the galaxy. It is of the 1st magnitude. It is drawn on the astrolabe and called *al-'Ayyūq*.
11	HR 6556	1 Ophiuchus	3	*Ra's al-Ḥawwā* From the table: The star on the head. From the comments: The first of its stars is the one on the head in front of *al-Nasraīn (the two eagles)*. Together they form an isosceles triangle with this star on the top and *al- Nasraīn* its base. It is drawn on the astrolabe and called *Ra's al-Ḥawwā*.
12	HR5854	9 Serpens	3	*'Unuq al-Ḥayya* From the table:

				The middle one of the three. From the comments: The ninth star is the one drawn on the astrolabe and called ‘*Unuq al-Ḥayya*.
13	Altair HR7557	3 Aquila	2(m)=1.5	*al-Nasr al-Ṭāir* From the table: The bright star on the place between the shoulders called *al-Nasr al-Ṭāir*. From the comments: The third star is the famous bright one which is drawn on the astrolabe. It is called *al-Nasr al-Ṭāir*. It is much greater than the 2^{nd} magnitude.
14	HR7852	1 Delphinus	4(m)=3.5	*Dhanab al-Dulfin* From the table: The most advanced of the 3 stars in the tail. From the comments: The first is the bright star on the tail. It is much greater than 4^{th} magnitude. Ptolemy mentioned it is less than 3^{rd} magnitude. It is drawn on the astrolabe and called *Dhanab al-Dulfin.*
15	HR15	1 Pegasus	2(s)=2.25	*Surrat al-Faras* *Ra’s al-Musalsala* From the table: The star on the navel which is common to the head of Andromeda. From the comments: The first star is the one on the navel. It is also in common with the one on the head of Andromeda. It is less than 2^{nd} magnitude. It is drawn on the astrolabe and called *Surrat al-Faras* and *Ra’s al-Musalsala.*
16	HR8739	2 Pegasus	2(s)=2.25	*Janāḥ al-Faras* From the table: The star on the rump and the wing tip. From the comments: The second star is on the rump at the end of the back. It is also drawn on the astrolabe and called *Janāḥ al-Faras*. It is less than 2^{nd} magnitude. It is south of the first star with a distance between them of one *Rumḥ*
17	HR8775	3 Pegasus	2(s)=2.25	*Mankib al-Faras* From the table: The star on the right shoulder and the place where the leg joins it.

				From the comments: The third is the southernmost of the two stars: the first and the second. It is on the right shoulder and the start of the hand. The distance between it and the first is one *Rumḥ*. It is less than 2nd magnitude. It is drawn on the astrolabe and called *Mankib al-Faras.*
18	HR8781	4 Pegasus	2(s)=2.25	*Matn al-Faras* From the table: The star on the place between the shoulders and shoulder part of the wing. From the comments: The fourth star is the southern bright one on the back at the beginning of the neck. The distance between it and the third star is one *Rumḥ*. It is less than 2nd magnitude. It is drawn on the astrolabe and is called *Matn al-Faras*.
19	HR8308	17 Pegasus	3	*Fam al-Faras* From the table: The star in the muzzle. From the comments: The seventeenth star is drawn on the astrolabe and is called *Fam al-Faras*.
20	HR337	12 Andromeda	2(s)=2.25	*Janab al-Musalsala* *Baṭn al-Ḥūt* From the table: The southernmost of the 3 stars over the girdle. From the comments: The twelfth star is to the left side and it is the southernmost and brightest of the three stars in the middle behind the three stars on the shoulders. It is less than 2nd magnitude. Ptolemy mentioned it is exactly of the 3rd magnitude. However it is brighter than the southern star which is on the rump of Pegasus and the edge of the wing which Ptolemy considered to be of the 2nd magnitude. Therefore it is incorrect that this twelfth star and the first star between the shoulders of this constellation are of the same magnitude. It is drawn on the astrolabe and is called *Janab al-Musalsala* and also *Baṭn al-Ḥūt.*
21	HR603	15 Andromeda	3	*Rijl al-Musalsala* *al-'Anāq* From the table: The star over the left foot called *al-'Anāq*.

				From the comments: The fifteenth star is the bright one on the left foot. It is of the 3rd magnitude. It is drawn on the astrolabe and is called *Rijl al-Musalsala*.
22	HR544	1 Triangulum	3	*Ra's al-Muthallath* From the table: The star in the apex of the triangle. From the comments: The first of its stars is one on the apex of the triangle. It is of the 3rd magnitude. It is drawn on the astrolabe and is called *Ra's al-Muthallath*.
23	HR617	14 Aries	3(k)=2.5	*al-Nāṭiḥ* From the table: The star over the head, which Hipparchus calls "the one on the muzzle". From the comments: As for the stars outside of the constellation the first is the bright star north of the two stars on the horn. It is greater then 3rd magnitude. The distance between it and the northernmost of its stars is a distance of two Thira. It is drawn on the astrolabe and is called *al-Nāṭiḥ*.
24	Aldebaran HR1457	1 Taurus	1	*al-Dabarān* From the table: The bright star: the reddish one of the letter (Δ) *al-Dāl* on the southern eye and it is *al-Dabarān*. From the comments: The fourteenth is the large bright red (star) on the south edge of the stars that resemble *al-Dāl*. It is located on the south eye and is drawn on the astrolabe. It is called *al-Dabarān* and *'Ain al-Thawr* (the eye of Taurus) and is of the 1st magnitude.
25	Pollux HR2990	2 Gemini	2	*Ra's al-Taw'am* From the table: The reddish star on the head of the rear twin. From the comments: The second (star) follows the first on the head of the rear twin. It is a little south (of the first) with a distance of more than 2 Thira between them. It is also of the 2nd magnitude.
26	Regulus HR3982	8 Leo	1	*Qalb al-Asad* *al-Malikī* From the table: The star on the heart, called *al-Malikī* and *Qalb*

				al-Asad. From the comments: The eighth is the great bright star south of the four stars on the heart. It is of the 1st magnitude. It is called *al-Malikī*. It is drawn on the astrolabe and is called *Qalb al-Asad*.
27	HR4357	20 Leo	2	*Zhahr al-Asad* (lion's back) From the table: The rearmost of them. From the comments: As for the twentieth star it the most advanced of the two (nineteenth and the twentieth). It is of the 2nd magnitude. It is drawn on the astrolabe and is called *Zhahr al-Asad*.
28	HR4534	27 Leo	1	*Dhanab al-Asad* (lion's tail) *al-Ṣarfa* From the table: The star on the end of the tail. From the comments: The twenty seventh is the great bright star on the tail. It is of the 1st magnitude. It is behind the bright twentieth star on the body. It is drawn on the astrolabe and is called *Thanab al-Asad* and *al-Ṣarfa*.
29	Spica HR5056	14 Virgo	1	*al-Simāk al-A'zal* *al-Sunbula* *Sāq al-Asad* (the leg of the lion) *al-Rāmiḥ* From the table: The star on the left hand, called *al-Sunbula* and *al-Simāk al-A'zal.* From the comments: The fourteenth is on the left hand. It is a famous bright star less than the 1st magnitude. It is drawn on the astrolabe and is called *al-Simāk al-A'zal*. It is the fourteenth of the lunar mansions.
30	Antares HR6134	8 Scorpio	2	*Qalb al-'Aqrab* From the table: The middle one of these which is reddish and called *Qalb al-'Aqrab* (Antares). From the comments: The eighth is the bright red (star) that is close to the seventh. It is of the 2nd magnitude. It is (one of the stars that are) drawn on an astrolabe. It is called *Qalb al-'Aqrab* (the heart of Scorpio). It is

				the eighteenth of the lunar mansions.
31	HR 7343	23 Sagittarius	4(s)=4.25	*'Urqūb al-Rāmī* From the table: The star on the front left hock. From the comments: The twenty-third star is on the tip of the left hand. It is south of the constellation Corona Australis by a distance of two and a half *Thira*. It is less than the 4th magnitude. Ptolemy mentioned it is of the 2nd magnitude. It is a double star because next to it is a close star which makes it a double star. It is drawn on the southern astrolabes as a star of the 2nd magnitude. It is called *'Urqūb al-Rāmī.*
32	HR8322	24 Capricorn	3	*Dhanab al-Jadī* From the table: The rearmost of them. From the comments: The twenty-fourth is the one in advance of the two. It is of the 3rd magnitude. It is drawn on the astrolabe and is called *Dhanab al-Jadī.*
33	HR8728	42 Aquarius	1	*Fam al-Ḥūt al-Janūbī* *al-Dhulaīm* From the table: The star at the end of the water and on the mouth of Piscis Austrinus called *al-Dhulaīm*. From the comments: The forty-second is the great bright star in advance and south of these last three stars. It is of the 1st magnitude. It is on the mouth of Piscis Austrinus. It is drawn on the astrolabe and is called *Fam al-Ḥūt al-Janūbī*.
34	HR911	2 Cetus	3	*al-Kaff al-Jadhmā* From the table: The three stars in the snout: the rearmost, on the end of the jaw. From the comments: From the stars on the head of constellation Cetus which should be drawn on the astrolabes and on the globes is the 2nd star on the snout called *al-Kaff al-Jadhmā.*
35	HR74	21 Cetus	3(s)=3.25	*Dhanab Qītus* From the table: The 2 stars at the ends of the tail-fins: the one on the northern tail-fin.

				From the comments: The twenty-first is drawn on the astrolabe and is called *Dhanab Qītus*.
36	Betelgeuse HR2061	2 Orion	1	*Mankib al-Jauzā'* *Yad al-Jauzā'* From the table: The bright reddish star on the right shoulder. From the` comments: The second is the great bright red star located on the right *Mankib* (shoulder). It is less than the 1st magnitude. The distance between it and the three stars on the head is three *Thira*. It is (one of the stars that are) drawn on an astrolabe. It is called *Mankib al-Jauzā'* (the shoulder of Orion) and also *Yad al-Jauzā'* (the hand of Orion).
37	Rigel HR1713	35 Orion	1	*Rijl al-Jauzā'* (the leg of Orion). From the table: The bright star in the left foot, which is (applied in) common to the water (of Eridanus). From the comments: The thirty-fifth is the large bright star on the left leg. It is of the 1st magnitude. It is (one of the stars that are) drawn on an astrolabe. It is called *Rijl al-Jauzā'* (the leg of Orion).
38	HR897	34 Eridanus	1	*Ākhir al-Nahr* From the table: The last star of the river, the bright one. From the comments: The thirty-fourth is in front of these three close stars. The distance between it and the closest of these three stars is four *Thira*. It is of the 1st magnitude. It is drawn on the southern astrolabes and is called *Ākhir al-Nahr*.
39	Sirius HR2491	1 Canis Major	1	*al-Shi'ra al-Yamāniya* *al-'Ayyūq* *al-Kalb* From the table: The star in the mouth, the brightest, which is called *al-Kalb* (Dog) and *al-Shi'ra al-Yamāniya* and *al-'Ayyūq*. From the comments: The first star is the great bright star on the mouth. It is drawn on the astrolabe. It is called *al-Yamāniya*.
40	Procyon	2 Canis Minor	1	*al-Shi'ra al-Shāmīya* *al-Shi'ra al-Ghumaiṣa*

	HR2943			From the table: The bright star just over the hindquarters, called *al-Shi'ra al-Shāmīya* and *al-Ghumaiṣa*. From the comments: One of them is the bright star of the 1st magnitude. It is drawn on the astrolabe and is called *al-Shi'ra al-Shāmīya*….The Arabs called it *al-Shāmīya* because it sets from the location of *al-Sham* (Greater Syria). They (also) call it *al- Shi'ra al-Ghumaiṣa.*
41	Canopus HR2326	44 Argo Navis	1	*Suhail* From the table: The more advanced of the 2 stars in the other steering-oar, called *Suhail*. From the comments: The forty-fourth is the great bright star on the end of the southern hemisphere. It is the furthest star of Argo in the south. It is of the 1st magnitude. It is drawn on the southern astrolabes and is called *Suhail*.
42	Alpha hydrae HR3748	12 Hydra	2	*'Unuq al-Shujā'* *al-Fard* From the table: The bright one of these two close stars called *al-Fard.* From the comments: The twelfth star is the bright red star at the end of the neck and at the beginning of the back. It is of the 2nd magnitude. It is drawn on the astrolabe. It is called '*Unuq al-Shujā'* (the Neck of Hydra). It is also called *al-Fard*.
43	HR4662	4 Corvus	3	*Janāḥ al-Ghurāb al-Ayman* From the table: The star in the advance, right wing. From the comments: The fourth star is on the right wing. It is in advance of the two bright stars on the wings. It is distant from the second bright star on the head towards the south a distance of one third of a *Thira*. It is of the 3rd magnitude. It almost forms a straight line together with the star on the head and the star on the beak. It is drawn on the astrolabe and is called *Janāḥ al-Ghurāb al-Ayman*.
44	HR5459	35 Centaurus	1	*Rijl Qanṭūris* (leg of Centaurus) From the table:

				The star on the end of the right front leg. From the comments: As for the thirty-fifth it is the rearmost of the two. It is of the 1st magnitude. It is located on the tip of the right hand of the animal. It is drawn on the southern astrolabes. It is called *Rijl Qanṭūris* (leg of Centaurus). It is very close to the horizon. Its height in all localities is less than (the star) *Suhail*.

5.8 Double Stars in al-Ṣūfī's Book

The word *Muḍ'af* was used many times in al-Ṣūfī's book to mean double star. For example in the constellation Orion, al-Ṣūfī wrote: "The twelfth star is to the rear of the two. It is less than the 5th magnitude. Ptolemy mentioned that it is exactly 5th magnitude. It is a *Muḍ'af* (double star) because there is a star next to it." In many cases al-Ṣūfī only mentioned the presence of a double star but in other cases he describes the location and the magnitude of these double stars. For example in the constellation Ara he wrote: "Behind the second star is another star also of the 4th magnitude. The distance between them is one third of a Thira. It was not mentioned by Ptolemy. This star is a double star because next to it is a star of the 6th magnitude which makes it a double". It is not clear whether these stars are actually physically double stars or are visually close stars as was seen at the time of al-Ṣūfī. Most of these stars are probably not double stars in the modern understanding of the word. However I have tried to make a small investigation on this subject to identify these stars and check if any are actually double stars or not. This exercise can also shed some light on the level of accuracy and the ability of this astronomer to resolve close pairs of stars. It also gives us an estimate on what was the minimum angular separation which al-Ṣūfī managed to achieve in his observation of these stars.

From al-Ṣūfī's description I tried to identify below all the double stars found in al-Ṣūfī's book (Table 14). In Column 3 of this table I included the HR number and magnitude of these stars with the first HR number for the main star as mentioned in the catalog. The second HR number and magnitude is for the companion star as per the description of al-Ṣūfī. I also included the coordinate of these stars after accounting for precession for the epoch of A.D. 960. For example the HR number for the first star is HR1995 which according to al-Ṣūfī has the magnitude of 5 and a modern magnitude of 4.52. Its RA coordinates is 4:38:8 and Dec +39:10:52. Whereas the HR number for the companion star is HR2012. Al-Ṣūfī did not assign a magnitude for this star however it has a modern magnitude of 3.97. Its RA coordinate is 4:40:25 and Dec +38:02:38. In column 4 of this table I calculated the angular distance between these stars in order to identify the minimum angular distance which al-Ṣūfī managed to achieve. In the last column of the table I included a brief summary on every one of these stars as they were mentioned by al-Ṣūfī. This summary included all the descriptions both from the tables as well as from the comments in the constellation chapters which mentioned these stars according to al-Ṣūfī.

Table 14: Double stars according to al-Ṣūfī

Number	Star Number according to al-Ṣūfī	-HR -Al-Ṣūfī' Magnitude -Modern Magnitude -Coordinates	Angular Distance	Description according to al-Ṣūfī
1	5 Auriga	HR1995 (5) (4.52) 4:38:8 +39:10:52 HR2012 (not mentioned) (3.97) 4:40:25 +38:02:38	1.22 deg	From the table: The star on the right elbow. From the comments: The fifth is on its right elbow. It is of the 5th magnitude. Ptolemy mentioned it as the 4th magnitude. This is a double star because next to it is a close star.
2	29 Ophiuchus	HR6771 (4) (3.73) 17:18:22 +09:59:46 HR6770 (small-faint star)=5 or 6 (4.64) 17:12:58 +09:10:17	1.57 deg	From the table: The lone star north of these 4. From the comments: The fifth (which is the twenty ninth star – fifth out side of the constellation) is the lone star to the north. It is farthest from the other four by a distance of two *dhirā'*. It is a double star because next to it is a small (faint) star close to it.
3	11 Serpens	HR5881 (4) (3.53) 14:56:10 +00:13:20 HR5895 (small-faint star)=5 or 6 (5.11) 14:57:54 +00:31:44	0.53 deg	From the table: The star after the next bend which is in advance of the left hand of Ophiuchus. From the comments: Then it bends towards the south-east by a distance of two Thira to the eleventh star which is a double star of the 4th magnitude. Next to it is a small (faint) star close to it which makes it a double star.
4	4 Triangulum	HR664 (3s)=3.25 (4.01) 1:17:59 +28:42:08	0.57 deg	From the table: The rearmost of the three. From the comments: The fourth is the southernmost star of less than the 3rd magnitude. Ptolemy mentioned

		HR655 (6) (5.28) 1:16:48 +28:11:58		it is exactly of the 3rd magnitude. It is a double star because next to it is a star of the 6th magnitude close to it, which was not mentioned by Ptolemy. It resembles the third star on the base in magnitude.
5	31 Virgo	HR5019 (5) (4.74) 12:24:01 -12:41:12 HR5044 (not mentioned) (5.37) 12:28:33 -12:08:13	1.24 deg	From the table: The middle one of these, which is a double star. From the comments: The fifth is to the rear of the two. It is a double star. The distance from the fourth star towards the south-east is one *dhirā'*. It is of the 5th magnitude.
6	8 Sagittarius	HR7116 (nebulous) (4.83) 17:51:27 -23:19:02 HR7120 (not mentioned) (5.00) 17:52:26 -23:16:04	0.23 deg	From the table: The star on the eye, which is nebulous and double. From the comments: The eighth is the nebulous star on the eye of Sagittarius. It is towards the north from the sixth star by a distance of two *dhirā'*.
7	23 Sagittarius	HR7343 (4s)=4.25 (4.29) 18:07:20 -45:55:57 HR7337 (not mentioned) (4.01) 18:07:01 -45:34:50	0.36 deg	From the table: The star on the front left hock. From the comments: The twenty third star is on the tip of the left hand. It is south of the constellation Corona Australis by a distance of two and a half *dhirā'*. It is less than the 4th magnitude. Ptolemy mentioned it is of the 2nd magnitude. It is a double star because next to it is a close star which makes it a double star. It is drawn on the southern astrolabes as a star of the 2nd magnitude. It is called '*Urqūb al-Rāmī.*
8	31Aquarius	HR8968 (5) (5.00) 22:45:23 -19:51:45 HR8987 (6)	2.83 deg	From the table: The more advanced of the 2 stars close together after the latter. From the comments: Next to the two close stars (the thirtieth and the thirty first) is a star of the 6th magnitude which makes it a double star. It

		(5.28) 22:48:02 -21:06:07		was not mentioned (by Ptolemy).
9	16 Cetus	HR334 (3s)=3.25 (3.45) 00:16:38 -15:50:49 HR329 (6) (5.82) 00:15:46 -15:27:15	0.45 deg	From the table: The more advanced of them. From the comments: The sixteenth is the more advanced of them. The distance between them is approximately two *dhirā'*. It is less than the 3rd magnitude. Ptolemy mentioned it is exactly of the 3rd magnitude. Under it is a close star of the 6th magnitude which makes it a double and which was not mentioned by Ptolemy.
10	12 Orion	HR2135 (5s)=5.25 (4.63) 5:02:43 +19:28:01 HR2130 (not mentioned) (5.14) 5:02:28 +19:00:37	0.46 deg	From the table: The rearmost of them. From the comments: The twelfth star is to the rear of the two. It is less than the 5th magnitude. Ptolemy mentioned that it is exactly 5th magnitude. It is a *Muḍ'af* (double star) because there is a star next to it.
11	15 Eridanus	HR925 (5) (5.26) 2:13:53 -12:02:00 HR917 (5) (5.32) 2:12:19 -12:08:34	0.40	From the table: The one in advance of this. From the comments: The fifteenth is in front of the fourteenth star towards the north. It is of the 5th magnitude while Ptolemy mentioned it is of the 4th. The distance between them is one *dhirā'*. It is a double star.
12	21 Eridanus	HR1003 (4) (3.69) 2:33:40 -25:53:47 HR994 (4) (4.88) 2:32:45 -26:40:05	1.25 deg	From the table: The middle one of these. From the comments: The twenty-first follows the twentieth. It is of the 4th magnitude. The distance between them is two *dhirā'*. It is a double star because to the south and close to it is a star which makes it a double.
13	8&9 Argo	HR2996	0.55	From the table:

		(4) (3.96) 7:02:17 -26:54:33 HR2993 (5) (4.59) 7:01:46 -26:22:29	deg	-The rearmost of them. -The middle one of the three. From the comments: The ninth is close to the eighth, a little inclined towards the north-west. The eighth star is double (with the ninth).
14	12 Argo	HR2773 (3) (2.70) 6:40:37 -35:37:51 HR2787 (not mentioned) (4.66) 6:41:32 -35:14:32	0.43 deg	From the table: The southernmost of them From the comments: The twelfth is south of the eleventh star. It is far from it with a distance between them of three *dhirā'*. It is of the 3rd magnitude. It is on the plank where the *Kawthal* (front sail) is built. It is a double star because next to it is a close star which makes it a double.
15	34 Argo	HR3055 (6) (4.11) 7:17:38 -44:05:00 HR3037 (faint)=5 or 6 (5.23) 7:16:11 -44:21:19	0.38 deg	From the table: The faint star to the rear of this. From the comments: The thirty-fourth is behind the thirty-third star. It is inclined towards the south with a distance between them of one third of a *dhirā'*. It is of the 6th magnitude. It is a double star because next to it is a faint star which makes it a double.
16	3 Hydra	HR3482 (4) (3.38) 7:51:07 +09:42:22 HR3492 (5s)=5.25 (4.36) 7:52:58 +09:09:41	0.71 deg	From the table: The northernmost of the 2 to the rear of these, which is about on the skull. From the comments: Next to the third is a star less than the 5th magnitude. Together with the third they form a double star. It was not mentioned by Ptolemy.
17	5&6 Corvus	HR4757 (3) (2.95) 11:36:49 -10:44:59	0.62 deg	From the table: -The more advanced of the 2 stars in the rear wing. -The rearmost of them. From the comments:

		HR4775 (4) (4.31) 11:38:58 -10:25:53		The sixth follows the fifth close to it with a distance of less than a *Shibr*. It is of the 4th magnitude. Together with the fifth they form a double star.
18	22 Centaurus	HR4940 (5) (4.71) 12:09:26 -42:46:31 HR4933 (not mentioned) (4.85) 12:06:51 -43:49:42	1.06 deg	From the table: The star in advance of this on the horse's back. From the comments: The twenty-second is in front of the twenty-first and oriented towards the south. The distance between them is two and half *dhirā'*. It is of the 5th magnitude. It is a double star because next to it is star which makes it a double star.
19	8 Ara	HR6897 (4) (3.51) 17:10:17 -45:40:50 HR6934 (6) (4.96) 17:15:02 -45:44:50	0.85 deg	From the table: (not in the table) From the comments: Behind the second star is another star also of the 4th magnitude. The distance between them is one third of a *dhirā'*. It was not mentioned by Ptolemy. This star is a double star because next to it is a star of the 6th magnitude which makes it a double.
20	5 Piscis Australis	HR8431 (5) (4.17) 21:05:53 -37:40:12 HR8447 (not mentioned) (4.92) 21:07:55 -37:15:26	0.54	From the table: The star on the belly. From the comments: The fifth star is in front of the first on the belly. It is of the 5th magnitude. The distance between it and the first is close to two *dhirā'*. It is a double star because next to it is a star which makes it a double.

From the Table 14 the minimum angular separation for the above *Muḍ'af* (double) stars (discounting the reference star) was achieved by 8 Sagittarius (star number according to al-Ṣūfī), which according to Ptolemy and al-Ṣūfī is both a nebulous and a double star. The two stars which are in the magnitude range which could be seen in this nebula are: HR7116 and HR7120. The angular separation between these two stars at the epoch of al-Ṣūfī was 0.23

degrees. It is an interesting point to note here that the star HR7120 is next to the globular cluster NGC6717 (magnitude 9.3). The two stars HR7116 and HR7120 together with the globular cluster might have been the cause of the comments that 8 Sagittarius is double and nebulous even though a globular cluster of magnitude 9.3 would be far below the limit of unaided eye visibility.

I have included in the below Table 15 the star 26 Ursa Major as a reference star, which is the star Mizar. Next to Mizar is the star Alcor. The angular separation between these two stars is 0.20 degrees. However al-Ṣūfī did not refer to these two stars as *Muḍ'af* or double but he only mentioned that adjacent to *al-'Anāq* (Mizar) is the star called *al-Suhā* (the neglected one (Kunitzsch, 2006)). It was well known that the Arabs were able to separate these two stars long before the time of al-Ṣūfī. These stars were used by the Arabs as an eyesight test for the ability to separate and distinguish between the two. The proverb "I showed him *al-Suhā* and he showed me the Moon" was used as a metaphor indicating the strength of ones eyesight meaning "I can distinguish the very small detail while he can only see large objects such as the Moon". The separation of 8 Sagittarius is quite close to the separation 26 Ursa Major. Even though this shows the ability of al-Ṣūfī as an accomplished observer, however he still did not achieve the level which was reached by the Arabs before him or the minimum visual separation with the unaided eye.

Table 15: Reference Star

Number	Star Number according to al-Ṣūfī	-HR -al-Ṣūfī' Magnitude -Modern Magnitude -Coordinates	Angular Distance	Description according to al-Ṣūfī
Reference star	26 Ursa Major	HR5054 *-al-'Anāq* -Mizar (2) (2.27) 12:40:47 +60:28:44 HR5062 *-al-Suhā* -Alcor (small-faint)=5 or 6 (4.01)	0.20 deg	From the table: The middle one. *al-'Anāq*. Above *al-'Anāq* is a small star adjacent to it which the Arabs call *al-Suhā*. In other Arab dialects it is (also) called by the name of: *al-Shitā'* and al-*Saidaq* and *Nu'aish*. This star has not been mentioned by Ptolemy. This star is also used by people to test their eyesight, for they say: "I showed him *al-Suhā* and he showed me the Moon".

		12:42:19 +60:31:55		

5.9 The Nebulae in al-Ṣūfī's Book

The term 'nebula' comes from the Latin word for cloud. A nebula is a cloud of dust and gas in space. In the past the term nebula was also used for distant galaxies, clusters and any other hazy patches of light which resembles a cloud among the stars. After the use of telescopes, the discovery of spectroscopy and the invention of photography, it was possible to distinguish real nebulae from galaxies.

The Arab and Islamic astronomers observed and identified several nebulae very early in their scientific endeavors. The Arabic term used for a nebula was *al-Saḥābi* which also means a cloud. In his major astronomical treatise (*al-Qānūn al-Mas'ūdī*), al-Bīrūnī describes *al-Saḥābiāt* (plural for nebula) by these words:

> "In the sky there are objects which do not resemble the stars in their round shape and by the bright light which they have. These are the *al-Laṭkhāt al-Bīḍ* (the white smears) called *al-Saḥābia* (nebula). Some believe that these (nebulae) are part of the (the Milky Way) galaxy; however they are both alike and both resemble clouds. These (nebulae) are believed to be an *Ishtibāk* (a mass) of small stars grouped together"

Al-Bīrūnī clearly distinguished between nebulae and the Milky Way and he described the nature of these nebulae as a concentration or group of stars. As for the Milky Way it was called *al-Majarra* in Arabic, which is directly translated as just 'the Galaxy'. According to al-Marzūqī, in his book *Kitāb al-Azminah wa al-Amkina*, he said: "…the ancient Arabs called *al-Majarra*: *Um al-Nujūm* (the mother of all stars) because there is no area in the sky which has more stars then it." The Arabs also called the Milky Way: *Sharj al-Sama'* (the dome of the sky) and *Nahr al-Majarra* (the galaxy river). However the name by which the Milky Way was mostly used was *Darb al-Tabbānah* (the path of straws). The term *Darb al-Tabbānah* describes a picture of farmers coming back from planting their fields while dropping straws every once in a while thus producing white patches on the ground. Abū Ḥanīfa al-Daīnawari also described the location of the galaxy in those words: "*al-Majarra* (the galaxy) is a connected circle like a ring. Even though it is narrow in some places and wide in others however this is due to its circular nature. It is most wide between (the Asterism) *Shawlat al-'Aqrab* (the sting of Scorpio) and *al-Nasrān* (the two constellations: Lyra and Aquila)".

From the above descriptions which we find in many historical references we see that the ancient Arabs were well aware of these cloud-like objects. The Arabic and Islamic scholars and astronomers later described in detail the nature and location of these nebulae as well as the Milky Way galaxy which they could clearly see in the sky. Al-Ṣūfī also refers to the nebulae as *al-Laṭkhā al-Saḥābiya* (the nebulous smear or smudge) and *al-Ishtibāk al-Saḥābi* (the nebulous mass). As his work was based on Ptolemy's book, al-Ṣūfī again identifies the five nebulae which Ptolemy mentioned before. However al-Ṣūfī goes further to describe several other nebulae which he observed himself or were previously identified by the Arabs.

From al-Ṣūfī's description I tried to identify below all the nebulae found in al-Ṣūfī's *Book of the Fixed Stars* (Table 16). I have included the modern names or designations which correspond to these nebulae. I also indicated the magnitude and surface brightness of these deep sky extended objects. By definition the magnitude of an extended astronomical objects such as galaxies and nebulae is the measure of the concentration of their light at a point source where as the surface brightness of an object is the measure of brightness or magnitude per square arc minute. Therefore the surface brightness of an object is a more practical way to estimate the degree of visibility of extended deep sky objects than using magnitude methods only. Finally in the last column of the table I have included a brief summary on every one of these nebulae as they were mentioned by al-Ṣūfī. This summary includes all the descriptions taken from both the tables as well as from the comments in the constellation chapters of al-Ṣūfī's book.

Table 16: Nebulae found in al-Ṣūfī's book

Number	Modern name & designation, Magnitude & Surface brightness	Star/Nebula & magnitude according to al-Ṣūfī	Description according to al-Ṣūfī
1	NGC 869/884 Open clusters Magnitude 5.30/6.10 Surface brightness 12.43/13.23	1 Perseus Nebula	From the table: The nebulous mass on the right hand. From the comments: The first of its stars is *al-Laṭkhā al-Saḥābiya* (nebulous smear) on the camel's thigh which we have talked about when we discussed the constellation Cassiopeia. It is on the edge of its (Perseus) right hand.
2	M44	1 Cancer	From the table:

	(NGC 2632) Open cluster Magnitude 3.10 Surface brightness 13.00	Nebula	The middle of *al-Ishtibāk al-Saḥābi* (nebulous mass) in the chest, called *al-Mi'laf* (Praesepe). From the comments: The first of its stars is a *Laṭkhā* (smear) which resembles a piece of cloud surrounded by four close stars with the patch in the middle. Two stars are in front and two are behind.
3	M7 (NGC 6575) Open Cluster Magnitude 3.30 Surface brightness 12.00 Or NGC6441 Globular cluster Magnitude 7.40 Surface brightness 11.6	22 Scorpio 4(s)=4.25	From the table: The nebulous star to the rear of the sting. From the comments: As for the three stars outside of the constellation, the first is a star to the rear of *al-Shawla* and behind the nineteenth star which is on the seventh joint. It is less than 4th magnitude. Ptolemy mentioned that it is a nebulous object. The distance between it and the nineteenth star which is on the seventh *Kharaza* (joint) is a little more than one *dhirā'*. And the distance between it and *al-Shawla* is close to one and a half *dhirā'*.
4	HR7116 HR7120 NGC6717 Globular cluster Magnitude 9.30 Surface brightness 12.00	8 Sagittarius Nebula	From the table: The star on the eye, which is nebulous and double. From the comments: The eighth is the nebulous star on the eye of Sagittarius. It is towards the north from the sixth star by a distance of two *dhirā'*.
5	CR69 Open cluster HR1879 HR1883 HR1876 HR1907 Magnitude 2.80 Surface	1 Orion Nebula	From the table: The nebulous star in the head of Orion, which consists of three close stars. From the comments: The first of its stars is the *Saḥābi* (nebula) on the head. This nebula is made up of three small stars close together forming a small *Muthallath* (triangle). Ptolemy mentioned it to be one star located in the middle of the triangle and he indicated its longitude and latitude in his book. It is located on the head between the two shoulders and further away towards the north but closer to the left shoulder.

	brightness 11.60		
6	CR399 Open cluster Magnitude 3.60 Surface brightness 12.95	----- Magnitude not mentioned	From the table: (Description is only mentioned in the comments on the constellation Aquila). From the comments (Constellation Aquila): There is an image of a bowl (cup) with its stars beginning from the bright star on the tail, continuing towards the north-west then going to the east to the base of the bowl; then towards the south-east until it reaches a nebula located north of two stars in the notch of the constellation Sagitta. The distance between the nebula and the top of the bowl is two *dhirā'* ; the nebula is located on the east edge and the bright star on the tail on its western edge.
7	M31 Andromeda Galaxy Magnitude 3.40 Surface brightness 13.50	---- Magnitude not mentioned	From the table: (Description is only mentioned in the comments on the constellation Andromeda) From the comments: The Arabs mentioned two lines of stars surrounding an image resembling a large fish below the throat of the Camel. Some of these stars belong to this constellation (Andromeda) and others belong to the constellation Pisces which Ptolemy mentioned as the twelfth constellation of the Zodiac. These two lines of stars begin from the *al-Laṭkhā al-Saḥābiya* (nebulous smear) located close to the fourteenth star which is found at the right side of the three (stars) which are above the girdle.
8	IC2391 Omicron Velorum open cluster Magnitude 2.50 Surface brightness 12.00	---- Magnitude not mentioned	From the table: (Description is only mentioned in the comments on the constellation Argo Navis) From the comments: Above the thirty-seventh star at a distance of one *dhirā'* there is a nebulous star.
9	Large Magellanic cloud Magnitude 0.40 Surface brightness 14.10	---- Magnitude not mentioned	From the table: (Description is only mentioned in the comments on the constellation Argo Navis) From the comments: Some claim that under the star *Suhail* (the star Canopus) is a star called *Qaḍam Suhail* (feet of *Suhail*) and under *Qaḍam Suhail* are many bright white stars which are not seen from Iraq and *Najd* (area north of Arabia). The people of *Tehāma* (area south of Arabia) call them *al-Baqar* (Oxen). Ptolemy does not mention any of this and we do not know if this is right or wrong.
10	M45 Pleiades	29 Taurus 30 Taurus 31 Taurus	From the table: -The Pleiades: the northern end of the advanced side. -the southern end of the advanced side.

	Open cluster Magnitude 1.20 Surface brightness 11.00	32 Taurus 5 5 5 4	-The rearmost and narrowest end of the Pleiades. -The small star outside the Pleiades towards the north. From the comments: The Arabs called the twenty-ninth, the thirtieth, the thirty-first and the thirty-second, *al-Thurayyā* (the Pleiades). Inside (the Pleiades) are two stars or three together with the other four looking like a bunch of grapes that are close together. Therefore they considered them as one star and named it *al-Najem* (The Star) par excellence. They also named it *Nujūm al-Thurayyā* (the stars of the Pleiades). It was called *al-Thurayyā* because they were blessed by it and by its rise, and they claimed that the rain which falls when it *Naw* (sets) brings good luck. (*al-Thurayyā)* means a small fortune (the diminutive noun for fortune). They (the Arabs) diminutised it because its stars are close and small. They mentioned in their books that it is located on the *Aliet* (the buttocks or the fat tail of a sheep) of (the constellation) Aries, (however) it is located on the *Sinām* (hump) of Taurus. The distance between it and the last star on the buttocks of Aries is three *dhirā'* as is seen by the eye. It is the third of *Manāzil al-Qamar* (the lunar mansions).

5.9.1 Notes on the Nebulae found in al-Ṣūfī's Book

I have included below some comments on the above nebulae which were identified by al-Ṣūfī. I also included their modern pictures in order to describe and identify these objects much more clearly:

1. The double clusters NGC884 and NGC869 (Figure 42) were observed by many cultures such as the Greeks, Indians and others long before the time of al-Ṣūfī. These clusters were cataloged by Hipparchus as well as Ptolemy. These clusters are bright enough to be clearly seen by the naked eye.

Figure 42 Double clusters NGC884 and NGC869.

In his comments al-Ṣūfī refers to the “camel’s thigh” which he mentioned also in his description of the constellation Cassiopeia. Al-Ṣūfī mentioned that the ancient Arabs described a picture of a camel which they identified between the constellation of Cassiopeia and Perseus.

2. The open cluster M44 (Figure 43) is another nebula which was clearly seen by the naked eye and recognized a long time ago by the Greeks and other cultures.

Figure 43 M44 open cluster.

3. Formerly the nebula which was associated with the star 22-Scorpio was considered to be the open cluster M7. It is interesting to note that al-Ṣūfī assigns a magnitude to the star 22-Scorpio of 4(s)=4.25. For all other nebulae he only mentions that they are nebulous objects. This procedure was also used in the *Almagest* therefore al-Ṣūfī again tried to adhere to Ptolemy’s method of description in this regard except for the star 22-Scorpio. However for the star 22-Scorpio al-Ṣūfī might have been referring to the star HR6630 (magnitude 3.21) which also has next to it the globular cluster NGC6441 (surface brightness 11.6). Al-Ṣūfī states that Ptolemy mentioned that this star is a nebulous object. He then goes on to determine the distance between this nebulous object and the nineteenth star which is on the seventh *Kharaza* (joint) as a little more than one *dhirā’*, and the distance between it and *al-Shawla* (stars 20/21 Scorpio) as close to one and a half *dhirā’*. From these distance approximations this nebula should be about 2 deg 20 min from the nineteenth star of Scorpio and 3 deg 30 min from the twentieth and the twenty first stars of Scorpio. I have calculated the distance between these nebulae and these stars and the results are indicated in the following table 17:

Table 17: Distance between Nebulae and Stars

Distance from NGC6441 to 19 Scorpio	Distance from NGC6441 to 21/20 Scorpio	Distance from M7 to 19 Scorpio	Distance from M7 to 21/20 Scorpio
2 deg 34 min	3 deg 38 min	4 deg 53 min	5 deg 07 min

From these approximate distances and the fact that one *dhirā'* is 2 deg 20 minutes according to al-Ṣūfī himself it looks more likely that the nebula which al-Ṣūfī was referring to in this case is the globular cluster NGC6441 and not M7 as was supposedly known. This distinction was first recognized by Manitius (1912) then by Peters and Knobel (1915) and later confirmed by Toomer in his translation of the *Almagest* (1984).

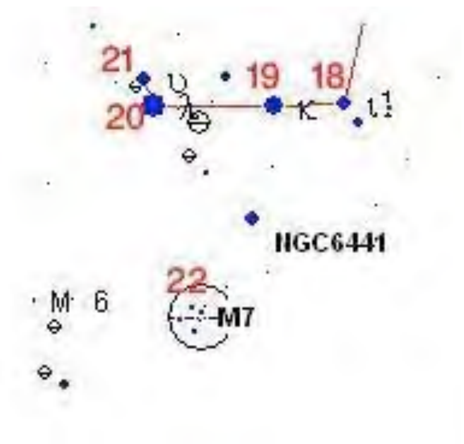


Figure 44: Map which shows NGC6441


Figure 45: Image of NGC6441

Figure 44 is a map which shows that NGC6441 is much closer to the nineteenth, twentieth and the twenty-first stars of Scorpio than is M7. Figure 45 is an image of the globular cluster NGC6441 to the left of the star HR6630 taken from the Digitized Sky Survey

4. Al-Ṣūfī mentioned the star 8-Sagittarius as a double star together with a nebulous star. The two stars were identified as HR7116 and HR7120. Next to HR7120 is the NGC6717 globular cluster. Al-Ṣūfī might have been referring to these three objects as a nebulous asterism. I have obtained the image from the Digitized Sky Survey (Figure 46) which shows the star HR7116 on the right edge of the image and star HR7120 in the center with NGC6717 just under it.

Figure 46: Stars HR7116, HR7120 and globular cluster NGC6717.

5. The image below is of the open cluster CR69 with the star HR1879 centered in the middle. This image was obtained from the Digitized Sky Survey

Figure 47: CR69 open cluster.

6. The CR399 open cluster (see Figure 48) was first discovered by al-Ṣūfī and described in his *Book of the Fixed Stars*. It was later independently rediscovered by Giovanni Hodierna in 1654. It is also sometimes named *Brocchi's Cluster* after the astronomer D.F. Brocchi, who created a map of it in the 1920s. It was included in Collinder’s 1931 catalog of open clusters and given the designation of Collinder 399.

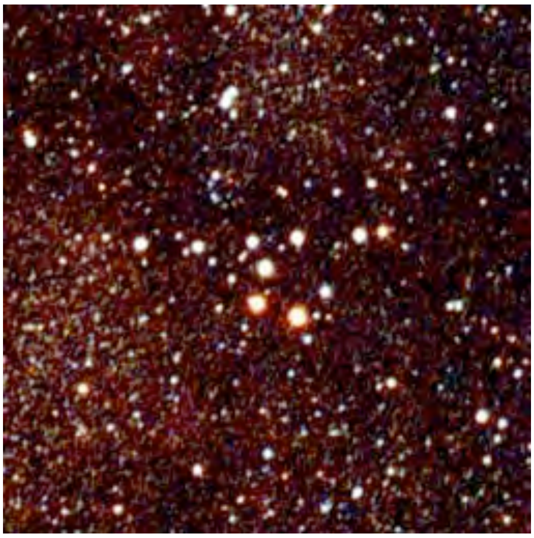


Figure 48: CR399 open cluster.

7. Messier 31 (M31 is the famous Andromeda Galaxy (see Figure 49). It is the nearest large spiral galaxy to us. It was first discovered by al-Ṣūfī and described in his *Book of the Fixed Stars*. It was later included in early European star catalogs, for example Simon Marius in 1612, Giovanni Hodierna in 1654 and Charles Messier in 1764.

Figure 49: M31 Andromeda Galaxy.

8. The Omicron Velorum open cluster (CR399) was first discovered by al-Ṣūfī and described in his *Book of the Fixed Stars* (see Figure 50). It was later rediscovered by Abbe Lacaille in 1752 and he cataloged it as ‘Lac II.5’.

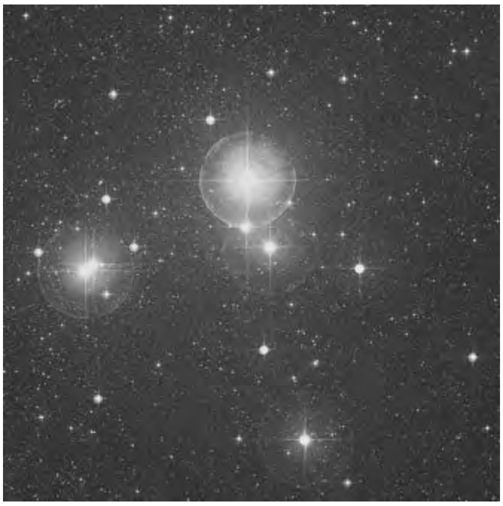


Figure 50: Omicron Velorum open cluster.

9. The Large Magellanic Cloud (Figure 51), together with its small neighbor the Small Magellanic Cloud, are well known objects in the southern hemisphere. They must have been very well recognized by ancient cultures living in the Southern Hemisphere. However there is very little preserved evidence to document these facts. Some Arab researchers claim that the earliest documented proof of observation of the Magellanic Clouds might be found in al-Ṣūfī's *Book of the Fixed Stars* (Mujahed, 1997). However, al-Ṣūfī only mentioned that there are stars under the stars of *Suhail* (Canopus) and *Qadam Suhail* (feet of *Suhail*) which the Arabs call *al-Baqar* (Oxen) but he does not mention that there is any nebula. This recent claim is probably due to the fact that *al-Baqar* was mentioned by the 15th century Arab seafarer Ibn-Majed who mentioned the Large Magellanic Cloud as a nebula and named it *al-Baqar* before it was documented by Magellan in A.D. 1519. However, al-Ṣūfī does not claim that he observed these stars himself. He attributed this to the southern people of Arabia (region of *Tehāma*). He admits that he does not know if this is right or wrong. This is a tribute to this author's scientific integrity whereby in the same paragraph he admits to making his observations from the city of Shiraz which according to the observation he made with the '*Aḍudī* Ring is 29 deg and 36 min and at this latitude these stars could not be seen.

Figure 51: Large Magellanic Cloud.

10. Al-Ṣūfī mentioned that inside the Pleiades (Figure 52) there are two stars or three together with the other four looking like a bunch of grapes. These additional stars are HR1149, HR1165 and HR1142. Therefore, together with the other four, al-Ṣūfī managed to observe seven stars of the Pleiades.

Figure 52: M45 Pleiades open cluster.

5.10 Old Arabic Astronomical Traditions in al-Ṣūfī's Work

When ancient civilization were watching the heavens they observed that many groups of stars formed patterns in the sky that resembled people, animals and objects similar to what they experienced in their daily lives. Among those early civilizations were the ancient Arabic cultures that inhabited what we call now the Middle East. They named many of the stars, which they observed according to their own experience, and the environment which they lived in. This endeavor started more than 3000 years even before the emergence of Islam, which transformed the history of the region. At first this scientific movement was connected to the development of the lunar calendar. It then transformed into the unique science of the lunar mansions. From this effort another study emerged which was called '*Ilm al-Anwā'*. The *Anwā'* were a form of astrological-meteorological system of predicting the weather and identifying the beginning of the seasons in order to specify the dates of festivals, holidays, pilgrimage and the best times for traveling and commerce (see Section 2.3). These ancient fields of study are what were to be called 'Arabic folk astronomy'. They were very popular among many Arab and Islamic religious and scientific scholars such as al-Battānī and al-Daīnawari, as well as al-Ṣūfī.

In his introductory chapter al-Ṣūfī divided those who study the stars into two groups. The first group was the astronomers *(Munajjimīn)*. The second group studied the Arabic method of the sciences of *al-Anwā'* and the Moon mansions. From this identification we can deduce that al-Ṣūfī considered 'Arabic folk astronomy' to be an important scientific field of study in its own right. He took upon himself to explain the development of this field as well as to identify all the various names of stars, asterisms, mansions and constellations as per the method of the Arabs. He also tried to correct many of the mistakes which were mentioned by previous authors in this subject such as al-Battānī and al-Daīnawari (see my translation of al-Ṣūfī's Introductory chapter Section 4.1).

I have tabulated below the names of stars and asterisms for some of the constellations that have been used in Arabic folk astronomy. This exercise is only to give an idea on the scope of information which is contained in each of the chapters on the constellations according to the explanation of al-Ṣūfī:

Table 18: Names of stars in constellation Ursa Minor as per Arabic folk astronomy.

Arabic Name	Name in Arabic	Star/s (HR)	Explanation
al-Farqadain	الفرقدين	5563, 5735	The meaning of this word in Arabic is: "The two calves".
Banāt Na'sh al-Ṣughra	بنات نعش الصغرى	The bier 5903, 6116, 5563, 5735 The daughters 424, 6789, 6322	"The little daughters of the bier (or coffin)". The Arabs likened the image of this constellation to three women "the daughters" who are pulling "a bier (or coffin)".
al-Juday	الجدي	424	"The kid or goat" (This is the polar star "Polaris". It is not to be confused with the constellation Capricorn even thought the Arabic folk name is the same as the constellation Capricorn).
Fa's al-Raḥā	فاس الرحا		"A type of a fish", which is round and looks like a round "grinding axe".

Table 19: Names of stars in constellation Ursa Major as per Arabic folk astronomy.

Arabic Name	Name in Arabic	Star/s (HR)	Explanation and comments
al-Mirāq	المراق	4295	The flank or groin.
al-Khaṭem	الخطم	3323	The snout.
Banāt Na'sh al-kubra	بنات نعش الكبرى	5191,5054,4905 4301,4295,4660,4554	"The great daughters of the bier (or coffin)". The Arabs likened the image of this constellation to three women "the daughters" (*Banat)* who are pulling "a bier (or coffin)". *al-Naeesh means the* bier (or coffin).
Bani Na'sh	بني نعش		The clan of *al-Na'sh* (bier).
Sarīr Banāt Na'sh	سرير بنات نعش	4301,4295,4660,4554	The bed of the daughters of the Bier. The coffin was sometimes referred to as a bed.
al-Qā'īd	القائد	5191	The leader.
al-'Anāq	العناق	5054	A young female goat.
al-Jūn	الجون	4905	The bull.
al-Suhā	السها	5062	The Arabic translation of the word means the neglected one. This is the star "Alcor". As al-Ṣūfī wrote, it is also called by other names which are: *al-Shitā'*, al-*Saidaq* and *Nu'aish.*
Kafazāt al-Ẓibā	قفزات الظبى	The first *Kafza* (*al-Kafza al-Ūla*)	The Arabic translation means: the leaps of a Gazelle.

al-Thu'ailibān *al-Qarā'in*	الثعيلبان القراين	4377, 4375 The second *Kafza* (*al-Kafza al-Thānīa*) 4033, 4069 The third *Kafza* (*al-Kafza al-Thālitha*) 3569, 3594	These six stars represent the footprints or leaps of a Gazelle. (*Al Kafazāt)* are also called by the Arabs by other names such as: *al-Thu'ailibān* and *al-Qarā'in.*
Athar Zulfa al-Ẓibā	اثر ظلفى الظبى		The hoof trail or footprints of a gazelle.
al-Ṣarfa	الصرفة	4534	This is the bright star called Denebola which is on the tail of (constellation) Leo.
al-Ḍafira, *al-Halba*	الظفيرة الهلبة	4357, 4300, 4259,4362	A group of stars above *al-Ṣarfa that* are (also) named by the Arabs *al-Halba*. These are four stars which are also found in the constellation of Leo.
al-Hawḍ	الحوض	3624, 3757, 3888, 3894, 3775, 3662, 3619	These stars form a semi-circle which is sometimes called *Sarīr Banat Na'sh*. Here al-Ṣūfī contradicts himself by naming *Sarīr* twice.
al-Ẓibā	الظبى	3323, 3354, 3403, 3576, 3616, 3771	It is translated to: Gazelle. These are the six stars on the eyebrow, the eyes, the ears and the snout.
Kibd al-Asad	كبد الاسد	4915	This is translated in Arabic to: the liver of the lion. This star is now in the modern constellation of Canes Venatici.

Table 20: Names of stars in constellation Taurus as per Arabic folk astronomy.

Arabic Name	Name in Arabic	Star/s (HR)	Explanation and comments
al-Thurayyā, *al-Najm,* *Nujūm al-Thurayyā*	الثريا النجم نجوم الثريا	1145,1156,1178,1188 Additional stars: 1149,1165,1142	The Arabs call the twenty-ninth, the thirtieth, the thirty-first and the thirty-second, al-*Thurayyā* (the Pleiades). Inside (the Pleiades) are two stars or three together with the other four looking like a bunch of grapes that are close together. Therefore they considered them as one star and named it *al-Najm* (The Star) par excellence. It is the third of *Manāzil al-Qamar* (the lunar mansions).

al-Dabarān, *Ain al-Thawr,* *Tāb' al-Najm,* *al-Tāb',* *al-Mijdaḥ,* *al-Mujdaḥ,* *Ḥadī al-Najm,* *al-fanīq*	الدبران عين الثور تابع النجم التابع المِجدح المُجدح حادي النجم الفنيق	1457	The star Aldebaran which is also known by the other name *Ain al-Thawr* (eye of Taurus). It is (also) called *Tāb' al-Najm* (star follower) and *Tālī al-Najm* (rear star) and *al-Mijdaḥ* where the letter M is accented, as well as *al-Mujdaḥ*. It is just called *al-Tāb'* (follower) by itself without adding the word *al-Najm* (star). It is also called *Ḥadī al-Najm* (star follower – follower of the Pleiades) and *al-fanīq* which means the great Camel. It is the fourth of *Manāzil al-Qamar* (the lunar mansions).
al-Qilāṣ, *Qilāṣa,* *Ghunaīma*	القلاص القلاصة غنيمة		The stars around (*Aldebaran)* are called *al-Qilāṣ* which are the small Camels. (The Arabs) claim that (these stars) are named *Qilāṣ* and also (named) *Ghunaīma.*
al-Kalbain	الكلبين	1392, 1387	The two close stars on the northern ear which are the twenty- first and the twenty-second are called *al-Kalbain* (the two dogs). They claim they are the dogs of Aldebaran.
al-Ḍayīqa	الضيقة		This means the small gap in Arabic. As al-Ṣūfī explained, the Arabs found between the setting of al-*Thurayyā* and Aldebaran a small difference or gap which they called *al-Ḍayīqa* (small/narrow gap).
al-Dāl	الدال	1346,1373,1411,1457,1409	The five (stars) which resemble (the Greek letter Δ) *al-Dāl.* These are the stars the Greeks call the 'Hyades'.

Table 21: Names of stars in constellation Scorpio as per Arabic folk astronomy.

Arabic Name	Name in Arabic	Star/s (HR)	Explanation and comments
al-Iklīl	الاكليل	5984, 5953, 5944	Al-Ṣūfī explains that the Arabs call the three stars on the forehead *al-Iklīl*. However, he also refers to his explanation about this when he mentioned the constellation Libra and that the story from the Arabs about this is wrong.
al-Qalb (the heart). *Qalb al-'Aqrab*	القلب	6134	This star is the middle of two other stars and is reddish in color as al-Ṣūfī explains. It is called *Qalb al-'Aqrab* by the Arabs and (Antares) by the Greeks.
al-Nīyāṭ	النياط	6084, 6165	The seventh star in front of *al-Qalb* and the ninth star behind it are called *al-Nīyāṭ*.
al-Fiqarāt (plural) *Fiqra* (singular)	الفقرات	6241 (1st joint) 6247 (2nd joint) 6262 (3rd joint) 6271 (3rd joint) 6380 (4th joint) 6553 (5th joint) 6615 (6th joint) 6580 (7th joint)	*Fiqarāt* means spinal vertebrae. Al-Ṣūfī mentions that the stars on the *Kharazāt* (joints) are called *al-Fiqarāt* or singularly *Fiqra*.
al-Shawla (the sting) *Shawlat al-'Aqrab,* *Shawlat al-Sura* *al-Ibra*	الشولة شولة العقرب شولة السرة الابرة	6527 6508	Al-Ṣūfī mentions that the two stars on the tip of the tail which are the twentieth and the twenty-first are called *al-Shawla*. These two are also called *Shawlat al-'Aqrab* or *Shawlat al-Sura* and are also called *al-Ibra* (the needle). They were called *al-Shawla* because they always rise up vertically. They are the nineteenth of the lunar mansions.

Table 22: Names of stars in constellation Orion as per Arabic folk astronomy.

Arabic Name	Name in Arabic	Star/s (HR)	Explanation and comments
al-Haq'a *Haq'a al-Jauzā'* *al-Taḥātī* *al-Taḥiyat*	الهقعة هقعة الجوزاء التحاتي التحيات	1879, 1880, 1876	Al-Ṣūfī mentioned that this nebula is a combination of three stars which resembles the points of the letter *Tha* (ث). (This letter in Arabic is written with three points on it.) Al-Ṣūfī also mentioned that the Arabs call this nebula by many

al-Taḥia *al-Athāfī*	التحية الاثافي		names and that it is the fifth of the lunar mansions.
Mankib al-Jauzā' *Yad al-Jauzā'* *Mirzam al-Jauzā'* *Rā'ī al-Jauzā'*	منقب الجوزاء يد الجوزاء مرزم الجوزاء راعي الجوزاء	2061	Ṣūfī Al mentioned that the second star was called *Mankib al-Jauzā'* and also *Yad al-Jauzā'*. He also explained that some of the Arabs called it *Mirzam al-Jauzā'* and this was wrong of them, because it was the practice of the Arabs to begin the name of any bright star by the word *Mirzam* like the two (stars) *Mirzam al-Shi'rayan*. (These stars are: *al-Shi'ra al-Yamāniya* which is the star Sirius and *al-Shi'ra al-Shāmīya* which is the star Procyon). Al-Ṣūfī also mentioned that the second star was also sometimes called *Rā'ī al-Jauzā'*.
al-Nājid *al-Mirzam*	الناجد المرزم	1790	Al-Ṣūfī also mentioned that the third star was called *al-Nājid* and it was also called by *al-Mirzam*.
Minṭaqat al-Jauzā' *Niṭāq al-Jauzā'* *al-Niẓām* *al-Naẓm*. *Naẓm al-Jauzā'* *Faqār al-Jauzā'*.	منطقة الجوزاء نطاق الجوزاء النظام النظم نظم الجوزاء فقار الجوزاء	1852, 1903, 1948	Al-Ṣūfī mentioned that the three bright stars on the middle of Orion which are the twenty-sixth, the twenty-seventh and the twenty-eight were called collectively as *Minṭaqat al-Jauzā'*, *Niṭāq al-Jauzā'*, *al-Niẓām* and also *al-Naẓm*. They were also mentioned as *Naẓm al-Jauzā'* and *Faqār al-Jauzā'*. The separation of the names came later on where by the twenty-sixth is now named 'Mintaka'. The twenty-seventh is named 'Alnilam' which was a derivative from the word *al-Niẓām*. And the twenty-eighth is named 'Alnitak'.
al-Laqaṭ *Saif al-Jabbār*.	اللقط سيف الجبار	1892, 1897, 1899	Al-Ṣūfī mentioned here also that the three stars which are the thirtieth, the thirty-first and the thirty-second were called collectively as *al-Laqaṭ* and also *Saif al-Jabbār* (sword of Orion).
Rijl al-Jauzā' *Rā'ī al-Jauzā'* *al-Nājid*	رجل الجوزاء راعي الجوزاء الناجد	1713	The thirty-fifth which is the great bright star on the left leg was called *Rijl al-Jauzā'* (leg of Orion) and also *Rā'ī al-Jauzā'* (Shepherd of Orion). It was also mentioned by some Arabs that the thirty-fifth which is on the left leg was called *al-Nājid*.
Tāj al-Jauzā'	تاج الجوزاء	1676,1638, 1580,	Ṣūfī Al mentioned that the nine

Dhawā'īb al-Jauzā'	ذوايب	1570, 1544, 1543, 1552, 1567, 1601	stars forming a curve that are on the pelt and which are from the seventeenth until the twenty-fifth were called *Tāj al-Jauzā'* (crown of Orion) and also *Dhawā'īb al-Jauzā'* (this is the skin of the lion which a hunter usually wraps around his hand).

Table 23: Names of stars in constellation Centaurus as per Arabic folk astronomy.

Arabic Name	Name in Arabic	Star/s (HR)	Explanation and comments
al-Shamārīkh	الشماريخ		The Arabs called both the constellations Centaurus and Lepus by the name of: *al-Shamārīkh.*
Hiḍār, *al-Wazn,* *Muḥlifain,* *Muḥnithain*	حضار الوزن محليفين محنثين	5659,5267	The Arabs called these two stars by these 4 names. However al-Ṣūfī was not sure which one of these names referred to which star.

5.11 Comments on the Chapter of the Constellation Ursa Minor

5.11.1 The Explanation of *'Fa's al Raḥā'*

In this chapter of the constellation Ursa Minor, al-Ṣūfī wrote about an image which was used in Arabic folk astronomy called *Fa's al-Raḥā*. It is an area which had been compared by the Arabs to the likeness of a fish. It is formed by two rows of stars forming two arcs as al-Ṣūfī explains. The first arc is formed by: "… the three stars on the tail, together with the fourth and sixth form a curved lin." The second arc starts with "… this star is connected with the star on the end of the tail, forming a line of dim stars which is curved like the first line." Al-Ṣūfī then explains that: "… these two arcs enclose an area with the shape of a fish, called *al-Fa's*; this may be compared with *Fa's al-Raḥā*, where the pole is in the middle. However, the equatorial pole is on the outside of the second arc, close to the nearest star on the line to the star *al-Juday*."

Al-Ṣūfī stated here that the pole is located in the middle of the image of this fish. However as an accomplished astronomer, al-Ṣūfī must have known that this is clearly not the case. Therefore the explanation for this matter is that he must have been stating what the Arabs have said about this area or this image of the fish with the pole at its centre. For he then explains: "… the equatorial pole is on the outside of the second arc, close to the nearest star on the line to the star *al-Juday*." (See below the explanation and location of this (nearest) star)

This explanation of the image of the fish is found in many other books on Arabic folk astronomy. The most important was that of Abū Ḥanīfa al-Daīnawri in his book on al-Anwā', where he clearly states that the Arabs: "… believe that the pole is in the middle of this image." However al-Daīnawri goes on to explain that "… it is not the case for the pole is close to a star next to *al-Juday* on this curve of dim stars. I found that these stars are the closest stars to the pole. I found that the distance between this star and the pole is less then one degree. However the pole is not a star but a point on the sphere."

Al-Ṣūfī must have known this explanation by Abu Hanifa al-Dinawari because in the introductory chapter of his book he mentioned that the book by Abū Ḥanīfa al-Daīnawri is the best book on Arabic folk astronomy even though he has some misgivings about the accuracy of some of al-Daīnawri's information and his observational skills. (See translation of al-Ṣūfī introductory chapter)

The below picture (Figure 53) shows the image of the constellation with the two curves forming an image of a fish. The middle red point is the estimated area where the Arabs believed the equatorial pole was located. Even though this point is slightly off center however it is a remarkable achievement to those Arab observers who where able to locate this point in the sky without the aid of any instruments, but only relied on their naked eyes. In Figure 54 the star chart for the constellation Ursa Minor has been re-calculated to the year A.D. 960 taking into account of precession. The nearest visible star to the pole at that time was the star HR 4893 with visual magnitude of 5.28. This star was probably the star mentioned by al-Daīnawri and al-Ṣūfī. The distance between the pole and the star is close to 1 degree. This also shows the remarkable accuracy and observation skills of al-Daīnawri and al-Ṣūfī in identifying almost the precise location of the equatorial pole in that period of time.

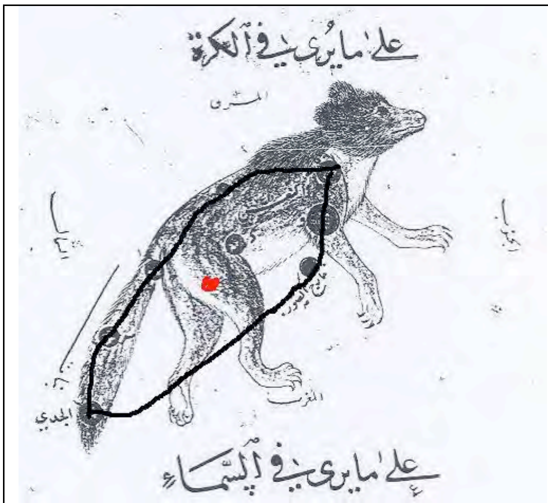


Figure 53: Constellation Ursa Minor with the two curves forming an image of a fish

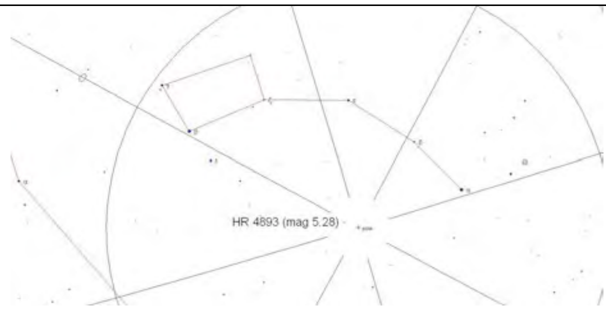


Figure 54: Chart for constellation Ursa Minor re-calculated to the year A.D. 960

5.11.2 The Directions for Using the Star Maps as per al-Ṣūfī Explanation

At the end of the chapter on Ursa Minor, al-Ṣūfī explains clearly the reasons why he made two different pictures. He also explains the method of using these maps where he wrote:

> “For every constellation we have drawn two pictures: one as it is projected on the globe and the other as it is seen in the heavens. Hence we have covered both of the different cases, so there is no confusion for anyone who sees that what is viewed on the globe is different from what is in the heavens. When we want to see the constellation as it is we lift the book over our heads and we look at the second picture. From beneath we are viewing it as it is seen in the heavens.”

It is apparent that as an observational astronomer and an instrument-maker al-Ṣūfī was very much concerned with the accuracy of the data he had and the way it should be used correctly when constructing a celestial globe.

5.11.3 Star Names and Modern Designations of the Stars

I have included below in Table 24 all the stars that are included in al-Ṣūfī's star tables for constellation Ursa Minor. I have also included the HR, numbers so each star can be correctly identified. The stars' identification are according to Toomer's book. I also tabulated below the names of the stars according to the Arabic tradition and according to what was described by al-Ṣūfī, together with the modern star names and any other common name.

Table 24: Star Names and Modern Designations of the Stars for Ursa Minor Constellation

Star number (as per al-Ṣūfī)	HR	Star name and description (as per al-Ṣūfī)	Star name/s in Arabic tradition	Modern star name/s	Other star name/s
1 Ursa minor	424	The star on the end of the tail which is *al-Juday*	*al-Juday*	Polaris	Alruccabah, Cynosura, Phoenice, Lodestar, Pole Star, Tramontana, Angel Stern, Navigatoria, Star of Arcady, Yilduz, Mismar
2 Ursa minor	6789	The one next to it on the tail		Yildun	Vildiur, Gildun
3 Ursa minor	6322	The one next to that before the place where the tail joins the body			
4 Ursa minor	5903	The southern most of the stars in the advanced side of the rectangle			
5 Ursa minor	6116	The northern most of those in the same side			
6 Ursa minor	5563	The southern star in the rear side which is the brightest of *al-Farqadain*	Brightest of *al-Farqadain*	Kocab	Kochab, Kochah
7 Ursa minor	5735	The northern one in the same side which is the dimmest of *al-Farqadain*	Dimmest of *al-Farqadain*	Pherkad	Pherkad Major

8 Ursa minor	5430	The southern star parallel to *al-Farqadain*			

5.11.4 Modern Star Chart of Ursa Minor Constellation

In Figure 55 below I have included a modern star chart of Ursa Minor constellation showing the star's modern name, al-Ṣūfī designation number and HR number. The software used to generate above chart is: Cartes du Ciel version 2.76.

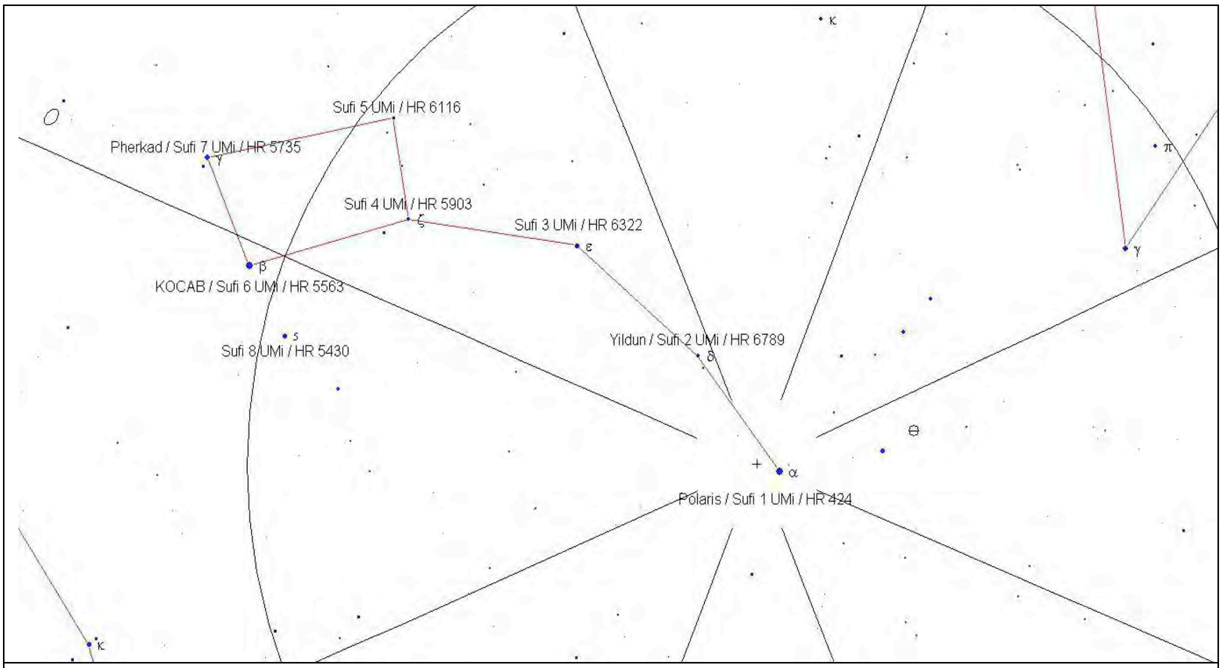


Figure 55: Modern Star Chart of Ursa Minor Constellation

5.12 Comments on the Chapter of the Constellation Ursa Major

5.12.1 Differences in Coordinates and Magnitudes between Manuscripts Marsh144 and MS 5036

The below table shows the differences in coordinates and magnitude values for the constellation Ursa Major which were identified in the manuscripts Marsh144 and MS5036. These differences were identified and compared with al-Ṣūfī's written description of the constellation. In the comments below I have also referred to other manuscripts, which are: The French translation by Schjellerup which was based on the rather late Copenhagen Manuscript MS83 dated A.D. 1601. The other is the London manuscript OR5323 dated 14th century A.D. The last is the Hyderabad copy which was based on several manuscripts but mainly that of MS5036; however I found that the Hyderabad edition contains many errors which do not make it very reliable.

Table 25: Differences in Coordinates and Magnitudes between Manuscripts.

Star number (as per al-Ṣūfī)	Lat. Marsh144	Lat. MS 5036	Mag. Marsh144	Mag. MS 5036	Explanations and Comments
7 Ursa major			4.25	3.75	The value in al-Ṣūfī's written description is 4s while the MS5036 chart shows it as 4k, however the Marsh144 chart shows it correctly as 4s.
17 Ursa major	45 30	44 30			The value for Lat indicated in Schjellerup French translation (based on the Copenhagen Manuscript MS83) is similar to the MS5036 which is 44 30.
34 Ursa major	20 20	23 05			The value for Lat indicated in Schjellerup French translation is 23 00 which is also a different value but closer to the MS5036 value. This proves that the copy of the Copenhagen manuscript is similar to the MS5036. The London manuscript OR5323 shows the Lat 20 20

5.12.2 Star names and modern designations of the stars

I have included below in Table 26 all the stars that are included in al-Ṣūfī's star tables for constellation Ursa Minor. I have also included the HR, numbers so each star can be correctly identified. The stars identifications are according to Toomer's book. I also tabulated below the names of the stars according to the Arabic tradition and according to what was described by al-Ṣūfī, together with the modern star names and any other common name.

Table 26: Star Names and Modern Designations of the Stars for Ursa Major

Star number (as per al-Ṣūfī)	HR	Star name and description (as per al-Ṣūfī)	Star name/s in Arabic tradition	Modern star name/s	Other star name/s
1 Ursa major	3323	The star on the end of the snout.	*al-Khaṭem*	Muscida	
2 Ursa major	3354	The more advanced of the two stars in the two eyes.			
3 Ursa major	3403	The other one of the two.			
4 Ursa major	3576	The more advanced of the two stars in the forehead.			
5 Ursa major	3616	The other one of the two.			
6 Ursa major	3771	The star on the tip of the advance ear.			
7 Ursa major	3624	The more advanced of the two stars in the neck.			
8 Ursa major	3757	The other one of the two, longitude or latitude are wrong.			
9 Ursa major	3888	The northern most of the two stars in the chest.			
10 Ursa major	3894	The southernmost of them.			
11 Ursa major	3775	The star on the left knee.			
12 Ursa major	3569	The northern most of the two in the front left paw. *al-Kafza*		Talitha	
13 Ursa major	3594	The southern most of them. *al-Kafza*			
14 Ursa major	3662	The star above the right knee.			
15 Ursa major	3619	The star below the right knee.			
16 Ursa major	4301	The star on the back which is part of the quadrilateral.		Dubhe	Dubb, al-dubb
17 Ursa major	4295	The one on the flank.	*al-Mirāq*	Merak	Mirak
18 Ursa major	4660	The one on the place where the tail joins		Megrez	Kaffa in Becvar

		the body.			
19 Ursa major	4554	The remaining one on the left hind thigh.		Phad	Phecda, Phekda, Phegda, Phekha, Phacd
20 Ursa major	4033	The more advanced of the two stars in the left hind paw. *al-Kafza*		Tania Borealis	Al-Kafza al-Thānīa
21 Ursa major	4069	The next one. *al-Kafza*		Tania Australis	
22 Ursa major	4335	The star on the left knee bends.			
23 Ursa major	4377	The northern most of the two stars in the right hind paw. *al-Kafza*		Alula Borealis	
24 Ursa major	4375	The southernmost of them. *al-Kafza*		Alula Australis	
25 Ursa major	4905	The first of the three stars on the tail next to the place where it joins the body. *al-Jaoun*	*al-Jūn*	Aliioth	Alioth, Aliath
26 Ursa major	5054	The middle one. *al-Inak*	*al-'Anāq*	Mizar	Mirzar, Mizat
27 Ursa major	5191	The third on the end of the tail. *al-Kaed*	*al-Qā'īd*	Alkaid	Benetnash, Benetnasch, Elkeid
28 Ursa major	4915	The star under the tail at some distance towards the south.	*Kibd al-Asad*		
29 Ursa major	4785	The rather faint star in advance of it.			
30 Ursa major	3705	The southernmost of the two stars between the front legs of Ursa Major and the head of Leo.			
31 Ursa major	3690	The one north of it.			
32 Ursa major	3800	The next of the remaining three faint stars.			
33 Ursa major	3809	The one in advance of this.			
34 Ursa major	3612	The one in advance again of the latter.			
35 Ursa major	3275	The star between the front legs (of Ursa Major) and Gemini.		Alsciaukat	Mabsuthat

5.12.3 Explanation of al-Ṣūfī’s Distance Approximation

Throughout al-Ṣūfī’s work the author indicated some measurements, which might seem to be a very general approximation to the measurement of distance between the stars. However, upon careful examination of this method, which was made by Schjellerup in his French translation of al-Ṣūfī’s book, we can see that these measurements can be almost exactly defined in term of numerical distance values. These values are summarized as follows: one *dhirā’* = 2 deg 20 min; one *Shibr* = 1/3 *Thira*; one *Qasba* = 1/32 *Thira* and one *Rumḥ* = 14 deg. In the comments on the constellation Auriga al-Ṣūfī clearly mentioned that the value of one *dhirā’* is two degrees and one-third of a degree (20 minutes). For example in the constellation Ursa Major al-Ṣūfī mentioned that there are two stars close to the star *al-Qā’īd*. The distance between these two stars is one *Thira* and the distance between the closer of these two to *al-Qā’īd* is also close to one *Thira*. These two stars have not been mentioned by Ptolemy. Upon examination we can identify these two stars to be HR5023 and HR5112 and the distance between these two stars is almost 2 degrees and 26 min. The distance between *al-Qā’īd* and the closer of these two stars is also a little more then 2 degrees.

5.12.4 Modern Star Chart of Ursa Major Constellation

Figure 56 below is a modern Star chart of Ursa Major constellation. The stars indicated in red are the stars according to al-Ṣūfī’s star number. The stars indicated in green are the stars mentioned by al-Ṣūfī in his comments but not included in the charts nor are included in Ptolemy. There was no place to include the star’s modern name or the HR number for every star in this constellation, therefore I only included al-Ṣūfī star numbers where the details can be found in the above comments. The software used to generate above chart is Cartes du Ciel version 2.76.

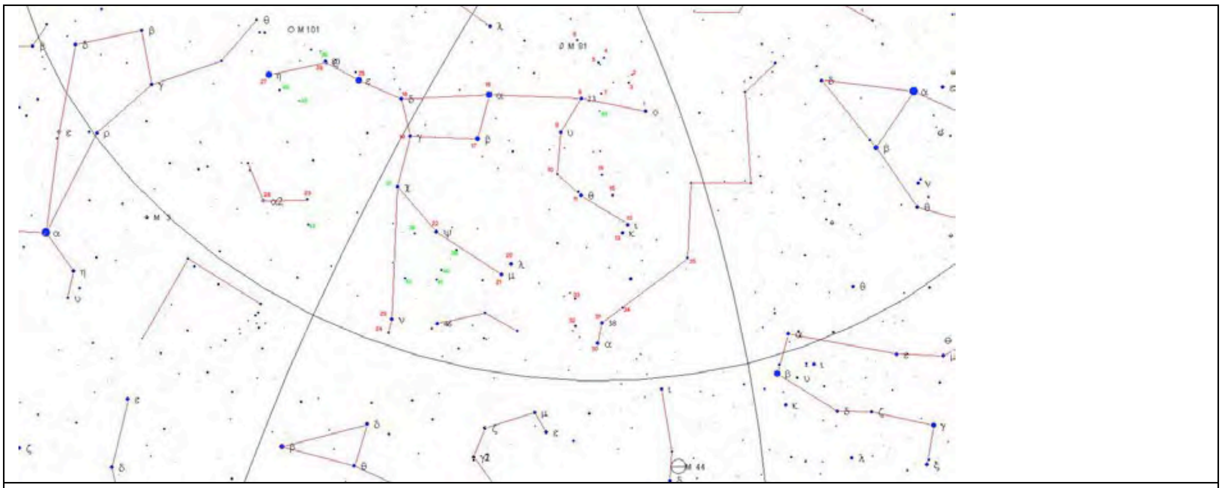


Figure 56: Modern Star Chart of Ursa Major Constellation

5.13 Comments on the Chapter of the Constellation Taurus

5.13.1 Star names and Modern Designations of the Stars

I have included below in Table 27 all the stars that are included in al-Ṣūfī's star tables for constellation Taurus. I have also included the HR, numbers so each star can be correctly identified. The stars identifications are according to Toomer's book. I also tabulated below the names of the stars according to the Arabic tradition and according to what was described by al-Ṣūfī, together with the modern star names and any other common name.

Table 27: Star Names and Modern Designations of the Stars for Taurus

Star number (as per al-Ṣūfī)	HR	Star name and description (as per al-Ṣūfī)	Star name/s in Arabic tradition	Modern star name/s	Other star name/s
1 Taurus	1066	The northernmost of the 4 stars in the cut-off position.			
2 Taurus	1061	The one after.			
3 Taurus	1038	The one after this also.			
4 Taurus	1030	The southernmost of the 4.			
5 Taurus	1174	The one on the rear of these, on the right shoulder blade.			
6 Taurus	1239	The star in the chest.			
7 Taurus	1320	The star in the right knee.			
8 Taurus	1251	The star on the right hock.			
9 Taurus	1473	The star on the left knee.			
10 Taurus	1458	The star on the left lower leg.			
11 Taurus	1346	The star on the nostrils in the face looks like the letter (Δ) *Dāl* from the books of the Greeks.		Hyadum I	
12 Taurus	1373	The one between this and the northern eye.		Hyadum II	
13 Taurus	1411	The one between it and the southern eye.			
14 Taurus	1457	The bright star the reddish one of the letter (Δ) *al-Dāl* on the southern eye and it is *Aldebaran.*	*al-Dabarān or Ain al-Thawr*	Aldebaran	Cor Tauri, Parilicium
15 Taurus	1409	The remaining one on the northern eye.		Ain	
16 Taurus	1547	The star on the place where the southern horn and the ear join the head.			

17 Taurus	1656	The southernmost of the 2 stars in the southern horn			
18 Taurus	1658	The northernmost of these			
19 Taurus	1910	The star on the tip of the southern horn			
20 Taurus	1497	The star on the northern horn triangle.			
Ptolemy 21 not included in al-Ṣūfī		"The star on the tip of the northern horn is the same star as the one on right leg of the constellation Auriga."			
21 Taurus (=Ptolemy 22)	1392	The northernmost of the 2 stars close together in the northern ear.	*al-Kalbain*		
22 Taurus	1387	The southern of them. The latitude as seen in the sky should be 00 00.	*al-Kalbain*		
23 Taurus	1256	The more advanced of the 2 small stars in the neck.			
24 Taurus	1329	The rearmost of them. Its latitude should be southerly because in the sky it is so.			
25 Taurus	1287	The quadrilateral in the neck, the southernmost star on the advanced side.			
26 Taurus	1269	The northernmost star on the advanced side.			
27 Taurus	1369	The southernmost star on the rear side.			
28 Taurus	1348	The northernmost one on the rear side.			
29 Taurus	1145	The Pleiades: the northern end of the advanced side.			Taygeta
30 Taurus	1156	The southern end of the advanced side.			Merope
31 Taurus	1178	The rearmost and narrowest end of the Pleiades.			Atlas
32 Taurus	1188	The small star outside the Pleiades towards the north.			
33 Taurus	1101	The star under the right foot and the shoulder blade.			
34 Taurus	1620	The most advanced of the 3 stars over the southern horn.			
35 Taurus	1739	The middle one of the three.			
36 Taurus	1810	The rearmost of them			
37 Taurus	1946	The northernmost of the 2 stars under the southern tip of the southern horn.			
38 Taurus	1985	The southernmost of them.			
39 Taurus	1875	The most advanced of the 5			

		stars under the northern horn.			
40 Taurus	1928	The one to the rear of this.			
41 Taurus	2002	The one to the rear again of the latter.			
42 Taurus	2034	The northernmost of the remaining rearmost 2.			
43 Taurus	2084	The southernmost of these two.			

5.13.2 The Explanation of *'al-Ḍayīqa'*.

At the end of this chapter on the constellation Taurus, al-Ṣūfī wrote about a location in the sky that the Arabs called *al-Ḍayīqa* which means 'the small gap' in Arabic. He dedicated almost two pages on this topic which might seem from first sight that it is a very important topic in traditional Arabic astronomy. However I believe that there are many astronomical concepts that the author tried to explain using this topic as an example in order confirm his scientific capability. The case below is an exercise in the idea 'Oblique Ascensions' which was a well-known concept in ancient and classical Greek astronomy. Therefore I will try here to analyze al-Ṣūfī's comments in order to identify some of these scientific astronomical ideas.

Al-Ṣūfī started by explaining that there are two close stars on the northern ear, and these stars are the twenty-first (HR1392) and the twenty-second (HR1387) which were called *al-Kalbain* (the two dogs). He then states that many Arab scholars narrate that these two stars are called *al-Ḍayīqa* because they believed that when the Moon slows down it stays in that location. However, he completely rejects this idea and states that this is wrong. He then explains in detail the reason why by saying that: "… the stars of *al-Thurayyā* are fifteen degrees of Taurus and these two stars are twenty-four and a half degrees of it. The distance between them and *al-Thurayyā* is nine degrees and the least amount the Moon travels in one day and one night when its is moving slowest and its most distance (from the Earth), is eleven degrees." Here we have several ideas which need further explanation. The Moon could not travel from *al-Thurayyā* directly to these two stars in the same or next day even when it is in its slowest and further orbit from the Earth. By this picture al-Ṣūfī explains several facts about the path and orbit of the Moon. First is that path of the Moon can be higher than the ecliptic. In the comments about the constellation Scorpio he explains that it is can reach up to five degrees further then the ecliptic. The other idea is that the orbit of the Moon is variable and the least amount the Moon travels in one day is eleven degrees. As al-Ṣūfī's work was based on Ptolemy's then it is safe to assume that he was well aware of the Ptolemy's epicycle and deferent system and the concept of the variable distance of the Earth and the Moon and the variable apparent speed of the Moon as well as the concept of the ‘Oblique Ascensions’. As we can see in Figure 57, which shows Ptolemy’s epicycle and deferent system, it is clear that the Moon-Earth distance varies depending on the time and position of the Moon in epicycle.

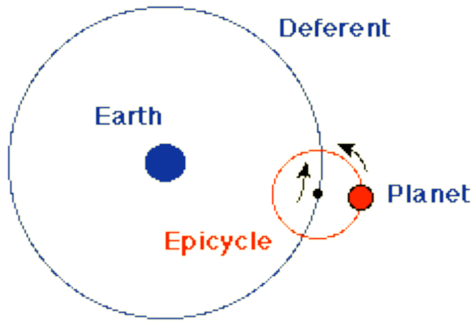


Figure 57 Ptolemy’s epicycle and deferent system

Next al-Ṣūfī explains that *al-Ḍayīqa* is the area or gap between *al-Thurayyā* and *al-dabarān* and not the two stars. He further explains that because the Arabs use *al-Anwā’* folk tradition this is why this area was called *al-Ḍayīqa.* Al-Ṣūfī explains that *al-Anwā’ or Naw’* “… is when a star sets in the west at dawn and when its *Raqīb* [companion star] rises in the east from under the light [of the Sun]. The *Raqīb* of each one is the fifteenth star [of the lunar mansions].” The *Naw’* of a star had been an area of controversy between Arab scholars on whether it is the rise or fall of a star. However, al-Ṣūfī here confirms that the *Naw’* of a star is not the rise but the fall of a star in the west at dawn. (Further explanations on *al-Anwā’* and lunar mansions are to be in the chapter on Arabic Folk astronomy)

Al-Ṣūfī then tries to go into detail on why this area or gap was called thus. His explanation is quite clear where he says that: “The middle of *al-Thurayyā* is on the fifteen degrees of Taurus and al-dabarān is on the twenty five degree of it. The distance on the degrees of the zodiac between them is ten degrees. However the latitude of *al-Thurayyā* in the north from its (zodiac) degrees is four degrees and few minutes. And the latitude of al-dabarān in the south is five degrees. And it is in the nature of the northern stars to rise before their (zodiac) degree rise and set after their (zodiac) degrees set, and the southern (stars) rise after their (zodiac) degree rise and set before their (zodiac) degrees set. Therefore *al-Thurayyā* approximately rises at thirteen degrees of Taurus and al-dabarān rises at twenty seven of it. Thereby the degrees between the rise of *al-Thurayyā* and al-dabarān are approximately fourteen degrees of the degrees of the zodiac and eleven degrees and a few minutes from the horizon in this third zone. And *al-Thurayyā* sets at seventeen degrees of Taurus because it sets after its zodiac degree. And al-dabarān sets at twenty three degrees of it because it sets before its zodiac degrees. Thereby the degrees between the setting of *al-Thurayyā* and al-dabarān are six degrees of the degrees of the zodiac and seven degrees from the horizon in this zone. The degrees of Taurus sets at the same time as the degrees of Scorpio rise. When they found between the setting of *al-Thurayyā* and al-dabarān this amount they called this gap between them *al-Ḍayīqa."* I have made below two diagrams in order to help explain the concept of the 'Oblique Ascensions' and what al-Ṣūfī was trying to convey. The first is Figure 58 shows the position and rising of *al-Thurayyā* and al-dabarān on May 13 at dawn in the east at the time of al-Ṣūfī. The second is Figure 59 shows the position and setting of *al-Thurayyā* and al-dabarān on November 13 at dawn in the west at the time of al-Ṣūfī. This is the *Naw'* of the *al-Thurayyā* and al-dabarān. We can see from below that because the Arabs considered the *Naw'* of a star as the setting at dawn and that the distance from the horizon between *al-Thurayyā* and al-dabarān is small (only 7 degrees) then they called this small gap *al-Ḍayīqa* which means 'the small or narrow gap' in Arabic. This is one important examples in which al-Sufi was trying to combine Greek astronomy with Arabic traditional astronomy.

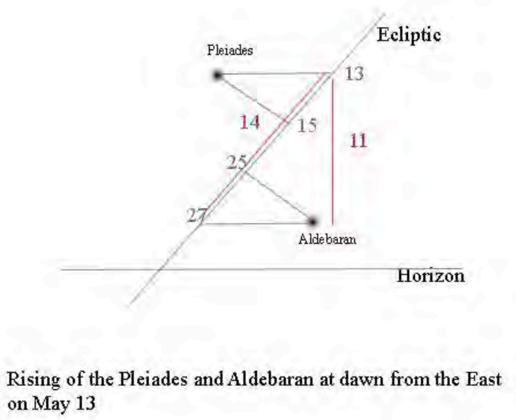
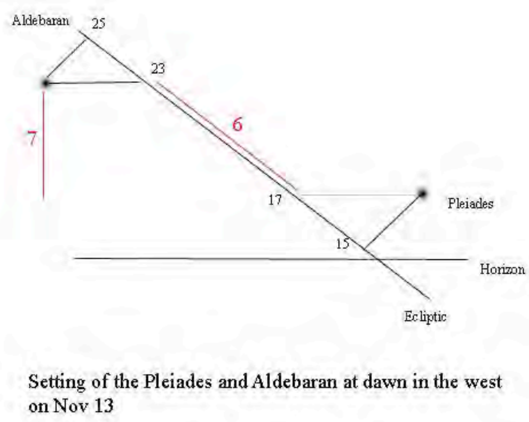
	

Figure 58: The Rising of *al-Thurayyā* and al-dabarān on May 13	Figure 59: The Setting of *al-Thurayyā* and al-dabarān on November 13

One last idea which al-Ṣūfī mentioned in this section is the Third Zone. This was the concept of dividing the Earth into climes or zones which were called *clima*, plural *climata or klimata* which in Greek means 'inclination'. However there seems to have been some dispute among ancient Greek scholars as to the exact number or arrangement of these zones. According to Strabo the concept of the division of the Earth into zones began as early as the 6th century B.C. with a Greek scholar named Permenides of Elea. The number of zones accepted by Strabo was five, and he criticizes another scholar Polybius for making the number six. The five zones accepted by Strabo were as follows: the uninhabitable Torrid Zone lying in the region of the equator; a zone on either side of this extending to the tropic; and then the temperate zones extending in either direction from the tropic to the arctic regions. However Ptolemy in his *Geography* divided the northern temperate zone into seven zones. This division in seven zones may go back to notions of geography predating the idea of a spherical Earth introduced by Pythagoras in the 6th century BC. Medieval Arabs and Persian scholars such as al-Bīrūnī, al-Idrīsī as well as al-Ṣūfī adopted Ptolemy's system of seven climes and divided the latitudes of the Earth into seven habitable zones starting from the equator. According to al-Bīrūnī the third zone is from latitude 27 to 33 degrees hence the middle of this zone is at latitude 30 deg. Therefore, according to al-Ṣūfī's comments these observations have been made in the third zone, most probably in the city of Shiraz (Latitude: 29.53. Longitude: 52.58). This confirms the historical record which mentions that al-Ṣūfī has conducted his astronomical observations or maybe constructed an observatory in Shiraz.

5.13.3 Modern Star chart of Taurus constellation

Figure 60 below is a modern Star chart of Constellation Taurus. The stars indicated in red are the stars according to al-Ṣūfī's star number. The stars indicated in green are the stars mentioned by al-Ṣūfī in his comments but not included in the charts nor are included in Ptolemy. There was no place to include the star's modern name or the HR number for every star in this constellation, therefore I only included al-Ṣūfī star numbers where the details can be found in the above comments. The software used to generate above chart is Cartes du Ciel version 2.76.

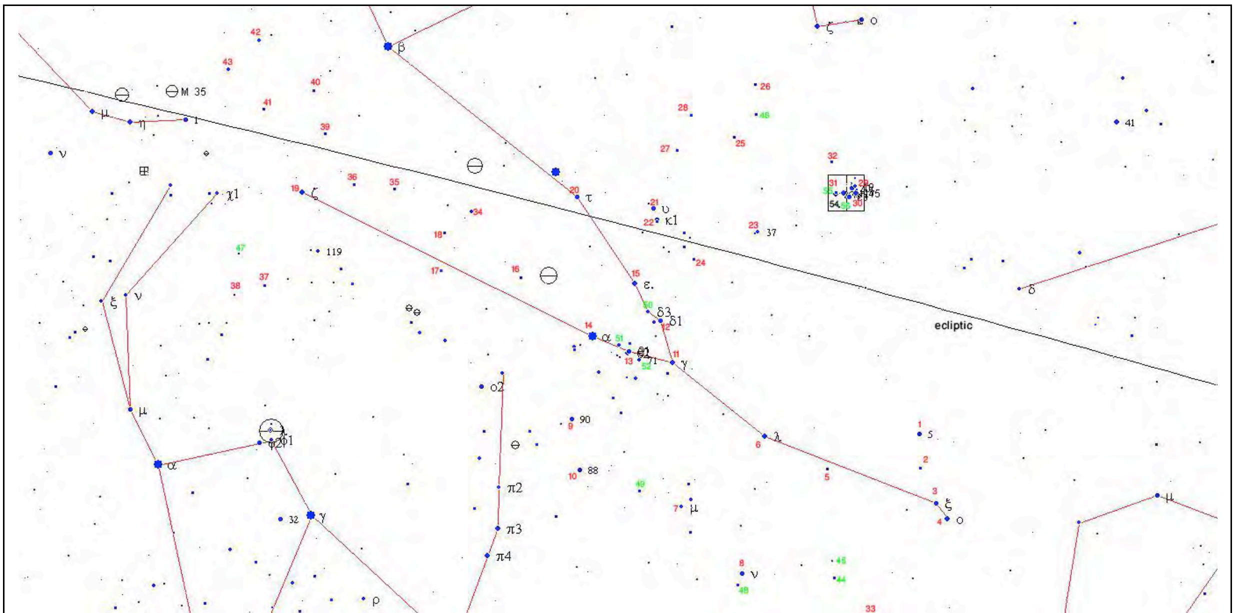


Figure 60: Modern Star Chart of Taurus Constellation

5.14 Comments on the Chapter of the Constellation Scorpio

5.14.1 Star Names and Modern Designations of the Stars

I have included below in Table 28 all the stars that are included in al-Ṣūfī's star tables for constellation Scorpio. I have also included the HR, numbers so each star can be correctly identified. The stars identifications are according to Toomer's book. I also tabulated below the names of the stars according to the Arabic tradition and according to what was described by al-Ṣūfī, together with the modern star names and any other common name.

Table 28: Star Names and Modern Designations of the Stars for Scorpio

Star number (as per al-Ṣūfī)	HR	Star name and description (as per al-Ṣūfī)	Star name/s in Arabic tradition	Modern star name/s	Other star name/s
1 Scorpio	5984	The northernmost of the 3 bright stars on the forehead.	*al-Iklīl*	Graffias	Grafias, Grassias, Acrab, Akrab, Elacrab
2 Scorpio	5953	The middle one of these.	*al-Iklīl*	Dschubba	Iclarkrau
3 Scorpio	5944	The southernmost of the three.	*al-Iklīl*		
4 Scorpio	5928	The star south again of this on one of the legs.			
5 Scorpio	6027	The southernmost of the 2 stars adjacent to the northernmost of the three bright one.		Jabbah	
6 Scorpio	5993	The southernmost of these.			
7 Scorpio	6084	The most advanced of the 3 bright stars in the body.	*al-Nīyāṭ*	Alniyat	
8 Scorpio	6134	The middle one of these which is reddish and called *Qalb al-'Aqrab* (Antares).	*-al-Qalb (the heart)* *-Qalb al-'Aqrab*	Antares	Cor Scorpii, Qalb al Aqrab, Vespertilio
9 Scorpio	6165	The rearmost of the 3.	*al-Nīyāṭ*		
10 Scorpio	6028	The advanced star of the 2 under these approximately on the last leg.			
11 Scorpio	6070	The rearmost of these.			
12 Scorpio	6241	The star in the first tail joint from the body.	*al-Fiqra*		
13 Scorpio	6247	The one after this in the 2nd joint.	*al-Fiqra*		
14 Scorpio	6262	The northern star of al-*Muḍ'af* (the double star) in the 3rd joint.	*al-Fiqra*		
15 Scorpio	6271	The southern star of the double star.	*al-Fiqra*		
16 Scorpio	6380	The one following in the 4th joint.	*al-Fiqra*		

17 Scorpio	6553	The one after that in the 5th joint.	*al-Fiqra*	Sargas	
18 Scorpio	6615	The next one again in the 6th joint.	*al-Fiqra*		
19 Scorpio	6580	The star in the 7th joint the joint next to the sting.	*al-Fiqra*		
20 Scorpio	6527	The rearmost of the 2 stars in the sting.	*-al-Shawla (the sting)* *-Shawlat al-'Aqrab* *-Shawlat al-Sura* *-al-Ibra*	Shaula	
21 Scorpio	6508	The more advanced of these.	*-al-Shawla (the sting)* *-Shawlat al-'Aqrab* *-Shawlat al-Sura* *-al-Ibra*	Lesath	Lesuth
22 Scorpio	6475	The nebulous star to the rear of the sting.		M7	
23 Scorpio	6492	The most advanced of the 2 stars to the north of the sting.			
24 Scorpio	6616	The rearmost of them.			

5.14.2 Modern Star Chart of Constellation Scorpio

Figure 61 below is a modern Star chart of Constellation Scorpio. The stars indicated in red are the stars according to al-Ṣūfī's star number. The stars indicated in green are the stars mentioned by al-Ṣūfī in his comments but not included in the charts nor are included in Ptolemy. There was no place to include the star's modern name or the HR number for every star in this constellation, therefore I only included al-Ṣūfī star numbers where the details can be found in the above comments. The software used to generate above chart is Cartes du Ciel version 2.76.

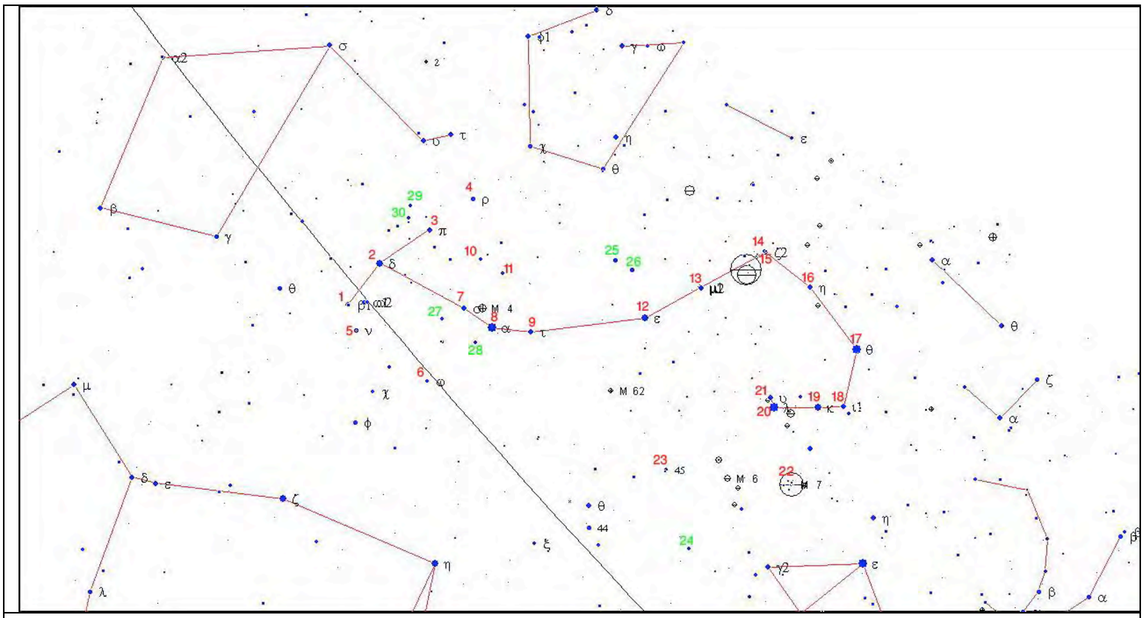


Figure 61: Modern Star Chart of Scorpio Constellation

5.15 Comments on the Chapter of the Constellation Orion

5.15.1 Star Names and Modern Designations of the Stars

I have included below in Table 29 all the stars that are included in al-Ṣūfī's star tables for constellation Scorpio. I have also included the HR, numbers so each star can be correctly identified. The stars identifications are according to Toomer's book. I also tabulated below the names of the stars according to the Arabic tradition and according to what was described by al-Ṣūfī, together with the modern star names and any other common name.

Table 29: Star Names and Modern Designations of the Stars for Orion

Star number (as per al-Ṣūfī)	HR	Star name and description (as per al-Ṣūfī)	Star name/s in Arabic tradition	Modern star name/s	Other star name/s
1 Orion	1879 1880 1876	The nebulous star in the head of Orion, which are the three close stars.	*-al-Haq'a* *-Haq'a al-Jauzā'* *- al-Taḥātī,* *-al-Taḥiyat* *- al-Taḥia* *- al-Athāfī*	Meissa	Heka
2 Orion	2061	The bright reddish star on the right shoulder.	*-Mankib al-Jauzā'* *-Yad al-Jauzā'* *-Mirzam al-Jauzā'*	Betelgeuse	Betelguex, Beteiguex, Betelgeuze, Al Mankib
3 Orion	1790	The star on the left shoulder.	*-al-Nājid* *-al-Mirzam*	Bellatrix	Amazon Star, the
4 Orion	1839	The one under this to the rear.			
5 Orion	2124	The star on the right elbow.			
6 Orion	2241	The star on the right forearm.			
7 Orion	2199	The quadrilateral in the right hand: The rear, double star on the southern side.			
8 Orion	2159	The advanced star on the southern side.			
9 Orion	2223	The rear one on the northern side.			
10 Orion	2198	The advanced one on the northern side			
11 Orion	2047	The more advanced of the 2 stars in the staff.			
12 Orion	2135	The rearmost of them.			

13 Orion	1934	The rearmost of the 4 stars almost on a straight line just over the back.			
14 Orion	1872	The one in advanced of this.			
15 Orion	1842	The one in advanced again of this.			
16 Orion	1811	The last and most advanced of the 4			
17 Orion	1676	The stars in the pelt on the left arm: The northernmost.	*-Tāj al-Jauzā* *-Dhawā'īb al-Jauzā'*		
18 Orion	1638	The 2nd from the northernmost.	*-Tāj al-Jauzā*		
19 Orion	1580	The 3rd from the northernmost.	*-Dhawā'īb al-Jauzā'*		
20 Orion	1570	The 4th from the northernmost.	*-Tāj al-Jauzā*		
21 Orion	1544	The 5th from the northernmost.	*-Dhawā'īb al-Jauzā'*		
22 Orion	1543	The 6th from the northernmost.	*-Tāj al-Jauzā*		
23 Orion	1552	The 7th from the northernmost.	*-Dhawā'īb al-Jauzā'*		
24 Orion	1567	The 8th from the northernmost.	*-Tāj al-Jauzā*		
25 Orion	1601	The last and the southernmost of those in the pelt.	*-Dhawā'īb al-Jauzā'*		
26 Orion	1852	The most advanced of the 3 stars on the belt.	*Minṭaqat al-Jauzā'*	Mintaka	
27 Orion	1903	The middle one.	*al-Niẓām* *al-Naẓm.* *Naẓm al-Jauzā'*	Alnilam	Alnihan, Alnitam
28 Orion	1948	The rearmost of the three.	*Niṭāq al-Jauzā'*	Alnitak	Alnitah
29 Orion	1788	The star near the handle of the sward.			
30 Orion	1892	The northernmost of the 3 stars joined together at the tip of the dagger.	*al-Laqaṭ* *Saif al-Jabbār*		
31 Orion	1897	The middle one.	*al-Laqaṭ* *Saif al-Jabbār*		
32 Orion	1899	The southernmost of the three.	*al-Laqaṭ* *Saif al-Jabbār*	Nair al Saif	Hatysa in Becvar
33 Orion	1937	The rearmost of the 2 stars under the tip of the sward.			

34 Orion	1855	The more advanced of them.		Thabit	Tabit
35 Orion	1713	The bright star in the left foot, which is (applied in) common to the water (of Eridanus).	*-Rijl al-Jauzā'* *-Rā'ī al-Jauzā'* *-al-Nājid*	Rigel	Algebar, Elgebar
36 Orion	1735	The star to the north of it in the lower leg over the ankle-joint.			
37 Orion	1784	The star under the left heel outside.			
38 Orion	2004	The star under the right rear knee.		Saiph	

5.15.2 Modern Star Chart of Constellation Orion

Figure 62 below is a modern Star chart of Constellation Scorpio. The stars indicated in red are the stars according to al-Ṣūfī's star number. The stars indicated in green are the stars mentioned by al-Ṣūfī in his comments but not included in the charts nor are included in Ptolemy. There was no place to include the star's modern name or the HR number for every star in this constellation, therefore I only included al-Ṣūfī star numbers where the details can be found in the above comments. The software used to generate above chart is Cartes du Ciel version 2.76.

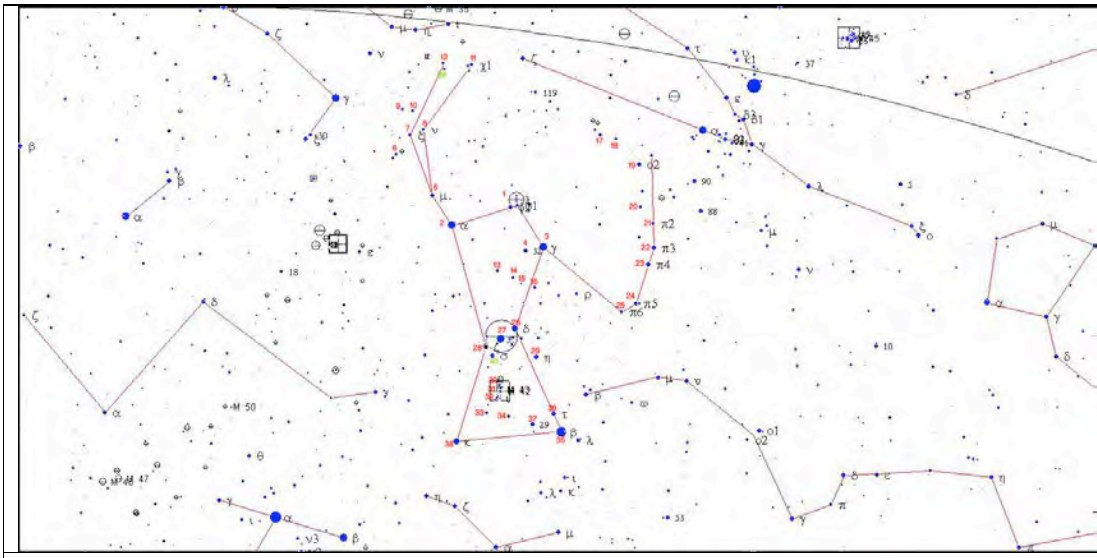


Figure 62: Modern Star Chart of Orion Constellation

5.16 Comments on the Chapter of the Constellation Centaurus:

5.16.1 Star names and modern designations of the stars:

I have included below in Table 30 all the stars that are included in al-Ṣūfī's star tables for constellation Scorpio. I have also included the HR, numbers so each star can be correctly identified. The stars identifications are according to Toomer's book. I also tabulated below the names of the stars according to the Arabic tradition and according to what was described by al-Ṣūfī, together with the modern star names and any other common name.

Table 30: Star Names and Modern Designations of the Stars for Centaurus

Star number (as per al-Ṣūfī)	HR	Star name and description (as per al-Ṣūfī)	Star name/s in Arabic tradition	Modern star name/s	Other star name/s
1 Centaurus	5192	The southernmost of the 4 stars in the head.			
2 Centaurus	5221	The northernmost of them.			
3 Centaurus	5168	The more advanced of the other, middle 2.			
4 Centaurus	5210	The rearmost of these, the last of the 4.			
5 Centaurus	5028	The star on the left advanced shoulder.			
6 Centaurus	5288	The star on the right shoulder.		Menkent	
7 Centaurus	5089	The star on the left shoulder-blade.			
8 Centaurus	5367	The four stare in the thyrsus. The northernmost of the advanced 2.			
9 Centaurus	5378	The southernmost of these.			
10 Centaurus	5485	The one of the other two which is at the tip of the thyrsus.			
11 Centaurus	5471	The last one south of the latter.			
12 Centaurus	5190	The most advanced of the 3 stars in the right side.			
13 Centaurus	5193	The middle one.			
14 Centaurus	5248	The rearmost of the three.			
15 Centaurus	5285	The star on the right upper arm.			
16	5440	The star on the right			

Centaurus		forearm.			
17 Centaurus	5576	The stars on the right hand.			
18 Centaurus	5231	The bright star in the place where the human body joins the horse.			
19 Centaurus	5260	The rearmost of the 2 faint stars to the north of this.			
20 Centaurus	5249	The more advanced of them.			
21 Centaurus	NGC 5139	The star on the place where the back joins the horse body.			
22 Centaurus	4940	The star in advanced of this on the horse back.			
23 Centaurus	4819	The rearmost of the stars on the rump.			
24 Centaurus	4802	The middle one.			
25 Centaurus	4743	The most advanced of the three.			
26 Centaurus	4621	The more advanced of the 2 stars close together on the right thigh.			
27 Centaurus	4638	The rearmost of them.			
28 Centaurus	5172	The star in the chest under the horse armpit.			
29 Centaurus	5132	The more advanced of the 2 stars under the belly.			
30 Centaurus	5141	The rearmost of them (Ptolemy) mentioned that it is of the 3rd magnitude however there is no star in this are which can be seen.			
31 Centaurus	4763	The star on the knee-bend of the right hind leg.		Gacrux	
32 Centaurus	4853	The star in the hock of the same leg.		Becrux	
33 Centaurus	4656	The star under the knee-bend of the left hind leg.			
34 Centaurus	4730	The star on the frog of the hoof on the same leg.		Acrux	
35 Centaurus	5459	The star on the end of the right front leg.	*Rijl Qanṭūris Hiḍār, Al-Wazn,*	Rigil Kentaurus	

			Muḥlifain, Muḥnithain,		
36 Centaurus	5267	The star on the knee of the left front leg.	*Hiḍār, Al-Wazn, Muḥlifain, Muḥnithain*	Agena	
37 Centaurus	4898	The star outside under the right hind leg.			

5.16.2 Modern Star Chart of Constellation Centaurus

Figure 63 below is a modern Star chart of Constellation Scorpio. The stars indicated in red are the stars according to al-Ṣūfī's star number. The stars indicated in green are the stars mentioned by al-Ṣūfī in his comments but not included in the charts nor are included in Ptolemy. There was no place to include the star's modern name or the HR number for every star in this constellation, therefore I only included al-Ṣūfī star numbers where the details can be found in the above comments. The software used to generate above chart is Cartes du Ciel version 2.76.

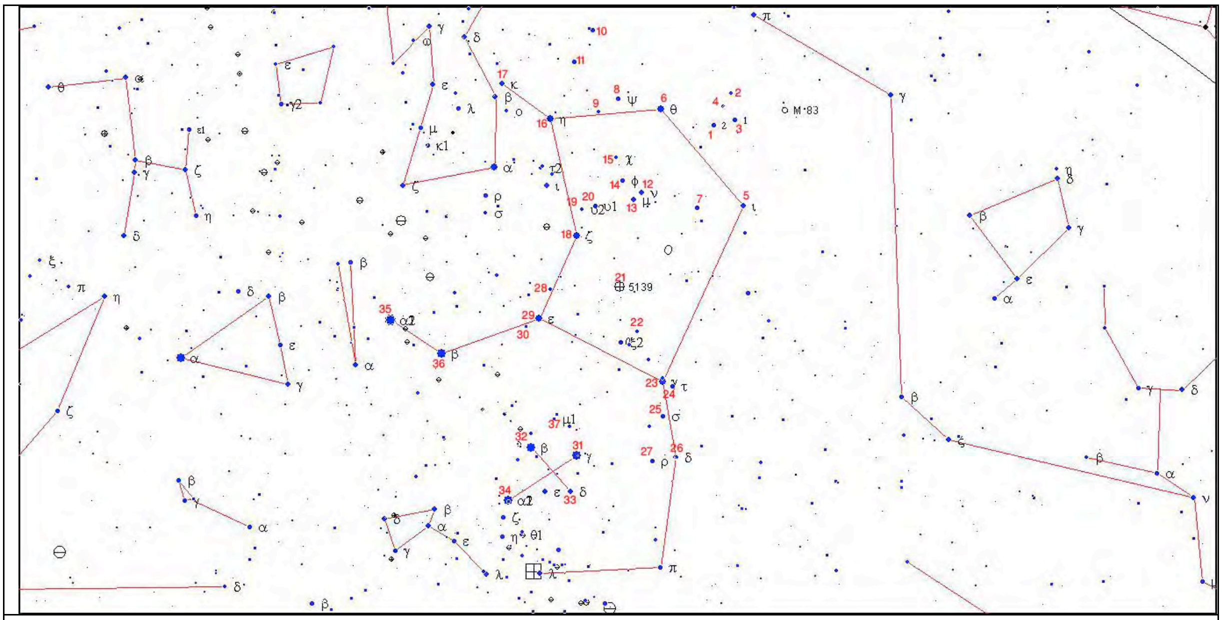


Figure 63: Modern Star Chart of Centaurus Constellation

6. Conclusion

Late one evening in the summer of A.D. 960 the 57 year old Persian astronomer ′Abd al-Raḥmān al-Ṣūfī was in the presence of the Buwayhid ruler, ‘Aḍud al-Dawla in the city of Shiraz. He wrote that "The grand prince ‘Aḍud al-Dawla, was visited by a renowned scholar while I was in his presence. The prince asked the astronomer about some of the known stars in the sky…" To his surprise the scholar was not able to distinguish between these stars correctly. He continued:

> "…when I saw that all these people who were well known and are leaders in this science so that people follow them and use their books without knowing the right from wrong …I found in their books many errors especially in the books of *al-Anwā'* and the stories which they obtained from the Arabs …the lunar mansions and the rest of the stars …I wanted many times to reveal this and expose it but I either felt sluggish or I had many things which occupied me from this task until God honored me with serving the benevolent king ‘Aḍud al-Dawla. "

How could ′Abd al-Raḥmān al-Ṣūfī know that his book which was completed four years later in A.D. 964 was to become one of the most important medieval Arabic treatises in astronomy? This book was *Ṣuwar al-Kawākib al-Thamāniyah wa-al-Ārba'een* which was later known as *The Book of the Fixed Stars*. As we have seen in this study, this major work contained an extensive star catalogue, which lists star coordinates and magnitude estimates, as well as detailed star charts. It also included other topics such as the descriptions of stars, nebulae, and a good summary on old Arabic folk astronomy. My journey to discover this book has been as fascinating as the results, which came out of this effort.

I have begun this study by giving a general account on the key elements of Arabic and Islamic astronomy. I started the first chapter of this study with the history of ancient astronomy going on to the development of Babylonian astronomy. Then I made a brief description on the contribution of Greek astronomers leading up to Arabic and Islamic Astronomy. I also gave a general description on the Greek cosmological concept of the geocentric universe and the development of the Ptolemaic system with Deferent and Epicycle. Then I gave a brief history of the Arabic and Islamic empire from its early start to its golden age, as well as the main events, which shaped the development of science and astronomy during that time.

However in order to understand al-Ṣūfī's work it was important to understand some of the general characteristics of Arabic and Islamic astronomy. I started chapter 2.2 by giving a brief background on the religion of Islam and its contribution to the development of science and Astronomy. The effect of this religion was evident in al-Ṣūfī's work as well as in many other works during that period. The Greek cosmological geocentric model, where by the Earth is a sphere which lies at the center of a spherical heaven, was accepted as correct for over a thousand years by almost all Arabic and Islamic astronomers. The culmination of the Arab and Islamic science of astronomy was in the development of the astronomical tradition called *al-Zīj*. These were astronomical tables based on trigonometric and mathematical techniques. In this chapter I included a general account on observatories and astronomical instruments, which were used by al-Ṣūfī as well as by many other Arab astronomers of his time.

The third chapter of this section deals with old Arabic astronomical tradition. The lunar astronomical tradition was an important tool used by these old Arabs. This was merged with a form of astrological-meteorological experience that came to be known as the *Anwā'*. This system was used to predict the weather and to identify the beginning of the seasons in order to specify the dates of festivals, holidays, pilgrimage and the best times for traveling and commerce. In order to systemize this lunar motion, the Arabs divided the apparent path of the Moon in the sky into 28 divisions. These 28 divisions are called "*Manāzil al-Qamar*" or the Lunar Mansions.

The final chapter in part 2 of this thesis is a brief study on Ptolemy and his book called the *Almagest* which is a mathematical as well as an astronomical treatise, detailing the motions of the Stars, the Sun, the Moon and the five known planets at that time. The *Almagest* includes a catalog with descriptions, positions and magnitudes for 1022 stars grouped into 48 constellations for the epoch of A.D. 137. This work became the standard star catalogue used in the Western, Arab and Islamic worlds for over a thousand years.

In Part 3 of this thesis I started the first chapter with a brief biography on ′Abd al-Raḥmān al-Ṣūfī. However I was surprised that very little was known about al-Ṣūfī's life and career. From several important Arabic historical references I found that al-Ṣūfī's full name was: Abd al-Raḥmān, Ibn 'Umar, Ibn Muḥammad, Ibn Sahl, al-Rāzī, known as Abū al-Ḥusaīn al-Ṣūfī. I also found that al-Ṣūfī was born on Saturday the 14th of Muharram in the year A.H. 291 which corresponds to the 6th of December in 903. He died on Tuesday the 13th of Muharram in the year A.H. 376 which corresponds to 25th of May 986. I have also deduced several facts on al-Ṣūfī's life such as: The title of "*al-Rāzī*" which meant that he is from the city of *Rayy*, south east of the modern city of Tehran. Al-Ṣūfī was also a Persian not an Arab even though he wrote all his works in Arabic. The location of his death in not known, but most probably it was in Shiraz. From the introductory chapter of his work we know that he lived most of his life between the provinces of Rayy and Fars and in the cities of Rayy, Isfahan and Shiraz. In his work al-Ṣūfī wrote that he made his observations in Shiraz where he established his observatory. He also wrote that he visited Daīnawar, which is the home of the famous scholar and astronomer Abu Ḥanīfa al-Daīnawari. He also visited Isfahan to research a celestial globe constructed by another important astronomer of that period.

In this chapter I made a brief study on the political and social background of this period in order to understand the impact of the events which helped mould the life of our author. Al-Ṣūfī was born in the beginning of the 10^{th} century. From the time line of al-Ṣūfī's life we saw that he lived throughout most of the rule of the *Buwayhid* rulers. However the most significant scientific contributions of al-Ṣūfī were made during the reign of 'Aḍud al-Dawla who was one of the strongest of these rulers. The *Book of the fixed stars* was dedicated to 'Aḍud al-Dawla. However al-Ṣūfī also dedicated other books to other members of the *Buwayhid* dynasty. The title of *Ṣūfī* signifies that this person was part of an Islamic religious order. Since al-Ṣūfī was given this religious honorary title then we assume that he must have been influenced by such *Ṣūfī* movements during his time.

In his book al-Ṣūfī mentioned several important individuals. He also mentioned some of their works, which he commented upon and sometimes criticized in the introductory chapter of his work. The main person who was mentioned by al-Ṣūfī was of course Ptolemy. Al-Ṣūfī refers to Ptolemy 119 times in his Book. The other two main characters, which were frequently mentioned in al-Ṣūfī's work, were al-Battānī and Abu Ḥanīfa al-Daīnawari. Al-Ṣūfī criticized al-Battānī by stating that his star catalog is but a copy of Ptolemy's *Almagest* only with the correction for Precession. As for Abu Ḥanīfa al-Daīnawari he was another famous Persian scholar of the 10^{th} century. Al-Ṣūfī considered al-Daīnawari's work on Arabic Astronomical Tradition, called (*Kitab al-Anwā'*) or the *Book on Anwā'* to be the best written book on this subject. However al-Ṣūfī again criticized al-Daīnawari for his knowledge of the stars and their movements. In the second chapter 3.2 of this thesis I made a brief biographical study on all those individuals who were mentioned in al-Ṣūfī's book.

In chapter 3.3 I made a brief survey on all the works which were known to have been written by al-Ṣūfī. The first is, the *Book of the Fixed Stars,* which was al-Ṣūfī's most famous work and the topic of this study. The second is *Kitāb al-Urjūza fi al-Kawākib al-Thābitah Muṣawaran.* This is a Poem on the fixed stars. Some historians attributed this poem to al-Ṣūfī however this poem was probably written by al-Ṣūfī's son and not by al-Ṣūfī himself. Then we have *Kitāb al-Tathkira wa Matāreh al-Shu'a'* or *The Book of Information and Projection of the Rays*. Unfortunately it is no longer extant today. Al-Ṣūfī also wrote *Kitāb al-Madkhal Fi 'Ilm al-Āḥkām* (*Introductory Book to the Science of Astrology*), *Fi Sharḥ al-'Amal bi al-Kura* (*On the Explanation of the Use of the Celestial Globe*) and *Kitāb al-'Amal bi al-Isṭerlāb* (Book on using the Astrolabe). Finally there is *al-Zīj al-Ṣūfī.* This *Zīj* was mentioned by several important Arabic astronomers such as Ibn Yūnus in Cairo and Ibn-Ezra. Unfortunately it is also no longer extant.

Al-Ṣūfī mentioned in his Book that the observations he made were from the city of Shiraz, which is located south of Iran (Latitude: 29:53 and Longitude: 52:58). Al-Ṣūfī mentioned that the instrument, which was utilized for his observations, was an equatorial ring with a diameter of 250 cm, having a 5 min subdivision on its scale. This instrument was considerable in size and was thus called the *Aḍudi* Ring after the ruler Aḍud al-Dawla. He mentioned that it was used to determine the latitude of the city of Shiraz to be: 29 deg and 36 min. One of the Arabic historical references mentions that in 1043 there used to be in the Cairo library a celestial globe made of silver that was constructed by al-Ṣūfī for Aḍud al-Dawla. The weight of this globe was three hundred *dirhams* and it was purchased for three thousand *dinars*. Unfortunately this instrument is no longer available today. From the few available treaties written by al-Ṣūfī on the Astrolabe and the celestial Globe and from the available historical records, we know that al-Ṣūfī measured the obliquity of the ecliptic from the year A.D. 965 until A.D. 970 and located the vernal and the autumnal equinoxes and used several observational instruments such as a Sundial, a Quadrant, an Astrolabe, a Celestial Globe, and most probably different sizes of Rings such as the *Aḍudi* Ring. In chapter 3.4 of I tried to collect all references found in many Arabic historical references that were related to these instruments and the observatory in Shiraz

Many scientists and astronomers have based their astronomical observations on al-Ṣūfī's work. Through out history al-Ṣūfī's name was sometimes miss-spelled or miss-written. He has been named Esophi by Leo Africanus and Azophi by the Spanish Jewish astronomer Ibn Ezra. He was again mentioned by the name Azophi by the 16th century European map makers Albrecht Durer and by Peter Apian. In chapter 3.5 of this thesis, I tried to list some of the most important scholars and astronomers who have made use of al-Ṣūfī's work starting from al-Bīrūnī in the 11th centaury up to the beginning of the 20th century. Finally in the last chapter of this section I included a brief description on the crater on the Moon named Azophi and the main belt asteroid designated as "12621 al-Ṣūfī". I have identified this crater and included its picture as well as its coordinate and location on the Moon.

The main effort to revive the treasures hidden in al-Ṣūfī's book was in the translation of this work from Arabic to English. In part 4 of this thesis I started the translation with al-Ṣūfī's introductory chapter. This chapter is a very important part of his work. Al-Ṣūfī starts his introduction with the usual praise to God and prophet Muḥammad. He then divides those who are interested in learning of the stars into two groups. The first group includes the actual astronomers, which he called *al-Munajjimīn*. The other groups are those who study the Arabic *Anwā'* tradition. In this introductory chapter al-Ṣūfī criticizes the work of al-Battānī. He begins by praising al-Daīnawari's book on *Anwā'* then ends up with criticizing his knowledge on the stars. He writes about the reason he wrote his book and dedicates it to Aḍud al-Dawla. He explains the methods he used in calculating precession. Finally he explains why he made dual charts for the constellation and the method of using these charts. In this forth part of this thesis I tried to translate the main introductory chapter, the whole star catalog for the entire 48 constellations, as well as six complete constellation chapters of al-Ṣūfī's work. These constellations chapters are: Ursa Minor and Ursa Major of the Northern Constellations, Taurus and Scorpio of the Zodiac Constellations and Orion and Centaurus of the Southern Constellations. As I mentioned before that I did not translate all the constellation chapters of al-Ṣūfī's work because that would be beyond the scope of this thesis.

Before I started with the detailed study of al-Ṣūfī's work, and the complete English translation I had to identify the extant manuscripts of the *Book of the Fixed Stars*. There are many manuscripts that are still preserved in libraries throughout the world. Tracking of these manuscripts involved extensive travel worldwide and much library research. However, I managed to locate as many as 35 manuscripts and acquired copies of the major ones, which I needed for this study. I started the first chapter in part 5 of this thesis by listing all the existing manuscripts of al-Ṣūfī's work that I could find. I grouped these manuscripts by country or location of library they are being kept. Unfortunately not many manuscripts could be used for this study. I put several criteria that I used to choose the most suitable manuscript for the translation. The two main manuscripts which I identified to be the bases of the translation and discussion were the manuscript Marsh144 and MS5036. The Marsh144 manuscript is the earliest manuscript of the *Book of the Fixed Stars*. It is dated to 1009 only 23 years after al-Ṣūfī's death. This manuscript was actually copied by the authors' son himself. It is now located at the Bodleian library in Oxford. I managed to acquire a copy of this manuscript for this study and I used this as the bases of the English translation. The other manuscript is MS5036 which is found at the national library in Paris. It is dated to 1430. Even though this manuscript was written much later, however it is a much better written copy. Therefore in the translation I have relied on this manuscript whenever anything was not clear in manuscript Marsh144.

The study and analysis of al-Ṣūfī's book begins in the chapter 5.2 of this section of this thesis. It begins with the description of the structure of the book and the layout of the constellation chapters. Following that chapter 5.3 describes another important aspects of this study, which are the charts or the maps. One of al-Ṣūfī's innovations in charting the stars was the production of dual illustrations of each of Ptolemy's constellations: One illustration was as portrayed on a celestial globe, the other illustration as viewed directly in the night sky. These were considered a unique feature of al-Ṣūfī's work. Since al-Ṣūfī's work was based on Ptolemy's *Almagest* therefore most of the rendering of the constellation figures resemble classical style figures. However some of the figures have undergone a process of Orientalization as a result of misunderstanding of some of the Greek mythology figures as well as copyist errors in some versions of the *Almagest.* The other diversion from classical style constellation was also due to influence of the *Anwā'* tradition which al-Ṣūfī was very much interested in. An example of such addition is to be found in the constellations Andromeda. Al-Ṣūfī makes two additional illustrations for this constellation. The first is the figure of Andromeda with a fish covering her legs. The second is with two fishes covering her body. Some of the constellations in the Marsh144 manuscript were also influenced by another period in history which is found in the Art of the *Sassanid* era. An example of such *Sassanid* influence can be found in the illustration of the flying wings of Pegasus which resembles *Simurgh* the *Sassanian* mythical flying creature. Another interesting constellation to note is the constellation Lyra meaning the "Harp". Al-Ṣūfī gave several other names for this constellation which were based on the *Anwā'* tradition. Among these names was *al-Wazza* meaning the "Goose" and *al-Sulaḥfāt*, which is a "tortoise". The Marsh144 manuscript depicts this constellation as a kind of harp. However al-Ṣūfī mentioned that in many eastern works Lyra was illustrated as a *Sulaḥfāt* or a tortoise. In later western illustration this constellation was rendered as a harp superimposed on the image of the goose. Such an illustration can be found in Andreas Cellarius' stellar catalogue published in 1660 and in Johann Hevelius' *Uranographia* printed in 1690.

For the epoch of his catalog al-Ṣūfī adopted the beginning of the year 1276 of the era of Alexander the great (or *Thu al-Qarnain*) which corresponds to the year A.D. 964. However al-Ṣūfī mentioned that "Ptolemy used the observations of *Menelaus'* who made his observations in the year 845 of the year of *Naboukhat Nassar*. Al-Ṣūfī also mentioned that: "The time difference between the observations of *Menelaus* and the date of Ptolemy is 41 years". He concluded that Ptolemy added 25 minutes on *Menelaus* longitude values to account for precession. However it is still unknown why al-Ṣūfī refers to this fact because at this time there is no evidence or available text that mentions that Ptolemy used *Menelaus* observations other than al-Ṣūfī's claim. At the end of al-Ṣūfī's introductory chapter he described in detail the method he used in constructing his catalog especially in calculating precession. For his epoch of A.D. 964 he applied the most accurate Arabic precession constant at that time of 1 deg in 66 years rather than the correct value of 1 deg in 71.2 years, thereby adding 12 degrees 42 minutes on Ptolemy's longitude value to allow for precession. Over the 839 years between the tables of Ptolemy and al-Ṣūfī, precession would actually amount to 11 deg 47 min. Hence by using 12 deg 42 min, al-Ṣūfī over-corrected Ptolemy's stellar longitudes by 55 min. I started chapter 5.4 of this section with a brief analysis on the star coordinates in al-Ṣūfī's book before starting the magnitude analysis. Al-Ṣūfī and Ptolemy both added intermediate values to the magnitude class system for some stars. Ptolemy mentioned the words "more-bright" and "less-bright" for certain stars. However al-Ṣūfī expressed these intermediate magnitude values by the words "*Aṣghareh*" which means "less" or "*Akbareh*" which means "greater" and "*A'ẓameh*" which means "much-greater". Most scholars who studied al-Ṣūfī's work did not differentiate between the two words *Akbareh* and *A'ẓameh.* However when I looked at al-Ṣūfī's text in detail it was evident to me that he made a clear distinction between three intermediate magnitudes. I believe that al-Ṣūfī used what I have termed a 3-step intermediate magnitude system, which was more accurate than Ptolemy 2-step intermediate system. I think that with this system al-Ṣūfī managed to express all magnitude values by a constant difference of 0.25. One of the main topics of this study was to research this 3-step intermediate magnitude system, which would shed new light on the accuracy and independence of al-Ṣūfī's work. I have made a complete analysis on al-Ṣūfī's magnitude values whereby the magnitude values were numerically interpreted by a constant difference of 0.25 magnitudes: that is "+0.25" for "less", "-0.25" for "greater" and "-0.5" for "much-greater". Ptolemy's 2-step intermediate magnitude difference was interpreted by a constant of (0.3) magnitude. After the data collection I conducted an accuracy analysis for the magnitudes of al-Ṣūfī and Ptolemy by calculating the difference between these values and the modern visual magnitudes in order to see if al-Ṣūfī had in mind a two-step or three-step magnitude systems. The statistical results showed that the Mean for the 3-step system is slightly better. The standard deviation is the same whether we apply the 3 or 2 step system whereas it is higher with Ptolemy. The dispersion in al-Ṣūfī's data is thus significantly less than in Ptolemy. Even though the statistical results for al-Ṣūfī values might not be entirely conclusive to some, however I still believe that al-Ṣūfī intended to use the 3-step system. The main reason for this assumption is in the way al-Ṣūfī expressed or described the values of the stellar magnitudes in his book. From the many descriptions of the magnitude values which are found in constellation commentaries we see that al-Ṣūfī made clear distinction between the words *Akbareh* and *A'ẓameh.* In many instances we see that he expressed the terms *Aṣghareh* or *Akbareh* consecutively. As for the term *Aṣghareh,* al-Ṣūfī only used this word to indicate the meaning of less. He mentioned *Aṣghareh* in many cases through out the work. Therefore from the literary analysis of al-Ṣūfī's work I had the impression that he was not really concerned with word repetition or correct sentence structure. If al-Ṣūfī was concerned with the correct grammatical structure or with word repetition then he would not have used the term *Aṣghareh* in all his work even though there are many other words in Arabic vocabulary, which could have been used instead. Whereas he deliberately switched between the other two terms *Akbareh* and *A'ẓameh.*

In his written comments on the constellations al-Ṣūfī mentioned many additional stars that were not included in Ptolemy's star catalog. However it is surprising that al-Ṣūfī did not include these stars in his tables even though he identified many of them in detail and described their magnitudes and he even estimated their locations. In many instances al-Ṣūfī mentions that in several areas of the sky there are many stars but he fails to mention a definite number because of their large numbers. In chapter 5.5 of this thesis I have identified to a total number of 134 of these additional stars; 65 were located in the Northern constellations, 41 in the Zodiac constellations and 28 in the Southern constellations.

There are very few records on the color of stars in ancient star catalogs. "Red" was the color that attracted the most attention while the other colors such as "white" or "blue" were rarely mentioned. Ptolemy gave the color "red" to six stars in his catalog. These stars were *Aldebaran*, *Arcturus, Betelgeuse*, *Pollux*, *Antares* and strangely enough *Sirius*. In the *Book of the Fixed Stars* al-Ṣūfī described seven stars with red color. These stars were *Aldebaran*, *Arcturus*, *Betelgeuse*, *Pollux*, *Alpha Hydrae*, *Algol* and *Antares*. However al-Ṣūfī stays silent about the color of *Sirius*. He only describes it as a bright star on the mouth called *al-Kalb* (Dog). In chapter 5.6 of this study I tried to give a brief summary on each of these eight stars along with what al-Ṣūfī mentioned about them. The colors of these stars were sometimes mentioned in the tables and other times in his comments on the constellations.

The Astrolabe is an ancient analog calculator. It was used for solving problems relating to the time and position of the Sun and stars in the sky. The Astrolabe is thought to be a Greek invention. The first person credited with constructing an Astrolabe in the Islamic world was the eighth century astronomer Muhammad al-Fazari. By the 9th century the Astrolabe was very much in use in the Arab and Islamic world. Al-Ṣūfī wrote extensively on the construction and use of the Astrolabe. In one of his treatises al-Ṣūfī described more than 1000 different uses for an Astrolabe in fields such as astronomy, astrology, timekeeping, navigation, construction and surveying. Al-Ṣūfī's *Book of the Fixed Stars* included 44 of these astrolabe stars. It was the best and most accurate of al-Ṣūfī's works. However al-Ṣūfī did not make a list of the Astrolabe stars but rather the information on these stars were scattered throughout the various sections of the book. In chapter 5.7 I identified all the Astrolabe stars found in al-Ṣūfī's book. I also included a brief summary on every one of these stars as they were mentioned by al-Ṣūfī. This summary included all the descriptions both from the tables as well as from the comments in the constellation chapters that mentioned these stars.

In his book al-Ṣūfī mentioned the presence of 'double stars' which he referred to as *Muḍ'af* stars. In many case he describes their location and magnitude. From al-Ṣūfī's description I managed to identify as many as 20 of these *Muḍ'af* stars. I also calculated the angular distance between these stars in order to identify the minimum angular distance which al-Ṣūfī managed to achieve. From the results of this survey the minimum angular separation for these *Muḍ'af* stars was achieved by the star HR7116 and star HR7120 with a separation of 0.23 degrees. In this part of the study I have also included the star Mizar. Next to Mizar is the star Alcor. The angular separation between these two stars is 0.20 degrees. However al-Ṣūfī did not refer to these two stars as *Muḍ'af* but he only mentioned that adjacent to Mizar is the star called *al-Suhā* (the neglected one). It was well known that the Arabs were able to separate these two stars long before the time of al-Ṣūfī.

The next chapter in this study describes the Nebulea in al-Ṣūfī's book. Al-Ṣūfī refers to these nebulae as *al-Laṭkhāt al-Saḥābiya* (the nebulous smear or smudge) and *al-Ishtibāk al-Saḥābi* (the nebulous mass). Al-Ṣūfī again identified the five nebulae, which Ptolemy mentioned before. However he goes further to describe 10 nebulae, which he himself observed or were previously identified by the Arabs. From al-Ṣūfī's description I tried to identify all 10 of these nebulae or galaxies found in the *Book of the Fixed Star*s. It is now a well-known fact that al-Ṣūfī mentioned for the first time in recorded history the location of the Andromeda galaxy or M31.

Al-Ṣūfī considered Arabic folk astronomy to be an important scientific field of study in its own right. He took upon himself to identify all the various names of stars, asterisms, mansions and constellations as per the method of the Arabs. He also tried to correct many of the mistakes, which were mentioned by previous authors on this subject such as al-Battānī and al-Daīnawari. In chapter 5.10 of this thesis I tabulated the names of stars and asterisms that have been used in Arabic folk astronomy according to al-Ṣūfī. This table included the star name, the Arabic name, the HR number as well as the explanation and comments for every one of these stars. However for length purposes I made this study for only 6 of the constellations, which are: Ursa Minor, Ursa Major, Taurus, Scorpio, Orion and Centaurus. This exercise was only to give an idea on the importance of this subject in al-Ṣūfī’s book and the scope of information that is contained in each of the constellation chapters.

The last six chapters of the study of al-Ṣūfī’s book are the comments on the Constellations: Ursa Minor, Ursa Major, Taurus, Scorpio, Orion, and Centaurus. In these 6 chapters I made a detailed list of all the stars mentioned by al-Ṣūfī. This included the stars descriptions, which were included in al-Ṣūfī’s star tables as well as the commentaries. I also included the HR number so each star can be correctly identified. I have again included the star names according to the old Arabic tradition as mentioned in al-Ṣūfī’s book as well as some of the names, which have been given to these stars through out history. In these chapters I have also included a modern Star map in order to identify all the stars that were mentioned by al-Ṣūfī in these chapters.

As we have seen in this study al-Ṣūfī’s work has been translated and used by many astronomers throughout history starting from al-Bīrūnī in A.D. 1030, the authors of the Alfonsine tables in 1252, and the famous prince and astronomer Ulugh Bēg in 1437. Modern astronomers such as Ideler (1809) and Knobel (1917) also referred to his work. The last modern translation of al-Ṣūfī’s work was done in French by Schjellerup in 1874. In his introduction to this translation Schjellerup mentioned that:

> “These facts give to the work of al-Ṣūfī an importance which cannot be denied. Now the time has come when it shall be the duty of the future generations to study the work of the learned astronomers of the Levant and to reveal their importance and to draw conclusions there from.”

Following the instructions of important scholars such as Schjellerup and Kunitzsch, I began my own voyage of discovery, which started, with the translation of al-Ṣūfī’s work from Arabic to English. To my knowledge, this was the first time that a major English translation of this book was attempted. In this study I tried to translate as accurately as possible the first introductory chapter, six of the major constellation chapters as well as all the star catalogue which is found in this book. Al-Ṣūfī’s star catalog was mainly based on Ptolemy's classical work ‘*the Mathmatike Syntaxis*’ which was later called the *Almagest* by the Arabs. As we have seen earlier, al-Ṣūfī updated Ptolemy's stellar longitudes by adding 12 degrees 42 minutes on Ptolemy’s longitude value to allow for precession, as he explained in the introductory chapter of his book. He applied the precession constant of 1 deg in 66 years rather than the correct value of 1 deg in 71.2 years. However, it is in the star magnitudes where al-Ṣūfī distinguished himself. He corrected many of the values, which were mentioned in previous catalogues. My analysis in this regard showed that al-Ṣūfī was very accurate in his description of these stellar magnitudes. From the description of the stars which are to be found in each of the constellation chapters, al-Ṣūfī adopted a unique system in expressing these magnitudes which I termed 'the 3-step magnitude system'. The analysis of this system revealed that it was slightly more accurate then the older '2-step system' used by Ptolemy and others. From the various discussions on al-Ṣūfī's *Book of the Fixed Stars*, this work had a very important place in the history of Arabic and Islamic observational astronomy. As Winter (1955) said: "al-Ṣūfī not only corrected observational errors in the works of his predecessors, like the famous Arab astronomer al-Battānī, but he also exposed many of the faulty observations found in the various versions of the *Almagest*. He carefully defined the boundaries of each constellation, and recorded magnitudes and positions of stars using new and independent observations he made himself."

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8.1 Table of Coordinates, Magnitudes and Magnitude Analysis.

The first three columns of this table 31 show the number and the number sequence of the stars and constellations. The 4th to the 9th columns are the coordinated values according to al-Ṣūfī's tables. The 10th column (SM) shows the magnitudes of the stars according to al-Ṣūfī. The 11th (SM1) column shows the magnitudes after adjustment for the 3-step system and the 12th column (SM2) for the 2-step system. The 13th column (PM) shows the magnitude according to Ptolemy. The 14th column (PMA) shows Ptolemy's magnitudes after adjustment for the 2-step system. The 15th (VIS) and 16th (HR) columns show the modern visual magnitude and the HR number for each star.

Table 31: Table of Coordinates, Magnitudes and Magnitude Analysis

Seq	R.#	Constellation	Zodiac	Deg	min	D.	Lat	min	SM	SM1	SM2	PM	PMA	VIS	HR
1	1	UMi	2(60)	12	52	N	66	0	3	3.00	3.00	3	3.00	2.02	424
2	2	UMi	2(60)	15	12	N	70	0	4	4.00	4.00	4	4.00	4.36	6789
3	3	UMi	2(60)	28	42	N	74	0	4	4.00	4.00	4	4.00	4.23	6322
4	4	UMi	3(90)	12	22	N	75	40	4	4.00	4.00	4	4.00	4.32	5903
5	5	UMi	3(90)	16	22	N	77	40	5(k)	4.75	4.70	4	4.00	4.95	6116
6	6	UMi	3(90)	29	52	N	72	50	2	2.00	2.00	2	2.00	2.08	5563
7	7	UMi	4(120)	8	52	N	74	50	3	3.00	3.00	2	2.00	3.05	5735
8	8	UMi	4(90)	25	42	N	71	10	4	4.00	4.00	4	4.00	4.25	5430
1	9	UMa	3(90)	8	2	N	39	50	4	4.00	4.00	4	4.00	3.36	3323
2	10	UMa	3(90)	8	32	N	43	5	5	5.00	5.00	5	5.00	5.47	3354
3	11	UMa	3(90)	9	12	N	43	5	5	5.00	5.00	5	5.00	4.60	3403
4	12	UMa	3(90)	8	52	N	47	10	5	5.00	5.00	5	5.00	4.76	3576
5	13	UMa	3(90)	9	22	N	47	5	5	5.00	5.00	5	5.00	4.80	3616
6	14	UMa	3(90)	10	52	N	50	30	5	5.00	5.00	5	5.00	4.56	3771
7	15	UMa	3(90)	13	12	N	43	50	4(s)	4.25	4.30	4	4.00	4.67	3624
8	16	UMa	3(90)	15	12	N	44	20	4	4.00	4.00	4	4.00	3.67	3757
9	17	UMa	3(90)	21	42	N	42	5	4	4.00	4.00	4	4.00	3.80	3888
10	18	UMa	3(90)	23	42	N	44	5	4(s)	4.25	4.30	4(s)	4.30	4.59	3894
11	19	UMa	3(90)	23	22	N	35	5	3	3.00	3.00	3	3.00	3.17	3775
12	20	UMa	3(90)	18	12	N	29	20	3(s)	3.25	3.30	3	3.00	3.14	3569
13	21	UMa	3(90)	19	2	N	28	20	3(s)	3.25	3.30	3	3.00	3.60	3594
14	22	UMa	3(90)	13	22	N	36	5	5(m)	4.50	4.70	4	4.00	4.83	3662
15	23	UMa	3(90)	13	32	N	33	20	5(m)	4.50	4.70	4	4.00	4.48	3619
16	24	UMa	4(120)	5	22	N	49	5	2	2.00	2.00	2	2.00	1.79	4301
17	25	UMa	4(120)	4	52	N	44	30	3(m)	2.50	2.70	2	2.00	2.37	4295
18	26	UMa	4(120)	15	52	N	51	5	3(s)	3.25	3.30	3	3.00	3.31	4660
19	27	UMa	4(120)	15	42	N	46	30	3(m)	2.50	2.70	2	2.00	2.44	4554
20	28	UMa	4(120)	5	22	N	29	20	3(s)	3.25	3.30	3	3.00	3.45	4033
21	29	UMa	4(120)	6	52	N	28	15	3(s)	3.25	3.30	3	3.00	3.05	4069
22	30	UMa	4(120)	14	22	N	35	15	3(s)	3.25	3.30	4(m)	3.70	3.01	4335
23	31	UMa	4(120)	22	35	N	25	50	3(s)	3.25	3.30	3	3.00	3.48	4377
24	32	UMa	4(120)	23	2	N	25	0	3(s)	3.25	3.30	3	3.00	3.66	4375
25	33	UMa	4(120)	24	52	N	53	30	2	2.00	2.00	2	2.00	1.77	4905
26	34	UMa	5(150)	0	42	N	55	40	2	2.00	2.00	2	2.00	2.27	5054
27	35	UMa	5(150)	12	32	N	54	0	2	2.00	2.00	2	2.00	1.86	5191

28	36	UMa	5(150)	10	32	N	39	45	3	3.00	3.00	3	3.00	2.90	4915
29	37	UMa	5(150)	2	52	N	41	20	5	5.00	5.00	5	5.00	4.26	4785
30	38	UMa	4(120)	27	42	N	17	15	4	4.00	4.00	4	4.00	3.13	3705
31	39	UMa	4(120)	26	2	N	19	10	4	4.00	4.00	4	4.00	3.82	3690
32	40	UMa	4(120)	25	52	N	20	0	6	6.00	6.00	F	6.00	4.55	3800
33	41	UMa	4(120)	24	52	N	22	45	4	4.00	4.00	F	6.00	4.81	3809
34	42	UMa	4(120)	23	52	N	20	20	6	6.00	6.00	F	6.00	4.56	3612
35	43	UMa	4(120)	12	42	N	22	15	6	6.00	6.00	F	6.00	4.25	3275
1	44	Dra	7(210)	9	22	N	76	30	5	5.00	5.00	4	4.00	5.80	6370
2	45	Dra	7(210)	24	32	N	73	30	4	4.00	4.00	4(s)	4.30	4.88	6554
3	46	Dra	7(210)	25	52	N	75	40	3(s)	3.25	3.30	3	3.00	2.79	6536
4	47	Dra	8(240)	10	2	N	80	20	4(m)	3.50	3.70	4	4.00	3.75	6688
5	48	Dra	8(240)	12	22	N	75	30	3(m) or 2(s)	2.25	2.30	3	3.00	2.23	6705
6	49	Dra	9(270)	50	22	N	82	20	5	5.00	5.00	4	4.00	4.98	6923
7	50	Dra	9(270)	15	2	N	78	15	5	5.00	5.00	4	4.00	5.04	7049
8	51	Dra	9(270)	11	32	N	80	20	5	5.00	5.00	4	4.00	4.77	6978
9	52	Dra	10(300)	2	12	N	81	10	5	5.00	5.00	4	4.00	4.66	7125
10	53	Dra	11(330)	20	42	N	81	40	4	4.00	4.00	4	4.00	4.59	7371
11	54	Dra	0	3	12	N	83	0	3(s)	3.25	3.30	4	4.00	3.07	7310
12	55	Dra	0	20	22	N	78	50	4(m)	3.50	3.70	4	4.00	3.83	7582
13	56	Dra	0	5	32	N	77	50	5(m)	4.50	4.70	4	4.00	4.51	7685
14	57	Dra	0	23	22	N	80	30	5(m)	4.50	4.70	5	5.00	4.66	7462
15	58	Dra	1(30)	4	22	N	81	40	5(m)	4.50	4.70	5	5.00	4.82	7180
16	59	Dra	1(30)	8	52	N	80	15	5(m)	4.50	4.70	5	5.00	4.45	7352
17	60	Dra	2(60)	26	2	N	84	30	4	4.00	4.00	4	4.00	4.58	6636
18	61	Dra	2(60)	3	2	N	83	30	4	4.00	4.00	4	4.00	3.55	6927
19	62	Dra	1(30)	24	32	N	84	50	4(m)	3.50	3.70	4	4.00	4.22	6920
20	63	Dra	4(120)	11	22	N	87	30	6	6.00	6.00	6	6.00	5.05	6566
21	64	Dra	4(120)	4	22	N	86	50	6	6.00	6.00	6	6.00	4.80	6596
22	65	Dra	5(150)	21	42	N	81	15	5	5.00	5.00	5	5.00	4.83	6223
23	66	Dra	5(150)	22	2	N	83	0	5	5.00	5.00	5	5.00	4.90	6315
24	67	Dra	5(150)	21	2	N	84	50	3	3.00	3.00	3	3.00	3.17	6396
25	68	Dra	5(150)	22	42	N	78	0	3	3.00	3.00	3	3.00	2.74	6132
26	69	Dra	5(150)	25	42	N	74	40	4	4.00	4.00	4(m)	3.70	4.01	5986
27	70	Dra	5(150)	25	22	N	70	0	3(s)	3.25	3.30	3	3.00	3.29	5744
28	71	Dra	4(120)	20	2	N	64	30	5(m)	4.50	4.70	4	4.00	4.65	5226
29	72	Dra	4(120)	23	52	N	65	30	3(s)	3.25	3.30	3	3.00	3.65	5291
30	73	Dra	4(120)	1	52	N	61	15	3(s)	3.25	3.30	3	3.00	3.87	4787
31	74	Dra	3(90)	25	52	N	56	15	3(s)	3.25	3.30	3	3.00	3.84	4434
1	75	Cep	1(30)	17	42	N	75	90	5(m)	4.50	4.70	4	4.00	4.39	7750
2	76	Cep	1(30)	15	42	N	64	15	4	4.00	4.00	4	4.00	3.22	8974
3	77	Cep	0	20	42	N	71	10	4(m) or 3(s)	3.25	3.30	4	4.00	3.23	8238
4	78	Cep	11(330)	29	22	N	69	0	3	3.00	3.00	3	3.00	2.44	8162
5	79	Cep	11(330)	22	2	N	72	0	4	4.00	4.00	4	4.00	3.46	7957
6	80	Cep	11(330)	22	42	N	74	0	4	4.00	4.00	4	4.00	4.22	7850
7	81	Cep	0	11	12	N	65	30	5	5.00	5.00	5	5.00	4.29	8417
8	82	Cep	0	20	12	N	62	30	4(m)	3.50	3.70	4(m)	3.70	3.52	8694
9	83	Cep	11(330)	29	2	N	60	15	5	5.00	5.00	5	5.00	4.19	8494
10	84	Cep	0	0	2	N	61	15	4	4.00	4.00	4	4.00	3.35	8465
11	85	Cep	0	1	42	N	61	20	6	6.00	6.00	5	5.00	5.04	8469

12	86	Cep	11(330)	26	22	N	64	0	5(k)	4.75	4.70	5	5.00	4.08	8316
13	87	Cep	0	4	2	N	59	30	4(m)	3.50	3.70	4	4.00	3.75	8571
1	88	Boo	5(150)	15	2	N	58	40	5(m)	4.50	4.70	5	5.00	4.54	5328
2	89	Boo	5(150)	16	52	N	58	20	5(m)	4.50	4.70	5	5.00	4.75	5340
3	90	Boo	5(150)	18	22	N	60	10	5(m)	4.50	4.70	5	5.00	4.05	5404
4	91	Boo	5(150)	22	22	N	54	40	5	5.00	5.00	5	5.00	4.18	5351
5	92	Boo	6(180)	2	22	N	49	0	3	3.00	3.00	3	3.00	3.03	5435
6	93	Boo	6(180)	9	22	N	53	50	4(m)	3.50	3.70	4(m)	3.70	3.50	5602
7	94	Boo	6(180)	18	22	N	48	40	4(m)	3.50	3.70	4(m)	3.70	3.47	5681
8	95	Boo	6(180)	18	22	N	53	15	4(s)	4.25	4.30	4	4.00	4.31	5733
9	96	Boo	6(180)	17	42	N	57	30	4(s)	4.25	4.30	4	4.00	5.02	5763
10	97	Boo	6(180)	20	22	N	46	10	5(m)	4.50	4.70	4(m)	3.70	5.58	5727
11	98	Boo	6(180)	21	12	N	45	30	5	5.00	5.00	5	5.00	5.51	5709
12	99	Boo	6(180)	21	17	N	41	20	5	5.00	5.00	5	5.00	4.93	5634
13	100	Boo	6(180)	19	22	N	41	50	5	5.00	5.00	5	5.00	4.54	5616
14	101	Boo	6(180)	19	42	N	42	30	5	5.00	5.00	5	5.00	5.67	5638
15	102	Boo	6(180)	20	22	N	40	20	5	5.00	5.00	5	5.00	4.81	5600
16	103	Boo	6(180)	12	42	N	40	15	3	3.00	3.00	3	3.00	1.95	5506
17	104	Boo	6(180)	8	22	N	41	40	4	4.00	4.00	4	4.00	4.46	5447
18	105	Boo	6(180)	7	42	N	42	10	4	4.00	4.00	4(m)	3.70	3.58	5429
19	106	Boo	6(180)	18	2	N	28	0	4(k) or 4	3.75	3.70	3	3.00	3.68	5478
20	107	Boo	6(180)	4	2	N	28	0	3	3.00	3.00	3	3.00	2.68	5235
21	108	Boo	6(180)	3	12	N	26	30	4	4.00	4.00	4	4.00	4.50	5185
22	109	Boo	6(180)	4	2	N	25	0	4	4.00	4.00	4	4.00	4.07	5200
23	110	Boo	6(180)	9	42	N	31	30	1	1.00	1.00	1	1.00	0.04	5340
1	111	CrB	6(180)	27	22	N	44	30	2	2.00	2.00	2	2.00	2.23	5793
2	112	CrB	6(180)	24	22	N	46	10	4	4.00	4.00	4	4.00	3.68	5747
3	113	CrB	6(180)	24	32	N	48	0	4(s)	4.25	4.30	5	5.00	4.14	5778
4	114	CrB	6(180)	26	22	N	50	30	6	6.00	6.00	6	6.00	5.56	5855
5	115	CrB	6(180)	29	52	N	44	45	4	4.00	4.00	4	4.00	3.84	5849
6	116	CrB	7(210)	1	52	N	44	50	4	4.00	4.00	4	4.00	4.63	5889
7	117	CrB	7(210)	4	2	N	46	10	4	4.00	4.00	4	4.00	4.15	5947
8	118	CrB	7(210)	4	22	N	49	20	4	4.00	4.00	4	4.00	4.99	5971
1	119	Her	8(240)	0	22	N	37	30	3(s)	3.25	3.30	3	3.00	2.73	6406
2	120	Her	7(210)	16	22	N	43	0	3	3.00	3.00	3	3.00	2.77	6148
3	121	Her	7(210)	54	22	N	40	10	3(s)	3.25	3.30	3	3.00	3.75	6095
4	122	Her	7(210)	10	42	N	37	10	4(s)	4.25	4.30	4	4.00	5.00	6008
5	123	Her	7(210)	29	22	N	48	0	3	3.00	3.00	3	3.00	3.14	6410
6	124	Her	8(240)	4	42	N	49	30	5	5.00	5.00	4(k)	3.70	4.41	6526
7	125	Her	8(240)	10	22	N	52	0	4	4.00	4.00	4(m)	3.70	3.42	6623
8	126	Her	8(240)	18	12	N	52	50	4	4.00	4.00	4(m)	3.70	3.83	6779
9	127	Her	8(240)	54	22	N	54	0	4	4.00	4.00	4(m)	3.70	4.41	6707
10	128	Her	8(240)	54	12	N	53	0	4	4.00	4.00	4(m)	3.70	3.70	6703
11	129	Her	7(210)	16	32	N	53	10	3	3.00	3.00	3	3.00	2.81	6212

12	130	Her	7(210)	22	52	N	53	30	4	4.00	4.00	4(m)	3.70	3.92	6324
13	131	Her	7(210)	22	42	N	56	10	5(s) or 6(m)	5.50	5.70	5	5.00	5.25	6332
14	132	Her	7(210)	28	52	N	38	30	5(s) or 6(m)	5.50	5.70	5	5.00	5.39	6377
15	133	Her	7(210)	26	42	N	59	50	4(k)	3.75	3.70	3	3.00	3.16	6418
16	134	Her	7(210)	28	2	N	60	20	5	5.00	5.00	4	4.00	4.65	6436
17	135	Her	7(210)	29	2	N	61	15	4	4.00	4.00	4(m)	3.70	4.72	6484
18	136	Her	8(240)	53	32	N	61	0	4	4.00	4.00	4	4.00	3.86	6695
19	137	Her	8(240)	4	52	N	69	20	4	4.00	4.00	4	4.00	3.80	6588
20	138	Her	7(210)	28	2	N	70	15	6	6.00	6.00	6	6.00	5.59	6464
21	139	Her	7(210)	29	32	N	71	15	6	6.00	6.00	6	6.00	5.80	6509
22	140	Her	8(240)	2	22	N	72	0	6	6.00	6.00	6	6.00	5.37	6574
23	141	Her	7(210)	53	22	N	60	15	4	4.00	4.00	4(m)	3.70	3.53	6220
24	142	Her	7(210)	8	2	N	63	0	4	4.00	4.00	4	4.00	4.20	6168
25	143	Her	6(180)	28	22	N	65	30	4 or 4(m)	4.00	4.00	4(m)	3.70	3.89	6092
26	144	Her	6(210)	26	2	N	63	40	4	4.00	4.00	4	4.00	4.26	6023
27	145	Her	6(180)	22	52	N	64	15	4	4.00	4.00	4	4.00	4.76	5982
28	146	Her	6(180)	23	52	N	60	0	5	5.00	5.00	4	4.00	4.62	5914
29	147	Her	7(210)	15	22	N	38	10	4	4.00	4.00	5	5.00	4.57	6117
1	148	Lyr	9(270)	0	2	N	62	0	1	1.00	1.00	1	1.00	0.04	7001
2	149	Lyr	9(270)	3	2	N	62	40	4(k)	3.75	3.70	4(k)	3.70	5.06	7051
3	150	Lyr	9(270)	3	2	N	61	0	4(k)	3.75	3.70	4(k)	3.70	4.36	7056
4	151	Lyr	9(270)	6	22	N	60	0	4	4.00	4.00	4	4.00	4.30	7139
5	152	Lyr	9(270)	52	42	N	61	20	4(s)	4.25	4.30	4	4.00	4.39	7298
6	153	Lyr	9(270)	52	22	N	60	20	4(s)	4.25	4.30	4	4.00	4.36	7314
7	154	Lyr	9(270)	3	42	N	56	10	3(s)	3.25	3.30	3	3.00	3.45	7106
8	155	Lyr	9(270)	3	32	N	55	0	4(s)	4.25	4.30	4(s)	4.30	5.25	7102
9	156	Lyr	9(270)	6	52	N	55	20	3	3.00	3.00	3	3.00	3.24	7178
10	157	Lyr	9(270)	6	42	N	54	45	5 or 5(s)	5.25	5.30	4(s)	4.30	4.93	7192
1	158	Cyg	9(270)	19	12	N	49	20	3(s)	3.25	3.30	3	3.00	3.08	7417
2	159	Cyg	9(270)	21	42	N	50	20	6(m)	5.50	5.70	5	5.00	4.69	7478
3	160	Cyg	9(270)	29	2	N	54	30	5	5.00	5.00	4(k)	3.70	3.89	7615
4	161	Cyg	10(300)	11	12	N	57	20	3(m)	2.50	2.70	3	3.00	2.20	7796
5	162	Cyg	10(300)	21	52	N	60	0	2	2.00	2.00	2	2.00	1.25	7924
6	163	Cyg	10(300)	2	2	N	64	40	3	3.00	3.00	3	3.00	2.87	7528
7	164	Cyg	10(300)	5	12	N	69	40	4(s)	4.25	4.30	4	4.00	4.49	7469
8	165	Cyg	10(300)	3	52	N	71	30	4	4.00	4.00	4(m)	3.70	3.79	7420
9	166	Cyg	9(270)	29	22	N	74	0	4	4.00	4.00	4(m)	3.70	3.77	7328
10	167	Cyg	10(300)	13	32	N	49	30	3	3.00	3.00	3	3.00	2.46	7949
11	168	Cyg	10(300)	16	32	N	52	10	4(s)	4.25	4.30	4(m)	3.70	4.53	7963
12	169	Cyg	10(300)	19	22	N	44	0	3	3.00	3.00	3	3.00	3.20	8115
13	170	Cyg	10(300)	22	42	N	55	10	4	4.00	4.00	4(m)	3.70	3.94	8028
14	171	Cyg	10(300)	27	12	N	57	0	4	4.00	4.00	4(m)	3.70	3.72	8079
15	172	Cyg	10(300)	33	52	N	64	0	4	4.00	4.00	4	4.00	3.79	7735

16	173	Cyg	10(300)	15	22	N	64	30	4	4.00	4.00	4	4.00	3.98	7751
17	174	Cyg	10(300)	24	52	N	63	45	5	5.00	5.00	5	5.00	5.44	7851
18	175	Cyg	10(300)	23	22	N	49	40	4	4.00	4.00	4	4.00	3.72	8130
19	176	Cyg	10(300)	26	32	N	51	40	4	4.00	4.00	4	4.00	4.23	8143
1	177	Cas	0	20	32	N	45	20	4(k)	3.75	3.70	4(m)	3.70	3.66	153
2	178	Cas	0	23	32	N	46	45	3	3.00	3.00	3	3.00	2.23	168
3	179	Cas	0	25	42	N	47	50	4	4.00	4.00	4	4.00	3.43	219
4	180	Cas	0	29	22	N	49	0	3(k)	2.75	2.70	3(m)	2.70	2.47	264
5	181	Cas	1(30)	3	22	N	45	30	3	3.00	3.00	3	3.00	2.68	403
6	182	Cas	1(30)	9	42	N	47	20	4	4.00	4.00	4	4.00	3.38	542
7	183	Cas	1(30)	14	22	N	47	20	4(s)	4.25	4.30	4	4.00	4.52	707
8	184	Cas	0	27	22	N	44	20	4(s)	4.25	4.30	4	4.00	4.33	343
9	185	Cas	1(30)	0	22	N	45	0	5	5.00	5.00	5	5.00	4.98	382
10	186	Cas	0	15	2	N	50	0	6	6.00	6.00	6	6.00	4.88	9071
11	187	Cas	0	27	42	N	52	40	4 or 4(s)	4.25	4.30	4	4.00	4.16	130
12	188	Cas	0	20	32	N	51	40	3	3.00	3.00	3	3.00	2.27	21
13	189	Cas	0	16	2	N	51	40	6	6.00	6.00	6	6.00	4.54	9045
1	190	Per	1(30)	9	22	N	40	30	-	-	-	-	-	-	ngc 869
2	191	Per	1(30)	13	52	N	37	30	4	4.00	4.00	4	4.00	3.76	834
3	192	Per	1(30)	15	22	N	34	30	3(s)	3.25	3.30	3(s)	3.30	2.93	915
4	193	Per	1(30)	10	12	N	32	20	4(s)	4.25	4.30	4	4.00	4.12	799
5	194	Per	1(30)	13	22	N	34	30	5	5.00	5.00	4	4.00	3.95	854
6	195	Per	1(30)	14	12	N	31	10	4	4.00	4.00	4	4.00	4.05	937
7	196	Per	1(30)	17	32	N	30	0	2	2.00	2.00	2	2.00	1.79	1017
8	197	Per	1(30)	18	2	N	27	50	4	4.00	4.00	4	4.00	4.36	1052
9	198	Per	1(30)	19	42	N	27	40	4	4.00	4.00	4	4.00	4.23	1087
10	199	Per	1(30)	20	22	N	27	20	3	3.00	3.00	3	3.00	3.01	1122
11	200	Per	1(30)	13	12	N	27	0	4	4.00	4.00	4	4.00	3.80	941
12	201	Per	1(30)	12	22	N	23	0	2(s)	2.25	2.30	2	2.00	2.12	936
13	202	Per	1(30)	11	52	N	21	0	4(s)	4.25	4.30	4	4.00	4.63	947
14	203	Per	1(30)	10	22	N	21	0	4(m)	3.50	3.70	4	4.00	3.39	921
15	204	Per	1(30)	9	32	N	22	15	4	4.00	4.00	4	4.00	4.70	879
16	205	Per	1(30)	27	32	N	28	15	4	4.00	4.00	4	4.00	4.61	1324
17	206	Per	1(30)	25	42	N	28	10	4	4.00	4.00	4	4.00	4.29	1261
18	207	Per	1(30)	25	2	N	25	0	4	4.00	4.00	4	4.00	4.04	1273
19	208	Per	1(30)	26	42	N	26	15	4	4.00	4.00	4	4.00	4.14	1303
20	209	Per	1(30)	24	52	N	24	30	5	5.00	5.00	5	5.00	4.85	1350
21	210	Per	1(30)	29	2	N	18	45	5	5.00	5.00	5	5.00	4.25	1454
22	211	Per	1(30)	19	32	N	21	50	4	4.00	4.00	4(m)	3.70	3.77	1135
23	212	Per	1(30)	21	22	N	19	15	3	3.00	3.00	3	3.00	2.89	1220
24	213	Per	1(30)	21	2	N	14	45	4	4.00	4.00	4	4.00	4.04	1228
25	214	Per	1(30)	16	52	N	12	0	3(s)	3.25	3.30	3(s)	3.30	3.83	1131
26	215	Per	1(30)	19	2	N	11	0	3(s)	3.25	3.30	3(m)	2.70	2.85	1203
27	216	Per	1(30)	24	32	N	18	0	5(s)	5.25	5.30	5	5.00	4.71	1306
28	217	Per	1(30)	27	42	N	31	0	5(s)	5.25	5.30	5	5.00	5.19	1314

29	218	Per	1(30)	7	22	N	20	40	5	5.00	5.00	6	6.00	4.23	840
1	219	Aur	2(60)	15	12	N	30	0	4	4.00	4.00	4	4.00	3.72	2077
2	220	Aur	2(60)	15	2	N	30	50	5	5.00	5.00	4	4.00	4.99	2029
3	221	Aur	2(60)	7	42	N	22	30	1	1.00	1.00	1	1.00	0.07	1708
4	222	Aur	2(60)	15	32	N	20	0	2	2.00	2.00	2	2.00	1.90	2088
5	223	Aur	2(60)	13	52	N	15	15	5	5.00	5.00	4	4.00	4.52	1995
6	224	Aur	2(60)	15	32	N	13	20	3	3.00	3.00	4(m)	3.70	2.62	2095
7	225	Aur	2(60)	4	42	N	20	40	4	4.00	4.00	4	4.00	2.99	1605
8	226	Aur	2(60)	4	52	N	18	0	4	4.00	4.00	4	4.00	3.17	1641
9	227	Aur	2(60)	4	42	N	18	0	4	4.00	4.00	4	4.00	3.75	1612
10	228	Aur	2(60)	2	32	N	10	10	3(s)	3.25	3.30	3(s)	3.30	2.69	1577
11	229	Aur	2(60)	8	22	N	5	0	2	2.00	2.00	3(m)	2.70	1.65	1791
12	230	Aur	2(60)	8	42	N	8	30	6	6.00	6.00	5	5.00	4.76	1843
13	231	Aur	2(60)	9	2	N	12	20	6	6.00	6.00	5	5.00	5.07	1805
14	232	Aur							-	-	-	-	-	-	2029
1	233	Oph	8(240)	7	32	N	36	0	3	3.00	3.00	3(m)	2.70	2.08	6556
2	234	Oph	8(240)	10	42	N	27	15	3(s)	3.25	3.30	4	4.00	2.77	6603
3	235	Oph	8(240)	11	42	N	26	45	4	4.00	4.00	4	4.00	3.75	6629
4	236	Oph	7(210)	26	2	N	33	0	4	4.00	4.00	4	4.00	4.38	6281
5	237	Oph	7(210)	27	22	N	31	50	3(s) or 4(m)	3.25	3.30	4	4.00	3.20	6299
6	238	Oph	7(210)	21	2	N	24	30	4	4.00	4.00	4	4.00	3.82	6149
7	239	Oph	7(210)	17	42	N	17	0	3	3.00	3.00	3	3.00	2.74	6056
8	240	Oph	7(210)	18	42	N	16	30	3(s)	3.25	3.30	3	3.00	3.24	6075
9	241	Oph	8(240)	9	22	N	15	0	5(m)	4.50	4.70	4	4.00	4.62	6567
10	242	Oph	8(210)	15	2	N	13	40	4(m)	3.50	3.70	4(s)	4.30	3.34	6698
11	243	Oph	8(240)	16	2	N	14	20	5	5.00	5.00	4	4.00	5.19	6733
12	244	Oph	8(240)	3	52	N	7	30	3	3.00	3.00	3	3.00	2.43	6378
13	245	Oph	8(210)	6	22	N	2	15	5(m) or 4(s)	4.50	4.70	4(m)	3.70	4.39	6445
14	246	Oph	8(240)	5	42	S	2	15	5(k) or 4(s)	4.75	4.70	4	4.00	5.33	6401
15	247	Oph	8(240)	7	2	S	1	1	4(k)	3.75	3.70	4(m)	3.70	3.27	6453
16	248	Oph	8(240)	7	42	S	0	20	4(s)	4.25	4.30	4	4.00	4.17	6486
17	249	Oph	8(240)	8	32	S	0	15	5	5.00	5.00	5	5.00	4.81	6519
18	250	Oph	8(240)	9	52	N	1	0	5(s)	5.25	5.30	5	5.00	4.87	6595
19	251	Oph	7(210)	24	52	N	11	50	3	3.00	3.00	3	3.00	2.56	6175
20	252	Oph	7(210)	23	22	N	5	20	5	5.00	5.00	5(m)	4.70	4.28	6147
21	253	Oph	7(210)	22	22	N	3	10	5	5.00	5.00	5	5.00	4.42	6118
22	254	Oph	7(210)	24	32	N	1	40	5	5.00	5.00	5(m)	4.70	4.50	6104
23	255	Oph	7(210)	25	2	N	0	40	5	5.00	5.00	5	5.00	4.45	6153
24	256	Oph	7(210)	23	22	N	0	45	5	5.00	5.00	4	4.00	4.27	6112
25	257	Oph	8(240)	14	42	N	28	10	4	4.00	4.00	4	4.00	4.64	6712
26	258	Oph	8(240)	15	22	N	26	20	4	4.00	4.00	4	4.00	3.97	6714
27	259	Oph	8(240)	13	2	N	25	0	4	4.00	4.00	4	4.00	4.45	6723
28	260	Oph	8(240)	16	2	N	27	0	4	4.00	4.00	4	4.00	4.03	6752

29	261	Oph	8(240)	17	22	N	33	0	4	4.00	4.00	4	4.00	3.73	6771
1	262	Ser	7(210)	1	32	N	38	0	4	4.00	4.00	4	4.00	4.52	5842
2	263	Ser	7(210)	4	22	N	40	0	4(s)	4.25	4.30	4	4.00	4.76	5899
3	264	Ser	7(210)	7	2	N	36	0	3(s)	3.25	3.30	3	3.00	3.85	5933
4	265	Ser	7(210)	4	42	N	34	15	3(s)	3.25	3.30	3	3.00	3.67	5867
5	266	Ser	7(210)	4	2	N	37	15	5	5.00	5.00	4	4.00	4.09	5879
6	267	Ser	7(210)	5	52	N	42	30	4(s)	4.25	4.30	4	4.00	4.83	5972
7	268	Ser	7(210)	4	22	N	29	15	3(s)	3.25	3.30	3	3.00	3.05	5788
8	269	Ser	7(210)	7	32	N	26	30	4	4.00	4.00	4	4.00	4.43	5868
9	270	Ser	7(210)	7	2	N	25	20	3	3.00	3.00	3	3.00	2.65	5854
10	271	Ser	7(210)	9	2	N	24	0	3(s)	3.25	3.30	3	3.00	3.71	5892
11	272	Ser	7(210)	11	22	N	16	30	4	4.00	4.00	4	4.00	3.53	5881
12	273	Ser	7(210)	20	52	N	16	15	5	5.00	5.00	5	5.00	4.63	6129
13	274	Ser	8(240)	6	22	N	10	30	4	4.00	4.00	4	4.00	4.33	5446
14	275	Ser	8(240)	9	42	N	8	30	4(m)	3.50	3.70	4(m)	3.70	3.54	6561
15	276	Ser	8(240)	10	32	N	10	30	4	4.00	4.00	4	4.00	4.26	6581
16	277	Ser	8(240)	16	22	N	20	0	4	4.00	4.00	4	4.00	4.62	6710
17	278	Ser	8(240)	21	22	N	21	15	4(m)	3.50	3.70	4(m)	3.70	3.26	6869
18	279	Ser	9(270)	1	2	N	27	0	4	4.00	4.00	4	4.00	3.87	7141
1	280	Sge	9(270)	22	52	N	39	20	4	4.00	4.00	4	4.00	3.47	7635
2	281	Sge	9(270)	19	22	N	39	10	6	6.00	6.00	6	6.00	5.00	7546
3	282	Sge	9(270)	18	32	N	39	50	5	5.00	5.00	5	5.00	3.82	7536
4	283	Sge	9(270)	16	22	N	39	0	5	5.00	5.00	5	5.00	4.37	7479
5	284	Sge	9(270)	16	2	N	38	40	5	5.00	5.00	5	5.00	4.37	7488
1	285	Aql	9(270)	19	52	N	26	50	6	6.00	6.00	4	4.00	5.52	7669
2	286	Aql	9(270)	17	32	N	27	10	3(s)	3.25	3.30	3	3.00	3.72	7602
3	287	Aql	9(270)	16	32	N	29	10	2(m)	1.50	1.70	2(m)	1.70	0.79	7557
4	288	Aql	9(270)	17	22	N	30	0	5	5.00	5.00	3(s)	3.30	5.11	7560
5	289	Aql	9(270)	15	52	N	31	30	3	3.00	3.00	3	3.00	2.72	7525
6	290	Aql	9(270)	18	42	N	31	30	6	6.00	6.00	5	5.00	5.28	7610
7	291	Aql	9(270)	12	22	N	28	40	6	6.00	6.00	5	5.00	4.45	7429
8	292	Aql	9(270)	13	52	N	26	40	6	6.00	6.00	5	5.00	5.17	7474
9	293	Aql	9(270)	4	52	N	36	20	3	3.00	3.00	3	3.00	2.99	7235
10	294	Aql	9(270)	16	52	N	21	40	3(s)	3.25	3.30	3	3.00	3.90	7570
11	295	Aql	9(270)	21	22	N	19	10	3	3.00	3.00	3	3.00	3.23	7710
12	296	Aql	9(270)	8	42	N	25	0	3(s)	3.25	3.30	4(m)	3.70	3.37	7377
13	297	Aql	9(270)	10	52	N	20	0	4(s)	4.25	4.30	3	3.00	4.36	7447
14	298	Aql	9(270)	12	22	N	15	30	5	5.00	5.00	5	5.00	4.95	7446
15	299	Aql	9(270)	3	52	N	18	10	3(s)	3.25	3.30	3	3.00	3.44	7236
1	300	Del	10(300)	0	22	N	29	10	4(m)	3.50	3.70	3(s)	3.30	4.03	7852
2	301	Del	10(300)	1	22	N	29	0	6	6.00	6.00	4(s)	4.30	5.43	7883
3	302	Del	10(300)	1	22	N	27	45	6	6.00	6.00	4	4.00	5.06	7896
4	303	Del	10(300)	1	12	N	32	0	3(s)	3.25	3.30	3(s)	3.30	3.63	7882
5	304	Del	10(300)	2	52	N	33	50	3(s)	3.25	3.30	3(s)	3.30	3.77	7906
6	305	Del	10(300)	4	2	N	32	0	3(s)	3.25	3.30	3(s)	3.30	4.43	7928
7	306	Del	10(300)	6	12	N	33	10	3(s)	3.25	3.30	3(s)	3.30	4.27	7948
8	307	Del	10(300)	0	12	N	34	0	6	6.00	6.00	6	6.00	5.38	7858
9	308	Del	10(300)	0	12	N	31	50	6	6.00	6.00	6	6.00	4.68	7871
10	309	Del	10(300)	1	42	N	31	30	6	6.00	6.00	6	6.00	5.72	7892
1	310	Equ	10(300)	9	2	N	20	30	4	4.00	4.00	7	7.00	3.92	8131

2	311	Equ	10(300)	10	42	N	20	40	6	6.00	6.00	7	7.00	5.16	8178
3	312	Equ	10(300)	9	2	N	25	20	5(s)	5.25	5.30	7	7.00	4.69	8097
4	313	Equ	10(300)	10	22	N	25	0	5(s)	5.25	5.30	7	7.00	4.49	8123
1	314	Peg	0	0	32	N	26	0	2(s)	2.25	2.30	2(s)	2.30	2.06	15
2	315	Peg	11(330)	24	52	N	12	30	2(s)	2.25	2.30	2(s)	2.30	2.83	8739
3	316	Peg	11(330)	14	52	N	31	0	2(s)	2.25	2.30	2(s)	2.30	2.42	8775
4	317	Peg	11(330)	9	22	N	19	40	2(s)	2.25	2.30	2(s)	2.30	2.49	8781
5	318	Peg	11(330)	17	12	N	25	30	4	4.00	4.00	4	4.00	4.60	8880
6	319	Peg	11(330)	17	42	N	25	0	4	4.00	4.00	4	4.00	4.40	8905
7	320	Peg	11(330)	11	42	N	35	0	5 or 3	3.00	3.00	3	3.00	2.94	8650
8	321	Peg	11(330)	11	12	N	34	30	5	5.00	5.00	5	5.00	4.79	8641
9	322	Peg	11(330)	8	52	N	29	0	4(k)	3.75	3.70	4	4.00	3.95	8667
10	323	Peg	11(330)	9	42	N	29	30	4(k)	3.75	3.70	4	4.00	3.48	8684
11	324	Peg	11(330)	1	32	N	18	0	3(s)	3.25	3.30	3	3.00	3.40	8634
12	325	Peg	11(330)	3	12	N	19	0	4(s)	4.25	4.30	4	4.00	4.19	8665
13	326	Peg	11(330)	4	2	N	15	0	6 or 5(s)	6.00	6.00	5	5.00	4.90	8717
14	327	Peg	11(330)	3	12	N	16	0	6 or 5(s)	6.00	6.00	5	5.00	5.16	8697
15	328	Peg	10(300)	22	2	N	16	50	3(s)	3.25	3.30	3	3.00	3.53	8450
16	329	Peg	10(300)	20	42	N	16	0	5(s)	5.25	5.30	4	4.00	4.84	8413
17	330	Peg	10(300)	18	2	N	22	30	3	3.00	3.00	3(m)	2.70	2.39	8308
18	331	Peg	11(330)	6	22	N	41	10	4	4.00	4.00	4(m)	3.70	4.29	8454
19	332	Peg	11(330)	5	22	N	34	15	4	4.00	4.00	4(m)	3.70	3.76	8430
20	333	Peg	10(300)	25	2	N	36	50	4	4.00	4.00	4(m	3.70	4.13	8315
1	334	And	0	8	2	N	24	30	3(s)	3.25	3.30	3	3.00	3.27	165
2	335	And	0	9	2	N	27	0	4	4.00	4.00	4	4.00	4.36	154
3	336	And	0	7	2	N	23	0	4	4.00	4.00	4	4.00	4.38	163
4	337	And	0	6	22	N	32	0	4(s)	4.25	4.30	4	4.00	4.52	68
5	338	And	0	7	22	N	33	30	4(s)	4.25	4.30	4	4.00	4.61	63
6	339	And	0	7	42	N	32	20	5(m) or 5(s)	5.25	5.30	5	5.00	5.18	82
7	340	And	0	2	22	N	41	0	4(m)	3.50	3.70	4	4.00	4.29	8965
8	341	And	0	3	22	N	42	0	4(m)	3.50	3.70	4	4.00	4.14	8976
9	342	And	0	4	52	N	44	0	4(m)	3.50	3.70	4	4.00	3.82	8961
10	343	And	0	6	52	N	17	30	4(s)	4.25	4.30	4	4.00	4.06	215
11	344	And	0	8	22	N	15	50	5(m)	4.50	4.70	4	4.00	4.42	271
12	345	And	0	16	32	N	26	20	2(s)	2.25	2.30	3	3.00	2.06	337
13	346	And	0	14	32	N	30	0	4	4.00	4.00	4	4.00	3.87	269
14	347	And	0	14	42	N	32	30	4(s)	4.25	4.30	4	4.00	4.53	226
15	348	And	0	29	32	N	28	0	3	3.00	3.00	3	3.00	2.26	603
16	349	And	0	29	52	N	37	20	4	4.00	4.00	4(m)	3.70	4.07	496
17	350	And	0	27	52	N	35	20	4(m)	3.50	3.70	4	4.00	3.57	464
18	351	And	0	25	2	N	29	0	4(m)	3.50	3.70	4	4.00	4.10	458

19	352	And	0	24	42	N	28	0	4	4.00	4.00	4	4.00	4.94	477
20	353	And	0	22	52	N	35	30	5	5.00	5.00	5	5.00	4.25	335
21	354	And	0	25	22	N	34	30	5(s) or 6	6.00	6.00	5	5.00	5.27	390
22	355	And	0	26	52	N	32	30	5(s) or 6	6.00	6.00	5	5.00	4.98	469
23	356	And	11(330)	24	22	N	44	0	4(m) or 4	3.50	3.70	3	3.00	3.62	8762
1	357	Tri	0	23	42	N	16	30	3	3.00	3.00	3	3.00	3.41	544
2	358	Tri	0	28	42	N	20	40	3	3.00	3.00	3	3.00	3.00	622
3	359	Tri	0	29	2	N	19	40	5(s)	5.25	5.30	4	4.00	4.87	660
4	360	Tri	0	29	32	N	19	0	3(s)	3.25	3.30	3	3.00	4.01	664
1	1	Ari	0	19	22	N	7	20	3(s)	3.25	3.30	3	3.00	4.75	546
2	2	Ari	0	20	22	N	8	20	3	3.00	3.00	3	3.00	2.64	553
3	3	Ari	0	23	42	N	7	40	5(s)	5.25	5.30	5	5.00	5.27	646
4	4	Ari	0	24	12	N	6	0	4(s)	4.25	4.30	4	4.00	5.62	669
5	5	Ari	0	19	12	N	5	30	5	5.00	5.00	5	5.00	5.10	563
6	6	Ari	1(30)	0	22	N	6	0	6	6.00	6.00	6	6.00	5.43	773
7	7	Ari	1(30)	4	2	N	4	50	5	5.00	5.00	5	5.00	4.63	887
8	8	Ari	1(30)	6	32	N	1	40	4	4.00	4.00	4	4.00	4.35	951
9	9	Ari	1(30)	8	2	N	2	30	4	4.00	4.00	4	4.00	4.89	972
10	10	Ari	1(30)	9	42	N	1	50	4	4.00	4.00	4	4.00	5.09	1015
11	11	Ari	1(30)	2	22	N	1	10	5	5.00	5.00	5	5.00	5.63	869
12	12	Ari	1(30)	0	42	N	1	30	5	5.00	5.00	5	5.00	5.49	847
13	13	Ari	0	27	42	N	5	15	4	4.00	4.00	4(m)	3.70	4.27	813
14	14	Ari	0	23	22	N	10	0	3(k)	2.50	2.70	3(m)	2.70	2.00	617
15	15	Ari	1(30)	4	22	N	10	10	4	4.00	4.00	4	4.00	3.63	838
16	16	Ari	1(30)	4	2	N	12	40	5	5.00	5.00	5	5.00	4.51	824
17	17	Ari	1(30)	2	22	N	11	10	5	5.00	5.00	5	5.00	4.66	801
18	18	Ari	1(30)	1	52	N	10	40	5(s)	5.25	5.30	5	5.00	5.30	782
1	19	Tau	1(30)	9	2	S	6	0	4	4.00	4.00	4	4.00	4.11	1066
2	20	Tau	1(30)	8	42	S	7	15	4	4.00	4.00	4	4.00	5.14	1061
3	21	Tau	1(30)	7	22	S	8	30	4(m)	3.50	3.70	4	4.00	3.74	1038
4	22	Tau	1(30)	7	2	S	9	15	4(m)	3.50	3.70	4	4.00	3.60	1030
5	23	Tau	1(30)	12	22	S	9	30	6	6.00	5.00	5	5.00	5.07	1174
6	24	Tau	1(30)	16	22	S	3	0	3	3.00	3.00	3	3.00	3.47	1239
7	25	Tau	1(30)	59	22	S	12	40	4	4.00	4.00	4	4.00	4.29	1320
8	26	Tau	1(30)	15	42	S	14	50	4(m)	3.50	3.70	4	4.00	3.91	1251
9	27	Tau	1(30)	24	52	S	10	0	4	4.00	4.00	4	4.00	4.27	1473
10	28	Tau	1(30)	15	42	S	13	0	4	4.00	4.00	4	4.00	4.25	1458
11	29	Tau	1(30)	21	42	S	5	45	3(s)	3.25	3.30	3(s)	3.30	3.65	1346
12	30	Tau	1(30)	23	2	S	4	15	3(s)	3.25	3.30	3(s)	3.30	3.76	1373
13	31	Tau	1(30)	23	32	S	5	50	3(s)	3.25	3.30	3(s)	3.30	3.84	1411

14	32	Tau	1(30)	25	22	S	5	10	1	1.00	1.00	1	1.00	0.85	1457
15	33	Tau	1(30)	24	32	S	3	0	3(s)	3.25	3.30	3(s)	3.30	3.53	1409
16	34	Tau	1(30)	29	52	S	4	0	5	5.00	4.00	4	4.00	5.10	1547
17	35	Tau	2(60)	3	2	S	5	0	5	5.00	5.00	5	5.00	5.00	1656
18	36	Tau	2(60)	2	42	S	3	30	5	5.00	5.00	5	5.00	5.29	1658
19	37	Tau	2(60)	10	22	S	4	30	3	3.00	3.00	3	3.00	3.00	1910
20	38	Tau	1(30)	28	22	S	4	0	4	4.00	4.00	4	4.00	4.28	1497
0	0	Tau													
21	39	Tau	1(30)	24	42	N	0	30	4	4.00	4.00	5	5.00	4.28	1392
22	40	Tau	1(30)	24	22	N	4	0	4	4.00	4.00	5	5.00	4.22	1387
23	41	Tau	1(30)	19	42	N	0	40	5	5.00	5.00	5	5.00	4.36	1256
24	42	Tau	1(30)	21	42	N	1	0	6	6.00	6.00	6	6.00	4.94	1329
25	43	Tau	1(30)	20	42	N	5	0	5	5.00	5.00	5	5.00	5.41	1287
26	44	Tau	1(30)	21	12	N	50	10	5	5.00	5.00	5	5.00	5.23	1269
27	45	Tau	1(30)	24	42	N	3	0	5	5.00	5.00	5	5.00	5.37	1369
28	46	Tau	1(30)	24	24	N	5	0	5	5.00	5.00	5	5.00	4.95	1348
29	47	Tau	1(30)	14	52	N	4	30	5	5.00	5.00	5	5.00	4.30	1140
30	48	Tau	1(30)	15	12	N	3	40	5	5.00	5.00	5	5.00	4.18	1142
31	49	Tau	1(30)	16	22	N	3	20	5	5.00	5.00	5	5.00	3.63	1165
32	50	Tau	1(30)	16	22	N	5	0	4	4.00	4.00	4	4.00	5.26	1188
33	51	Tau	1(30)	50	42	S	14	30	4	4.00	4.00	4	4.00	4.28	1101
34	52	Tau	2(60)	2	42	S	2	0	5	5.00	5.00	5	5.00	4.64	1620
35	53	Tau	2(60)	6	42	S	1	45	5	5.00	5.00	5	5.00	4.94	1739
36	54	Tau	2(60)	8	42	S	2	0	5	5.00	5.00	5	5.00	4.88	1030
37	55	Tau	2(60)	11	42	S	6	20	5	5.00	5.00	5	5.00	4.86	1990
38	56	Tau	2(60)	11	42	S	50	40	6(s)	6.25	6.30	5	5.00	6.00	1985
39	57	Tau	2(60)	9	42	N	2	40	5	5.00	5.00	5	5.00	5.38	1821
40	58	Tau	2(60)	11	42	N	1	0	5	5.00	5.00	5	5.00	5.18	1928
41	59	Tau	2(60)	13	42	N	1	20	5	5.00	5.00	5	5.00	4.86	2002
42	60	Tau	2(60)	15	2	N	3	20	5	5.00	5.00	5	5.00	4.58	2034
43	61	Tau	2(60)	16	2	N	1	15	5	5.00	5.00	5	5.00	4.82	2084
1	62	Gem	3(90)	6	2	N	9	40	2	2.00	2.00	2	2.00	1.98	2891
2	63	Gem	3(90)	9	22	N	6	15	2	2.00	2.00	2	2.00	1.14	2990
3	64	Gem	2(60)	29	22	N	10	0	4(m)	3.50	3.70	4	4.00	3.60	2540
4	65	Gem	3(90)	1	22	N	50	20	4	4.00	4.00	4	4.00	4.41	2697
5	66	Gem	3(90)	4	42	N	5	30	4	4.00	4.00	4	4.00	3.79	2821
6	67	Gem	3(90)	6	42	N	4	50	4	4.00	4.00	4	4.00	4.06	2905
7	68	Gem	3(90)	9	22	N	2	40	4(k)	3.75	3.70	4	4.00	3.57	2985
8	69	Gem	3(90)	4	22	N	2	40	5(s)	5.25	5.30	5	5.00	5.03	2808
9	70	Gem	3(90)	5	52	N	3	0	5	5.00	5.00	5	5.00	5.22	2846
10	71	Gem	2(60)	25	42	N	1	30	3(s)	3.25	3.30	3	3.00	2.98	2473
11	72	Gem	3(90)	4	22	S	0	30	3	3.00	3.00	3	3.00	3.79	2650
12	73	Gem	3(90)	0	57	S	2	30	4(m)	3.50	3.70	3	3.00	3.53	2777
13	74	Gem	3(90)	4	2	S	6	0	3(s)	3.25	3.30	3	3.00	3.58	2763
14	75	Gem	2(60)	19	12	S	1	30	4(k)	3.75	3.70	4(m)	3.70	3.28	2216
15	76	Gem	2(60)	20	52	S	1	15	4(k)	3.75	3.70	4(m)	3.70	2.88	2286
16	77	Gem	2(60)	22	52	S	3	30	3(s)	3.25	3.30	4(m)	3.70	4.15	2343
17	78	Gem	2(60)	24	42	S	50	30	3	3.00	3.00	3	3.00	1.93	2421
18	79	Gem	2(60)	27	22	S	10	30	4	4.00	4.00	4	4.00	3.35	2484

19	80	Gem	2(60)	16	52	S	0	40	4(s)	4.25	4.30	4	4.00	4.16	2134
20	81	Gem	2(60)	19	12	N	5	50	4(s)	4.25	4.30	4(m)	3.70	4.35	2219
21	82	Gem	2(60)	17	52	S	2	15	5(s)	5.25	5.30	5	5.00	5.27	2529
22	83	Gem	3(90)	11	2	S	1	20	5(s)	5.25	5.30	5	5.00	5.35	3086
23	84	Gem	3(90)	9	2	S	3	20	5(s)	5.25	5.30	5	5.00	4.88	3003
24	85	Gem	3(90)	8	42	S	4	30	5(s)	5.25	5.30	5	5.00	5.05	2938
25	86	Gem	3(90)	13	22	S	2	40	4(s)	4.25	4.30	4	4.00	5.63	3208
1	87	Cnc	3(90)	23	12	N	0	40	-	-	-	-	-	-	M44
2	88	Cnc	3(90)	20	22	N	1	15	4(s)	4.25	4.30	4(s)	4.30	5.33	3366
3	89	Cnc	3(90)	20	42	S	1	10	4(s)	4.25	4.30	4(s)	4.30	5.35	3357
4	90	Cnc	3(90)	23	2	N	2	40	4	4.00	4.00	4(m)	3.70	4.66	3449
5	91	Cnc	3(90)	24	2	S	0	10	4	4.00	4.00	4(m)	3.70	3.94	3461
6	92	Cnc	3(90)	29	12	S	5	30	4	4.00	4.00	4	4.00	4.24	3572
7	93	Cnc	3(90)	21	2	N	11	50	4	4.00	4.00	4	4.00	4.02	3475
8	94	Cnc	3(90)	14	22	N	1	0	5(s)	5.25	5.30	5	5.00	5.31	3176
9	95	Cnc	3(90)	20	12	S	7	30	4	4.00	4.00	3.7	3.70	3.52	3249
10	96	Cnc	4(120)	2	22	S	2	20	4(s)	4.25	4.30	4(s)	4.30	5.34	3669
11	97	Cnc	4(120)	4	22	S	5	40	4(s)	4.25	4.30	4(s)	4.30	5.24	3623
12	98	Cnc	3(90)	26	42	N	7	50	5	5.00	5.00	5	5.00	5.45	3595
13	99	Cnc	3(90)	29	42	N	5	15	5	5.00	5.00	5	5.00	5.14	3627
1	100	Leo	4(120)	1	2	N	10	0	4	4.00	4.00	4	4.00	4.46	3731
2	101	Leo	4(120)	3	52	N	7	30	4	4.00	4.00	4	4.00	4.31	3773
3	102	Leo	4(120)	7	2	N	12	0	3(s)	3.25	3.30	3	3.00	3.88	3905
4	103	Leo	4(120)	6	52	N	9	30	3(k)	2.75	2.70	3(k)	2.70	2.98	3873
5	104	Leo	4(120)	12	52	N	11	0	3	3.00	3.00	3	3.00	3.44	4031
6	105	Leo	4(120)	14	52	N	8	30	2	2.00	2.00	2	2.00	2.61	4057
7	106	Leo	4(120)	13	22	N	4	30	3	3.00	3.00	3	3.00	3.52	3975
8	107	Leo	4(120)	15	12	N	0	10	1	1.00	1.00	1	1.00	1.35	3982
9	108	Leo	4(120)	16	12	S	1	50	4	4.00	4.00	4	4.00	4.37	3980
10	109	Leo	4(120)	12	42	S	0	15	5	5.00	5.00	5	5.00	5.26	3937
11	110	Leo	4(120)	10	2	0	0	0	6	6.00	6.00	5	5.00	5.35	3866
12	111	Leo	4(120)	6	52	S	3	40	6	6.00	6.00	5	5.00	4.97	3782
13	112	Leo	4(120)	10	2	S	4	10	4(k)	3.75	3.70	4	4.00	3.52	3852
14	113	Leo	4(120)	15	12	S	4	15	4	4.00	4.00	4	4.00	4.70	3950
15	114	Leo	4(120)	21	52	S	0	10	4	4.00	4.00	4	4.00	3.85	4133
16	115	Leo	4(120)	19	42	N	4	0	6	6.00	6.00	6	6.00	5.46	4127
17	116	Leo	4(120)	25	42	N	5	20	6	6.00	6.00	6	6.00	5.48	4209
18	117	Leo	4(120)	25	2	N	2	20	6	6.00	6.00	6	6.00	5.34	4227
19	118	Leo	4(120)	24	2	N	12	15	5(m)	4.50	4.70	5	5.00	4.42	4300
20	119	Leo	4(120)	26	52	N	13	40	2	2.00	2.00	2(s)	2.30	2.56	4357
21	120	Leo	4(120)	27	2	N	11	20	5	5.00	5.00	5	5.00	5.57	4408
22	121	Leo	4(120)	29	2	N	9	40	3	3.00	3.00	3	3.00	3.34	4359
23	122	Leo	5(150)	3	2	N	5	50	3(s)	3.25	3.30	3	3.00	3.94	4399
24	123	Leo	5(150)	4	22	N	1	15	4(k)	3.75	3.70	4	4.00	4.05	4386
25	124	Leo	5(150)	4	22	S	5	50	4	4.00	4.00	4	4.00	4.95	4418
26	125	Leo	5(150)	10	12	S	3	0	5	5.00	5.00	5	5.00	4.30	4471

27	126	Leo	5(150)	7	12	N	11	50	1	1.00	1.00	1(s)	1.30	2.14	4534
28	127	Leo	4(120)	18	42	N	13	20	5	5.00	5.00	5	5.00	5.08	4192
29	128	Leo	4(120)	20	52	N	15	30	5	5.00	5.00	5	5.00	4.50	4259
30	129	Leo	5(150)	0	12	N	1	10	4(s)	4.25	4.30	4	4.00	4.63	4310
31	130	Leo	4(120)	29	52	S	0	30	5	5.00	5.00	5	5.00	4.99	4294
32	131	Leo	5(150)	0	42	S	2	40	5	5.00	5.00	5	5.00	4.84	4291
33	132	Leo	5(150)	7	32	N	30	0	5	5.00	5.00	7	7.00	4.36	4737
34	133	Leo	5(150)	7	2	N	25	0	5	5.00	5.00	7	7.00	4.95	4667
35	134	Leo	5(150)	11	12	N	25	30	5	5.00	5.00	7	7.00	4.81	4789
1	135	Vir	5(150)	9	2	N	4	15	5	5.00	5.00	5	5.00	4.03	4517
2	136	Vir	5(150)	9	42	N	5	40	5	5.00	5.00	5	5.00	4.85	4515
3	137	Vir	5(150)	13	22	N	8	0	5	5.00	5.00	5	5.00	4.12	4608
4	138	Vir	5(150)	12	52	N	5	30	5	5.00	5.00	5	5.00	4.66	4589
5	139	Vir	5(150)	11	42	N	0	10	3	3.00	3.00	3	3.00	3.61	4540
6	140	Vir	5(150)	20	57	N	1	10	3	3.00	3.00	3	3.00	3.89	4689
7	141	Vir	5(150)	25	52	N	2	50	3	3.00	3.00	3	3.00	3.66	4825
8	142	Vir	5(150)	29	52	N	2	50	6	6.00	6.00	5	5.00	5.99	4925
9	143	Vir	6(180)	3	42	N	1	40	4	4.00	4.00	4	4.00	4.38	4963
10	144	Vir	5(150)	27	2	N	8	30	3	3.00	3.00	3	3.00	3.38	4910
11	145	Vir	5(150)	20	52	N	13	50	5(s)	5.25	5.30	5	5.00	4.88	4828
12	146	Vir	5(150)	22	52	N	11	40	6	6.00	6.00	6	6.00	5.22	4847
13	147	Vir	5(150)	24	52	N	15	10	3	3.00	3.00	3(s)	3.30	2.83	4932
14	148	Vir	6(180)	9	22	S	2	0	1(s)	1.25	1.30	1	1.00	0.98	5056
15	149	Vir	6(180)	7	32	N	8	40	3(s)	3.25	3.30	3	3.00	3.37	5107
16	150	Vir	6(180)	9	2	N	3	20	5(s)	5.25	5.30	5	5.00	4.69	5095
17	151	Vir	6(180)	9	42	N	0	10	6	6.00	6.00	6	6.00	5.21	5100
18	152	Vir	6(180)	12	42	N	1	30	5(s)	5.25	5.30	4(s)	4.30	5.01	5150
19	153	Vir	6(180)	10	42	S	0	20	5(s)	5.25	5.30	5	5.00	5.25	5064
20	154	Vir	6(180)	14	22	N	1	30	5(s)	5.25	5.30	5	5.00	5.51	5173
21	155	Vir	6(180)	10	42	N	8	30	5	5.00	5.00	5	5.00	5.15	5232
22	156	Vir	6(180)	19	22	N	7	30	4	4.00	4.00	4	4.00	4.08	5338
23	157	Vir	6(180)	20	2	N	2	40	4	4.00	4.00	4	4.00	4.19	5315
24	158	Vir	6(180)	21	2	N	11	40	4(s)	4.25	4.30	4	4.00	4.81	5409
25	159	Vir	6(180)	22	42	N	0	30	4	4.00	4.00	4	4.00	4.52	5359
26	160	Vir	6(180)	25	22	N	9	50	4(m)	3.50	3.70	4	4.00	3.88	5487
27	161	Vir	5(150)	27	22	S	3	30	5	5.00	5.00	5	5.00	4.66	4813
28	162	Vir	6(180)	1	42	S	3	30	5	5.00	5.00	5	5.00	4.79	4902
29	163	Vir	6(180)	4	57	S	3	20	5	5.00	5.00	5	5.00	5.19	4955
30	164	Vir	6(180)	9	52	S	7	20	6	6.00	6.00	6	6.00	5.04	4981
31	165	Vir	6(180)	10	52	S	8	20	5	5.00	5.00	5	5.00	4.74	5019
32	166	Vir	6(180)	17	52	S	7	50	6	6.00	6.00	6	6.00	4.97	5196
1	167	Lib	7(210)	0	42	N	0	40	3(k)	2.75	2.70	2	2.00	2.75	5531
2	168	Lib	6(180)	29	42	N	2	30	5(s)	5.25	5.30	5	5.00	5.31	5523
3	169	Lib	7(210)	4	52	N	8	50	3(m)	2.50	2.70	2	2.00	2.61	5685
4	170	Lib	7(210)	0	22	N	8	30	5(s)	5.25	5.30	5	5.00	4.92	5586
5	171	Lib	7(210)	6	42	S	1	40	4	4.00	4.00	4	4.00	4.54	5652
6	172	Lib	7(210)	4	2	N	1	15	5(s)	5.25	5.30	4	4.00	5.20	5622
7	173	Lib	7(210)	10	32	N	4	45	4	4.00	4.00	4	4.00	3.91	5787
8	174	Lib	7(210)	15	42	N	3	30	4	4.00	4.00	4(s)	4.30	4.15	5908

9	175	Lib	7(210)	8	52	N	9	0	5	5.00	5.00	5	5.00	4.61	5777
10	176	Lib	7(210)	16	22	N	6	40	4(s)	4.25	4.30	4(s)	4.30	4.88	5941
11	177	Lib	7(210)	17	2	N	9	15	4(s)	4.25	4.30	4(s)	4.30	4.78	5978
12	178	Lib	7(210)	16	12	N	0	30	6	6.00	6.00	6	6.00	5.03	5902
13	179	Lib	7(210)	13	2	N	3	0	6	6.00	6.00	5	5.00	5.38	5814
14	180	Lib	7(210)	13	52	S	1	30	4	4.00	4.00	4	4.00	4.74	5838
15	181	Lib	7(210)	5	42	S	7	30	3(s)	3.25	3.30	3	3.00	3.29	5603
16	182	Lib	7(210)	13	52	S	8	10	4	4.00	4.00	4	4.00	3.58	5794
17	183	Lib	7(210)	14	42	S	9	40	4	4.00	4.00	4	4.00	3.66	5812
1	184	Sco	7(210)	19	2	N	1	20	3	3.00	3.00	3	3.00	2.62	5984
2	185	Sco	7(210)	18	22	S	1	40	3	3.00	3.00	3	3.00	2.32	5953
3	186	Sco	7(210)	18	22	S	5	0	3	3.00	3.00	3	3.00	2.89	5944
4	187	Sco	7(210)	18	42	S	50	50	4(m)	3.50	3.70	3	3.00	3.88	5928
5	188	Sco	7(210)	19	42	N	1	40	4	4.00	4.00	4	4.00	4.01	6027
6	189	Sco	7(210)	19	2	N	0	30	4	4.00	4.00	4	4.00	3.96	5993
7	190	Sco	7(210)	23	22	S	3	45	3(s)	3.25	3.30	3	3.00	2.89	6084
8	191	Sco	7(210)	25	22	S	4	0	2	2.00	2.00	2	2.00	0.96	6134
9	192	Sco	7(210)	17	12	S	5	30	3	3.00	3.00	3	3.00	2.82	6165
10	193	Sco	7(210)	22	10	S	6	10	5(s)	5.25	5.30	5	5.00	4.59	6028
11	194	Sco	7(210)	23	22	S	6	40	5(s)	5.25	5.30	5	5.00	4.78	6070
12	195	Sco	8(240)	1	12	S	11	0	3	3.00	3.00	3	3.00	2.29	6241
13	196	Sco	8(240)	1	32	S	15	0	3	3.00	3.00	3	3.00	3.08	6247
14	197	Sco	8(240)	2	42	S	18	40	4	4.00	4.00	4	4.00	4.73	6262
15	198	Sco	8(240)	2	52	S	19	30	4	4.00	4.00	4	4.00	3.62	6271
16	199	Sco	8(240)	5	52	S	19	30	3(s)	3.25	3.30	3	3.00	3.33	6380
17	200	Sco	8(240)	10	52	S	18	50	3	3.00	3.00	3	3.00	1.87	6553
18	201	Sco	8(240)	12	12	S	16	40	3(s)	3.25	3.30	3	3.00	3.03	6615
19	202	Sco	8(240)	11	42	S	15	20	3	3.00	3.00	3	3.00	2.41	6580
20	203	Sco	8(240)	10	12	S	13	20	3	3.00	3.00	3	3.00	1.63	6527
21	204	Sco	8(240)	9	42	S	13	30	3(s)	3.25	3.30	4	4.00	2.69	6508
22	205	Sco	8(240)	13	52	S	13	15	-	-	-	-	-	-	M7
23	206	Sco	8(240)	8	12	S	6	10	5	5.00	5.00	5	5.00	4.29	6492
24	207	Sco	8(240)	12	12	S	4	10	5	5.00	5.00	5	5.00	4.54	6616
1	208	Sgr	8(240)	17	12	S	6	20	3(s)	3.25	3.30	3	3.00	2.99	6746
2	209	Sgr	8(240)	20	22	S	6	30	3	3.00	3.00	3	3.00	2.70	6859
3	210	Sgr	8(240)	20	42	S	10	50	3(m)	2.50	2.70	3	3.00	1.85	6879
4	211	Sgr	8(240)	21	42	N	1	30	3	3.00	3.00	3	3.00	2.83	6913
5	212	Sgr	8(240)	19	2	S	2	50	4	4.00	4.00	4	4.00	3.86	6812
6	213	Sgr	8(240)	28	2	S	3	10	3	3.00	3.00	3	3.00	2.02	7121
7	214	Sgr	8(240)	25	42	N	3	50	4(k)	3.75	3.70	4	4.00	3.17	7039
8	215	Sgr	8(240)	27	52	N	0	45	-	-	-	-	-	-	7116
9	216	Sgr	8(240)	28	22	N	2	10	4	4.00	4.00	4	4.00	3.51	7150
10	217	Sgr	9(270)	0	22	N	1	30	4	4.00	4.00	4	4.00	3.77	7217

11	218	Sgr	9(270)	1	52	N	2	0	4	4.00	4.00	4	4.00	2.89	7264
12	219	Sgr	9(270)	4	2	N	2	50	5(s)	5.25	5.30	5	5.00	4.96	7304
13	220	Sgr	9(270)	5	2	N	4	30	4(s)	4.25	4.30	4	4.00	3.93	7340
14	221	Sgr	9(270)	5	32	N	6	30	4(s)	4.25	4.30	4	4.00	4.61	7342
15	222	Sgr	9(270)	8	22	N	5	30	6	6.00	6.00	6	6.00	5.06	7489
16	223	Sgr	9(270)	12	12	N	5	50	5(s)	5.25	5.30	5	5.00	5.02	7614
17	224	Sgr	9(270)	10	22	N	2	0	6	6.00	6.00	6	6.00	5.92	7561
18	225	Sgr	9(270)	5	2	S	1	50	5(s)	5.25	5.30	5	5.00	5.03	7362
19	226	Sgr	9(270)	7	32	S	2	50	4(s)	4.25	4.30	4	4.00	4.60	7440
20	227	Sgr	9(270)	2	42	S	2	30	5(s)	5.25	5.30	5	5.00	4.85	7292
21	228	Sgr	9(270)	0	22	S	4	30	4(k)	3.75	3.70	4(k)	3.70	3.31	7234
22	229	Sgr	8(240)	29	2	S	6	45	3	3.00	3.00	3	3.00	2.60	7194
23	230	Sgr	9(270)	0	22	S	23	0	4(s)	4.25	4.30	2	2.00	4.29	7343
24	231	Sgr	8(240)	29	42	S	18	0	4(s)	4.25	4.30	2(s)	2.30	3.97	7348
25	232	Sgr	8(240)	19	22	S	13	0	3(s)	3.25	3.30	3	3.00	3.11	6832
26	233	Sgr	9(270)	10	2	S	13	30	4(s)	4.25	4.30	3	3.00	4.37	7623
27	234	Sgr	9(270)	9	32	S	20	10	4(s)	4.25	4.30	3	3.00	4.13	7581
28	235	Sgr	9(270)	10	22	S	4	50	5	5.00	5.00	5	5.00	4.70	7597
29	236	Sgr	9(270)	11	32	S	4	50	5	5.00	5.00	5	5.00	4.83	7618
30	237	Sgr	9(270)	11	32	S	5	50	5	5.00	5.00	5	5.00	4.52	7604
31	238	Sgr	9(270)	12	22	S	6	30	5	5.00	5.00	5	5.00	4.58	7650
1	239	Cap	9(270)	20	2	N	7	20	3(s)	3.25	3.30	3	3.00	3.57	7754
2	240	Cap	9(270)	20	22	N	6	40	5(s)	5.25	5.30	6	6.00	4.76	7773
3	241	Cap	9(270)	20	2	N	5	0	3(s)	3.25	3.30	3	3.00	3.08	7776
4	242	Cap	9(270)	17	42	N	8	0	6(s)	6.25	6.30	6	6.00	6.34	7712
5	243	Cap	9(270)	21	42	N	0	45	6	6.00	6.00	6	6.00	5.94	7830
6	244	Cap	9(270)	21	22	N	1	45	6	6.00	6.00	6	6.00	5.25	7814
7	245	Cap	9(270)	21	32	N	1	30	6	6.00	6.00	6	6.00	4.78	7822
8	246	Cap	9(270)	18	52	N	0	40	6	6.00	6.00	5	5.00	5.28	7761
9	247	Cap	9(270)	24	22	N	3	50	6	6.00	6.00	6	6.00	5.22	7889
10	248	Cap	9(270)	24	32	N	0	50	6	6.00	6.00	5	5.00	5.10	7900

11	249	Cap	9(270)	23	32	S	6	30	4	4.00	4.00	4	4.00	4.11	7980
12	250	Cap	9(270)	24	22	S	8	40	4	4.00	4.00	4	4.00	4.13	7936
13	251	Cap	9(270)	29	22	S	7	40	4(s)	4.25	4.30	4	4.00	4.50	8080
14	252	Cap	10(300)	2	52	S	6	50	4(s)	4.25	4.30	4	4.00	3.74	8204
15	253	Cap	10(300)	3	2	S	6	0	5(m)	5.25	4.70	5	5.00	4.51	8213
16	254	Cap	10(300)	1	22	S	4	15	6	6.00	6.00	5	5.00	5.24	8127
17	255	Cap	9(270)	29	22	S	4	0	6	6.00	6.00	5	5.00	5.30	8087
18	256	Cap	9(270)	29	22	S	2	50	5(s)	5.25	5.30	5	5.00	4.84	8060
19	257	Cap	9(270)	29	22	0	0	0	4	4.00	4.00	4	4.00	4.07	8075
20	258	Cap	10(300)	3	42	S	0	50	4	4.00	4.00	4	4.00	4.28	8167
21	259	Cap	10(300)	6	2	S	4	45	4	4.00	4.00	4	4.00	4.68	8260
22	260	Cap	10(300)	7	42	S	4	30	4(s)	4.25	4.30	4	4.00	4.73	8288
23	261	Cap	10(300)	7	32	S	2	10	3(s)	3.25	3.30	3	3.00	3.68	8278
24	262	Cap	10(300)	9	2	S	2	0	3	3.00	3.00	3	3.00	2.87	8322
25	263	Cap	10(300)	9	32	N	0	20	5(s)	5.25	5.30	5	5.00	5.18	8283
26	264	Cap	10(300)	11	22	0	0	0	5	5.00	5.00	5	5.00	5.08	8351
27	265	Cap	10(300)	10	22	N	2	50	5	5.00	5.00	5	5.00	5.58	8319
28	266	Cap	10(300)	11	22	N	4	20	5	5.00	5.00	5	5.00	5.09	8311
1	267	Aqr	10(300)	13	2	N	15	45	6(s)	6.25	6.30	5	5.00	5.10	8277
2	268	Aqr	10(300)	19	2	N	11	0	3(s)	3.25	3.30	3	3.00	2.96	8414
3	269	Aqr	10(300)	17	52	N	9	40	5	5.00	5.00	5	5.00	4.69	8402
4	270	Aqr	10(300)	9	12	N	8	50	3(s)	3.25	3.30	3	3.00	2.91	8232
5	271	Aqr	10(300)	10	2	N	6	15	5	5.00	5.00	5	5.00	4.69	8264
6	272	Aqr	10(300)	0	22	N	5	30	6	6.00	6.00	3	3.00	4.51	8093
7	273	Aqr	9(270)	28	52	N	8	0	5(s)	5.25	5.30	4	4.00	4.73	7990
8	274	Aqr	9(270)	27	22	N	8	40	4(m)	3.50	3.70	3	3.00	3.77	7950
9	275	Aqr	10(300)	22	12	N	8	45	3(s)	3.25	3.30	3	3.00	3.84	8518
10	276	Aqr	10(300)	24	22	N	10	45	4(k)	3.75	3.70	3	3.00	4.66	8539
11	277	Aqr	10(300)	24	42	N	9	0	3(s)	3.25	3.30	3	3.00	4.42	8558
12	278	Aqr	10(300)	26	42	N	8	30	3(s)	3.25	3.30	3	3.00	4.02	8597
13	279	Aqr	10(300)	18	52	N	3	0	4	4.00	4.00	4	4.00	4.16	8499
14	280	Aqr	10(300)	19	42	N	3	10	5(s)	5.25	5.30	5	5.00	5.37	8512
15	281	Aqr	10(300)	21	22	S	0	50	4(s)	4.25	4.30	4	4.00	4.82	8573
16	282	Aqr	10(300)	14	22	S	1	40	4(s)	4.25	4.30	4	4.00	4.27	8418
17	283	Aqr	10(300)	15	52	N	4	0	6	6.00	6.00	6	6.00	5.46	8452
18	284	Aqr	10(300)	24	22	S	7	30	3	3.00	3.00	3	3.00	3.27	8709
19	285	Aqr	10(300)	24	2	S	5	0	4	4.00	4.00	4	4.00	4.01	8679
20	286	Aqr	10(300)	17	22	S	5	40	6	6.00	6.00	5	5.00	6.35	8544
21	287	Aqr	10(300)	21	2	S	10	0	5(s)	5.25	5.30	5	5.00	5.26	8670

22	288	Aqr	10(300)	20	32	S	9	0	5(s)	5.25	5.30	5	5.00	4.69	8649
23	289	Aqr	10(300)	27	42	N	2	0	4	4.00	4.00	4	4.00	5.03	8610
24	290	Aqr	10(300)	27	32	N	0	10	4(s)	4.25	4.30	4	4.00	3.74	8698
25	291	Aqr	11(330)	0	22	S	1	10	4(s)	4.25	4.30	4	4.00	5.43	8782
26	292	Aqr	11(330)	2	42	S	0	30	4(s)	4.25	4.30	4	4.00	4.22	8834
27	293	Aqr	11(330)	3	12	S	1	40	4	4.00	4.00	4	4.00	5.06	8850
28	294	Aqr	11(330)	1	42	S	3	30	4	4.00	4.00	4	4.00	4.21	8841
29	295	Aqr	11(330)	2	32	S	4	10	4	4.00	4.00	4	4.00	4.39	8858
30	296	Aqr	11(330)	3	32	S	8	15	5(s)	5.25	5.30	5	5.00	5.08	8866
31	297	Aqr	11(330)	5	22	S	12	0	5	5.00	5.00	5	5.00	5.00	8968
32	298	Aqr	11(330)	5	52	S	10	50	5	5.00	5.00	5	5.00	4.49	8988
33	299	Aqr	11(330)	4	22	S	14	0	5	5.00	5.00	5	5.00	4.82	8982
34	300	Aqr	11(330)	4	52	S	14	45	5	5.00	5.00	5	5.00	5.29	8998
35	301	Aqr	11(330)	5	52	S	15	40	5	5.00	5.00	5	5.00	5.18	9031
36	302	Aqr	10(300)	29	42	S	14	10	4	4.00	4.00	4	4.00	3.97	8892
37	303	Aqr	11(330)	0	12	S	15	0	4	4.00	4.00	4	4.00	4.71	8939
38	304	Aqr	11(330)	1	2	S	15	45	4	4.00	4.00	4	4.00	4.39	8906
39	305	Aqr	10(300)	24	32	S	14	50	4	4.00	4.00	4	4.00	4.47	8789
40	306	Aqr	10(300)	25	22	S	14	20	4	4.00	4.00	4	4.00	4.69	8817
41	307	Aqr	10(300)	25	52	S	14	0	4	4.00	4.00	4	4.00	3.66	8812
42	308	Aqr	10(300)	19	42	S	23	0	1	1.00	1.00	1	1.00	1.16	8728
43	309	Aqr	11(330)	9	22	S	15	30	4(m)	3.50	3.70	4(m)	3.70	4.55	9098
44	310	Aqr	11(330)	12	22	S	14	20	4(m)	3.50	3.70	4(m)	3.70	4.89	33
45	311	Aqr	11(330)	11	42	S	18	15	4(m)	3.50	3.70	4(m)	3.70	4.44	48
1	312	Psc	11(330)	4	22	N	9	15	4	4.00	4.00	4(m)	3.70	4.53	8773
2	313	Psc	11(330)	6	52	N	7	30	4(s)	4.25	4.30	4	4.00	3.69	8852
3	314	Psc	11(330)	8	42	N	9	20	4(s)	4.25	4.30	4	4.00	5.05	8878
4	315	Psc	11(330)	10	52	N	9	30	4	4.00	4.00	4	4.00	4.28	8916
5	316	Psc	11(330)	13	22	N	7	30	4	4.00	4.00	4	4.00	4.13	8969
6	317	Psc	11(330)	8	42	N	4	30	4	4.00	4.00	4	4.00	4.94	8911
7	318	Psc	11(330)	12	22	N	3	30	4	4.00	4.00	4	4.00	4.50	8984
8	319	Psc	11(330)	18	42	N	6	20	4	4.00	4.00	4	4.00	4.01	9072
9	320	Psc	11(330)	23	42	N	5	45	6	6.00	6.00	6	6.00	5.37	80
10	321	Psc	11(330)	25	42	N	3	45	6	6.00	6.00	6	6.00	5.67	132
11	322	Psc	11(330)	29	52	N	2	15	4	4.00	4.00	4	4.00	4.43	224
12	323	Psc	0	3	12	N	1	10	4	4.00	4.00	4	4.00	4.28	294
13	324	Psc	0	5	42	S	6	0	4	4.00	4.00	4	4.00	5.24	361
14	325	Psc	0	9	12	S	2	0	6	6.00	6.00	6	6.00	5.52	330
15	326	Psc	0	5	42	S	5	0	5	5.00	5.00	6	6.00	5.16	378
16	327	Psc	0	9	12	S	2	20	4(s)	4.25	4.30	4	4.00	4.84	434
17	328	Psc	0	11	22	S	4	40	4	4.00	4.00	4	4.00	4.44	489
18	329	Psc	0	13	22	S	7	45	4	4.00	4.00	4	4.00	4.62	549
19	330	Psc	0	15	12	S	8	30	4(m)	3.50	3.70	3	3.00	4.33	596
20	331	Psc	0	13	12	N	1	20	4	4.00	4.00	4	4.00	4.26	510
21	332	Psc	0	12	52	N	1	50	5(s)	5.25	5.30	5	5.00	5.57	463
22	333	Psc	0	13	2	N	5	20	4(m)	3.50	3.70	3	3.00	3.62	437
23	334	Psc	0	13	12	N	9	0	5	5.00	5.00	4	4.00	5.38	413
24	335	Psc	0	13	42	N	21	45	5	5.00	5.00	5	5.00	5.16	349
25	336	Psc	0	13	22	N	21	40	5	5.00	5.00	5	5.00	4.51	352

26	337	Psc	0	11	22	N	20	0	6(s)	6.25	6.30	6	6.00	5.42	274
27	338	Psc	0	10	22	N	19	50	6(s)	6.25	6.30	6	6.00	6.09	262
28	339	Psc	0	9	42	N	20	20	6(s)	6.25	6.30	6	6.00	7.00	230
29	340	Psc	0	8	22	N	14	20	4	4.00	4.00	4	4.00	5.34	310
30	341	Psc	0	9	2	N	13	0	4	4.00	4.00	4	4.00	5.55	328
31	342	Psc	0	10	22	N	12	0	4	4.00	4.00	4	4.00	4.66	351
32	343	Psc	0	14	52	N	17	0	4	4.00	4.00	4	4.00	4.76	383
33	344	Psc	0	12	32	N	15	20	4	4.00	4.00	4	4.00	4.65	360
34	345	Psc	0	12	42	N	11	45	4	4.00	4.00	4	4.00	5.97	397
35	346	Psc	11(330)	13	52	S	2	40	4	4.00	4.00	4	4.00	4.86	9067
36	347	Psc	11(330)	14	57	S	2	30	4	4.00	4.00	4	4.00	5.10	9087
37	348	Psc	11(330)	13	22	S	5	30	4	4.00	4.00	4	4.00	4.41	9089
38	349	Psc	11(330)	15	2	S	5	30	4	4.00	4.00	4	4.00	4.61	3
1	1	Cet	1(30)	0	22	S	7	45	4	4.00	4.00	4	4.00	4.70	896
2	2	Cet	1(30)	0	22	S	12	20	3	3.00	3.00	3	3.00	2.53	911
3	3	Cet	0	25	22	S	11	30	3	3.00	3.00	3	3.00	3.47	804
4	4	Cet	0	23	12	S	14	0	3(s)	3.25	3.30	3	3.00	4.07	779
5	5	Cet	0	22	2	S	8	10	4	4.00	4.00	4	4.00	4.86	754
6	6	Cet	0	25	22	S	6	20	4	4.00	4.00	4	4.00	4.28	718
7	7	Cet	0	20	22	S	4	10	4(s)	4.25	4.30	4	4.00	4.37	649
8	8	Cet	0	15	42	S	24	30	4	4.00	4.00	4	4.00	4.89	708
9	9	Cet	0	16	2	S	28	0	4	4.00	4.00	4	4.00	4.75	740
10	10	Cet	0	19	22	S	25	10	4	4.00	4.00	4	4.00	4.84	781
11	11	Cet	0	19	42	S	27	30	4(k)	3.75	3.70	3	3.00	4.25	811
12	12	Cet	0	4	42	S	25	20	3(s)	3.25	3.30	3	3.00	3.52	509
13	13	Cet	0	5	42	S	30	50	4	4.00	4.00	4	4.00	4.00	585
14	14	Cet	0	7	42	S	20	0	3(s)	3.25	3.30	3	3.00	3.73	539
15	15	Cet	0	2	22	S	15	20	3(s)	3.25	3.30	3	3.00	3.60	402
16	16	Cet	11(330)	27	42	S	15	40	3(s)	3.25	3.30	3	3.00	3.45	334
17	17	Cet	11(330)	23	42	S	13	40	6	6.00	6.00	5	5.00	5.19	235
18	18	Cet	11(330)	21	22	S	14	40	6	6.00	6.00	5	5.00	5.59	227
19	19	Cet	11(330)	22	2	S	13	0	5(s)	5.25	5.30	5(k)	4.70	4.76	194
20	20	Cet	11(330)	21	42	S	14	0	5(s)	5.25	5.30	5(k)	4.70	6.02	190
21	21	Cet	11(330)	17	2	S	9	40	3(s)	3.25	3.30	3(s)	3.30	3.56	74
22	22	Cet	11(330)	18	22	S	20	20	3(m	2.50	2.70	3	3.00	2.04	188
1	23	Ori	2(60)	9	42	S	13	50	-	-	-	-	-	-	1879
2	24	Ori	2(60)	14	42	S	17	0	1(s)	1.25	1.30	1(s)	1.30	0.50	2061
3	25	Ori	2(60)	6	42	S	17	30	2	2.00	2.00	2(m)	1.50	1.64	1790
4	26	Ori	2(60)	50	42	S	18	0	4(s)	4.25	4.30	4(s)	4.30	4.20	1839
5	27	Ori	2(60)	6	2	S	14	30	4	4.00	4.00	4	4.00	4.21	2124
6	28	Ori	2(60)	19	2	S	11	50	6	6.00	6.00	6	6.00	5.04	2241
7	29	Ori	2(60)	19	12	S	10	0	5	5.00	5.00	4	4.00	4.48	2199
8	30	Ori	2(60)	38	42	S	9	45	5	5.00	5.00	4	4.00	4.42	2159
9	31	Ori	2(60)	20	2	S	8	15	6	6.00	6.00	6	6.00	5.30	2223
10	32	Ori	2(60)	19	22	S	8	15	6	6.00	6.00	6	6.00	4.95	2198
11	33	Ori	2(60)	14	22	S	3	45	5	5.00	5.00	5	5.00	4.41	2047
12	34	Ori	2(60)	17	2	S	4	15	5(s)	5.25	5.30	5	5.00	4.63	2135
13	35	Ori	2(60)	10	12	S	19	40	4	4.00	4.00	4	4.00	4.57	1934
14	36	Ori	2(60)	9	2	S	20	0	6	6.00	6.00	6	6.00	5.36	1872
15	37	Ori	2(60)	8	2	S	20	20	6	6.00	6.00	6	6.00	5.46	1842

16	38	Ori	2(60)	6	52	S	20	40	5	5.00	5.00	5	5.00	4.59	1811
17	39	Ori	2(60)	3	12	S	8	0	4	4.00	4.00	4	4.00	4.82	1676
18	40	Ori	2(60)	2	2	S	8	10	4	4.00	4.00	4	4.00	4.68	1638
19	41	Ori	2(60)	0	42	S	10	15	4	4.00	4.00	4	4.00	4.07	1580
20	42	Ori	1(30)	29	2	S	12	50	4	4.00	4.00	4	4.00	4.65	1570
21	43	Ori	1(30)	27	52	S	14	15	4	4.00	4.00	4	4.00	4.36	1544
22	44	Ori	1(30)	27	32	S	15	50	3(s)	3.25	3.30	3	3.00	3.19	1543
23	45	Ori	1(30)	27	32	S	17	10	3(s)	3.25	3.30	3	3.00	3.69	1552
24	46	Ori	1(30)	18	2	S	20	20	3(s)	3.25	3.30	3	3.00	3.72	1567
25	47	Ori	1(30)	29	2	S	21	30	4	3.00	3.00	3	3.00	4.47	1601
26	48	Ori	2(60)	8	2	S	24	10	2	2.00	2.00	2	2.00	2.23	1852
27	49	Ori	2(60)	10	2	S	24	50	2	2.00	2.00	2	2.00	1.70	1903
28	50	Ori	2(60)	10	52	S	25	40	2	2.00	2.00	2	2.00	2.05	1948
29	51	Ori	2(60)	6	32	S	25	50	3(s)	3.25	3.30	3	3.00	3.36	1788
30	52	Ori	2(60)	9	12	S	28	40	4	4.00	4.00	4	4.00	4.59	1892
31	53	Ori	2(60)	9	22	S	29	10	3(s)	3.25	3.30	3(s)	3.30	6.39	1897
32	54	Ori	2(60)	9	42	S	29	50	3(s)	3.25	3.30	3	3.00	2.77	1899
33	55	Ori	2(60)	10	22	S	30	40	4(s)	4.25	4.30	4	4.00	4.80	1937
34	56	Ori	2(60)	8	52	S	30	50	4(s)	4.25	4.30	4	4.00	4.62	1855
35	57	Ori	2(60)	2	32	S	31	30	1	1.00	1.00	1	1.00	0.12	1713
36	58	Ori	2(60)	3	42	S	30	15	4(k)	3.75	3.70	4(k)	3.70	3.60	1735
37	59	Ori	2(60)	6	2	S	31	10	4	4.00	4.00	4	4.00	4.14	1784
38	60	Ori	2(60)	12	52	S	33	30	3(k)	2.75	2.70	3(k)	2.70	2.06	2004
1	61	Eri	2(60)	1	2	S	31	50	4	4.00	4.00	4(m)	3.70	4.27	1679
2	62	Eri	2(60)	1	32	S	28	15	4	4.00	4.00	4	4.00	2.79	1666
3	63	Eri	2(60)	0	42	S	29	50	5	5.00	5.00	4	4.00	4.81	1617
4	64	Eri	1(30)	27	22	S	28	15	4(s)	4.25	4.30	4	4.00	4.39	1560
5	65	Eri	1(30)	25	52	S	25	50	4	4.00	4.00	4	4.00	4.02	1520
6	66	Eri	1(30)	22	52	S	25	20	4	4.00	4.00	4	4.00	3.93	1463
7	67	Eri	1(30)	19	2	S	26	0	5(s)	5.25	5.30	5	5.00	5.17	1383
8	68	Eri	1(30)	18	12	S	27	0	4	4.00	4.00	4	4.00	4.47	1325
9	69	Eri	1(30)	15	32	S	27	50	4	4.00	4.00	4	4.00	4.04	1298
10	70	Eri	1(30)	9	42	S	32	7	3(s)	3.25	3.30	3	3.00	2.95	1231
11	71	Eri	1(30)	7	22	S	31	0	4	4.00	4.00	4	4.00	4.42	1162
12	72	Eri	1(30)	6	52	S	28	50	4(m)	3.50	3.70	3	3.00	3.54	1136
13	73	Eri	1(30)	4	42	S	28	0	3(s)	3.25	3.30	3	3.00	3.71	1084
14	74	Eri	0	29	52	S	25	30	4	4.00	4.00	3	3.00	4.80	984
15	75	Eri	0	27	32	S	23	50	5	5.00	5.00	4	4.00	5.26	925
16	76	Eri	0	24	52	S	23	50	4(m)	3.50	3.70	3	3.00	3.89	874
17	77	Eri	0	23	12	S	23	15	6	6.00	6.00	4	4.00	6.32	859
18	78	Eri	0	17	52	S	32	10	4	4.00	4.00	4	4.00	4.46	818
19	79	Eri	0	18	32	S	34	50	4(s)	4.25	4.30	4	4.00	4.75	850
20	80	Eri	0	21	32	S	38	30	4(m)	3.50	3.70	4	4.00	4.09	919
21	81	Eri	0	26	32	S	38	10	4	4.00	4.00	4	4.00	3.69	1003
22	82	Eri	1(30)	0	12	S	39	0	4	4.00	4.00	4	4.00	4.27	1088
23	83	Eri	1(30)	4	2	S	41	20	4	4.00	4.00	4	4.00	4.23	1173
24	84	Eri	1(30)	4	12	S	42	30	5(s)	5.25	5.30	5	5.00	5.24	1181
25	85	Eri	1(30)	4	52	S	43	15	4	4.00	4.00	4	4.00	4.65	1213
26	86	Eri	1(30)	7	22	S	43	20	4	4.00	4.00	4	4.00	4.66	1240
27	87	Eri	1(30)	16	52	S	50	20	4(s)	4.25	4.30	4	4.00	4.51	1453
28	88	Eri	1(30)	17	42	S	51	45	4	4.00	4.00	4	4.00	3.82	1464

29	89	Eri	1(30)	10	52	S	53	50	4	4.00	4.00	4	4.00	3.96	1393
30	90	Eri	1(30)	8	32	S	53	10	4(m)	3.50	3.70	4	4.00	3.56	1347
31	91	Eri	1(30)	0	32	S	53	0	4	4.00	4.00	4	4.00	5.11	1214
32	92	Eri	0	27	32	S	53	30	4	4.00	4.00	4	4.00	4.17	1195
33	93	Eri	0	24	32	S	52	0	4	4.00	4.00	4	4.00	4.59	1143
34	94	Eri	0	12	52	S	53	30	1	1.00	1.00	1	1.00	3.24	897
1	95	Lep	2(60)	2	22	S	35	0	5	5.00	5.00	5	5.00	4.45	1696
2	96	Lep	2(60)	2	32	S	36	30	5	5.00	5.00	5	5.00	4.36	1705
3	97	Lep	2(60)	4	2	S	35	40	5	5.00	5.00	5	5.00	5.30	1757
4	98	Lep	2(60)	4	2	S	36	40	5	5.00	5.00	5	5.00	4.29	1756
5	99	Lep	2(60)	1	52	S	39	15	4(k)	3.75	3.70	4(k)	3.70	3.31	1702
6	100	Lep	2(60)	28	52	S	45	15	4(m)	3.50	3.70	4(m)	3.70	3.19	1654
7	101	Lep	2(60)	8	32	S	41	30	3(s)	3.25	3.30	3	3.00	2.58	1865
8	102	Lep	2(60)	7	2	S	44	20	3(s)	3.25	3.30	3	3.00	2.84	1829
9	103	Lep	2(60)	18	42	S	44	15	4(k)	3.75	3.70	4(k)	3.70	3.80	2035
10	104	Lep	2(60)	11	42	S	45	50	4(k)	3.75	3.70	4(k)	3.70	3.60	1983
11	105	Lep	2(60)	12	42	S	38	20	4(k)	3.75	3.70	4(k)	3.70	3.55	1998
12	106	Lep	2(60)	15	22	S	38	10	4(k)	3.75	3.70	4(k)	3.70	3.71	2085
1	107	CMa	3(90)	0	22	S	39	10	1	1.00	1.00	1	1.00	-1.4	2491
2	108	CMa	3(90)	2	22	S	35	0	4(s)	4.25	4.30	4	4.00	4.06	2574
3	109	CMa	3(90)	4	2	S	36	30	5	5.00	5.00	5	5.00	5.00	2593
4	110	CMa	3(90)	6	2	S	37	45	4	4.00	4.00	4	4.00	4.12	2657
5	111	CMa	3(90)	8	2	S	40	0	4	4.00	4.00	4	4.00	4.37	2596
6	112	CMa	3(90)	3	12	S	42	40	5	5.00	5.00	5	5.00	4.68	2590
7	113	CMa	2(60)	28	52	S	41	15	5	5.00	5.00	5	5.00	4.43	2443
8	114	CMa	2(60)	28	42	S	42	30	5	5.00	5.00	5	5.00	3.95	2429
9	115	CMa	2(60)	23	42	S	41	20	3	3.00	3.00	3	3.00	1.98	2294
10	116	CMa	2(60)	27	22	S	46	30	5	5.00	5.00	5	5.00	4.33	2387
11	117	CMa	2(60)	28	52	S	45	50	5	5.00	5.00	5	5.00	4.54	2414
12	118	CMa	3(90)	7	22	S	46	10	4	4.00	4.00	4	4.00	3.02	2653
13	119	CMa	3(90)	4	22	S	47	0	5	5.00	5.00	5	5.00	3.87	2580
14	120	CMa	3(90)	9	22	S	48	45	3	3.00	3.00	3	3.00	1.84	2693
15	121	CMa	3(90)	6	22	S	51	30	3	3.00	3.00	3	3.00	1.50	2618
16	122	CMa	3(90)	5	42	S	54	10	4	4.00	4.00	4	4.00	3.98	2538
17	123	CMa	2(60)	22	22	S	53	45	3	3.00	3.00	3	3.00	3.02	2282
18	124	CMa	3(90)	14	52	S	50	40	3(s)	3.25	3.30	3(s)	3.30	2.45	2827
19	125	CMa	3(90)	2	12	S	25	15	4	4.00	4.00	4	4.00	4.99	2648
20	126	CMa	2(60)	22	42	S	61	30	4	4.00	4.00	4	4.00	5.02	2177

21	127	CMa	2(60)	24	2	S	58	45	5	5.00	5.00	4	4.00	4.37	2256
22	128	CMa	2(60)	25	42	S	57	0	4	4.00	4.00	4	4.00	3.85	2296
23	129	CMa	2(60)	26	52	S	56	0	5	5.00	5.00	4	4.00	4.48	2361
24	130	CMa	2(60)	10	42	S	55	30	4(s)	4.25	4.00	4	4.00	5.17	1996
25	131	CMa	2(60)	13	2	S	57	40	5	5.00	5.00	4	4.00	4.87	2056
26	132	CMa	2(60)	15	2	S	59	30	4(s)	4.25	4.00	4	4.00	4.36	2106
27	133	CMa	2(60)	11	42	S	59	40	3	3.00	3.00	2	2.00	3.11	2040
28	134	CMa	2(60)	8	42	S	57	40	3	3.00	3.00	2	2.00	2.64	1956
29	135	CMa	2(60)	4	52	S	59	30	4(s)	4.25	4.30	4	4.00	3.87	1862
1	136	CMi	3(90)	7	42	S	14	0	4	4.00	4.00	4	4.00	2.90	2845
2	137	CMi	3(90)	11	52	S	16	10	1	1.00	1.00	1	1.00	0.38	2943
1	138	Arg	3(90)	23	2	S	42	30	5	5.00	5.00	5	5.00	4.20	3102
2	139	Arg	3(90)	27	2	S	43	20	3	3.00	3.00	3	3.00	2.80	3185
3	140	Arg	3(90)	21	31	S	45	0	4(m)	3.50	3.70	4	4.00	3.34	3045
4	141	Arg	3(90)	21	22	S	46	0	5	5.00	5.00	4	4.00	4.50	3034
5	142	Arg	3(90)	18	2	S	45	30	5(s)	5.25	5.30	4	4.00	4.70	2944
6	143	Arg	3(90)	19	2	S	47	15	4(m)	3.50	3.70	3	3.00	4.50	2948
7	144	Arg	3(90)	18	2	S	49	30	4	4.00	4.00	4	4.00	4.64	2922
8	145	Arg	3(90)	22	2	S	49	30	4	4.00	4.00	4	4.00	3.96	2996
9	146	Arg	3(90)	21	12	S	49	15	5	5.00	5.00	4	4.00	4.59	2993
10	147	Arg	3(90)	26	42	S	49	50	4(s)	4.25	4.30	4	4.00	4.79	3113
11	148	Arg	3(90)	16	42	S	53	0	5(s)	5.25	5.30	4	4.00	5.35	2823
12	149	Arg	3(90)	16	42	S	58	40	3	3.00	3.00	3	3.00	2.70	2773
13	150	Arg	3(90)	22	52	S	55	30	5	5.00	5.00	5	5.00	4.53	2937
14	151	Arg	3(90)	24	52	S	58	40	5	5.00	5.00	5	5.00	4.84	2961
15	152	Arg	3(90)	26	22	S	57	15	4	4.00	4.00	4	4.00	3.61	3017
16	153	Arg	3(90)	29	12	S	57	45	4	4.00	4.00	4	4.00	4.49	3084
17	154	Arg	4(120)	3	52	S	58	20	2	2.00	2.00	2	2.00	2.25	3165
18	155	Arg	4(120)	0	52	S	60	0	5	5.00	5.00	5	5.00	3.73	3080
19	156	Arg	4(120)	3	42	S	59	20	5	5.00	5.00	5	5.00	5.52	3162
20	157	Arg	4(120)	5	42	S	56	40	5	5.00	5.00	5	5.00	4.45	3225
21	158	Arg	4(120)	7	2	S	57	0	5	5.00	5.00	5	5.00	4.44	3243
22	159	Arg	4(120)	18	22	S	51	30	4	4.00	4.00	4	4.00	5.82	3535
23	160	Arg	4(120)	18	52	S	55	40	4	4.00	4.00	4	4.00	4.07	3477
24	161	Arg	4(120)	16	42	S	57	10	4	4.00	4.00	4	4.00	4.14	3426
25	162	Arg	4(120)	21	52	S	60	0	4(k)	3.50	3.75	4(k)	3.70	3.91	3487
26	163	Arg	4(120)	21	42	S	61	15	4(k)	3.50	3.75	4(k)	3.70	3.84	3445
27	164	Arg	4(120)	12	52	S	51	30	4	4.00	4.00	3	3.00	3.97	3438
28	165	Arg	4(120)	12	2	S	49	0	4	4.00	4.00	3	3.00	3.68	3468
29	166	Arg	4(120)	10	42	S	43	30	4(s)	4.25	4.30	4	4.00	4.01	3518
30	167	Arg	4(120)	11	42	S	43	30	4(s)	4.25	4.30	4	4.00	4.89	3556
31	168	Arg	4(120)	26	52	S	54	30	2	2.00	2.00	2	2.00	2.21	3634
32	169	Arg	5(150)	0	12	S	51	15	3	3.00	3.00	2(s)	2.30	3.60	3786

33	170	Arg	3(90)	23	52	S	63	0	4(m)	3.50	3.70	4	4.00	3.24	2878
34	171	Arg	4(120)	1	42	S	64	30	6	6.00	6.00	6	6.00	4.11	3055
35	172	Arg	4(120)	12	42	S	63	50	2	2.00	2.00	2	2.00	1.78	3207
36	173	Arg	4(120)	21	12	S	64	40	4	4.00	4.00	2	2.00	3.47	3117
37	174	Arg	4(120)	27	52	S	65	40	3	3.00	3.00	3	3.00	3.62	3447
38	175	Arg	5(150)	4	2	S	65	30	3	3.00	3.00	3	3.00	1.96	3485
39	176	Arg	5(150)	8	42	S	66	20	3	3.00	3.00	2	2.00	4.49	3498
40	177	Arg	5(150)	13	42	S	62	50	4	4.00	4.00	3	3.00	2.50	3734
41	178	Arg	5(150)	20	42	S	62	15	4(m)	3.50	3.70	2	2.00	3.13	3803
42	179	Arg	2(60)	16	42	S	65	50	4	4.00	4.00	4(m)	3.70	3.96	2120
43	180	Arg	3(90)	2	52	S	65	40	3(s)	3.25	3.30	3	3.00	3.17	2451
44	181	Arg	2(60)	29	52	S	75	0	1	1.00	1.00	1	1.00	0.72	2326
45	182	Arg	3(90)	11	42	S	71	45	3(s)	3.25	3.30	3	3.00	2.93	2553
1	183	Hya	3(90)	26	42	S	15	0	4(s)	4.25	4.30	4	4.00	6.33	3418
2	184	Hya	3(90)	26	2	S	13	10	4	4.00	4.00	4	4.00	4.16	3410
3	185	Hya	3(90)	28	2	S	11	30	4	4.00	4.00	4	4.00	3.38	3482
4	186	Hya	3(90)	28	12	S	14	45	4	4.00	4.00	4	4.00	4.30	3454
5	187	Hya	4(120)	0	32	S	12	0	4(m)	3.50	3.70	4	4.00	3.11	3547
6	188	Hya	4(120)	3	2	S	14	40	6	6.00	6.00	6	6.00	4.97	3613
7	189	Hya	4(120)	6	2	S	19	20	4	4.00	4.00	4	4.00	3.88	3665
8	190	Hya	4(120)	11	32	S	15	20	4(s)	4.25	4.30	4	4.00	4.57	3787
9	191	Hya	4(120)	13	22	S	14	50	4(s)	4.25	4.30	4	4.00	3.91	3845
10	192	Hya	4(120)	11	12	S	17	10	4(s)	4.25	4.30	4	4.00	4.60	3759
11	193	Hya	4(120)	11	52	S	19	45	6(s)	6.25	6.30	6	6.00	5.37	3750
12	194	Hya	4(120)	12	42	S	20	30	2	2.00	2.00	2	2.00	1.98	3748
13	195	Hya	4(120)	18	42	S	26	30	4	4.00	4.00	4	4.00	5.06	3849
14	196	Hya	4(120)	21	22	S	26	0	4	4.00	4.00	4	4.00	4.12	3903
15	197	Hya	4(120)	23	52	S	23	15	4(k)	3.75	3.70	4	4.00	4.60	3970
16	198	Hya	5(150)	0	42	S	24	40	3(s)	3.25	3.30	3	3.00	3.81	4094
17	199	Hya	5(150)	2	42	S	23	0	4(s)	4.25	4.30	4	4.00	4.91	4171
18	200	Hya	5(150)	5	42	S	22	10	3	3.00	3.00	3	3.00	3.11	4232
19	201	Hya	5(150)	14	12	S	25	45	4	4.00	4.00	4(m)	3.70	4.48	4343
20	202	Hya	5(150)	15	2	S	30	10	4	4.00	4.00	4	4.00	4.94	4314
21	203	Hya	5(150)	24	52	S	31	20	4(k)	3.75	3.70	4	4.00	3.54	4450
22	204	Hya	5(150)	27	12	S	33	10	4	4.00	4.00	4	4.00	4.70	4494
23	205	Hya	5(150)	28	52	S	31	20	3	3.00	3.00	3	3.00	4.28	4552
24	206	Hya	6(180)	12	42	S	13	40	3(s)	3.25	3.30	4(k)	3.70	3.00	5020
25	207	Hya	6(180)	26	12	S	17	40	3(s)	3.25	3.30	4(k)	3.70	3.27	5287
26	208	Hya	3(90)	25	12	S	23	15	3	3.00	3.00	3	3.00	3.90	3314
27	209	Hya	4(120)	23	42	S	16	0	4	4.00	4.00	3	3.00	5.24	4042
1	210	Car	5(150)	9	2	S	23	0	4	4.00	4.00	4	4.00	4.08	4287
2	211	Car	5(150)	15	12	S	19	30	4	4.00	4.00	4	4.00	4.08	4405
3	212	Car	5(150)	12	42	S	18	0	4	4.00	4.00	4	4.00	3.56	4382
4	213	Car	5(150)	19	42	S	18	30	5(s)	5.25	5.30	4(k)	3.70	4.73	4514
5	214	Car	5(150)	52	2	S	13	40	4(s)	4.25	4.30	4	4.00	4.83	4402
6	215	Car	5(150)	21	52	S	16	10	4(s)	4.25	4.30	4(s)	4.30	5.18	4567

7	216	Car	5(150)	14	22	S	11	50	4(s)	4.25	4.30	4	4.00	4.70	4468
1	217	Crv	5(150)	28	2	S	21	40	3(s)	3.25	3.30	3	3.00	4.02	4623
2	218	Crv	5(150)	27	2	S	19	40	3	3.00	3.00	3	3.00	3.00	4630
3	219	Crv	5(150)	29	22	S	18	10	5	5.00	5.00	5	5.00	5.21	4696
4	220	Crv	5(150)	26	12	S	14	50	3	3.00	3.00	3	3.00	2.59	4662
5	221	Crv	5(150)	29	22	S	12	30	3	3.00	3.00	3	3.00	2.95	4757
6	222	Crv	5(150)	29	42	S	11	45	4	4.00	4.00	4	4.00	4.31	4775
7	223	Crv	6(180)	3	12	S	18	10	3	3.00	3.00	3	3.00	2.65	4786
1	224	Cen	6(180)	23	12	S	21	40	5	5.00	5.00	5(m)	4.70	4.19	5192
2	225	Cen	6(180)	22	42	S	18	50	5	5.00	5.00	5(m)	4.70	4.73	5221
3	226	Cen	6(180)	21	52	S	20	30	4	4.00	4.00	4(k)	3.70	4.23	5168
4	227	Cen	6(180)	22	42	S	20	0	5	5.00	5.00	5(m)	4.70	4.56	5210
5	228	Cen	6(180)	18	52	S	25	40	3	3.00	3.00	3	3.00	2.75	5028
6	229	Cen	6(180)	28	22	S	22	30	3	3.00	3.00	3	3.00	2.06	5288
7	230	Cen	6(180)	21	52	S	27	30	5	5.00	5.00	4	4.00	3.88	5089
8	231	Cen	7(210)	0	52	S	22	20	4(s)	4.25	4.30	4	4.00	4.25	5367
9	232	Cen	7(210)	1	52	S	23	45	4	4.00	4.00	4	4.00	4.42	5378
10	233	Cen	7(210)	4	42	S	18	15	4	4.00	4.00	4	4.00	4.05	5485
11	234	Cen	7(210)	5	12	S	20	50	4	4.00	4.00	4	4.00	4.00	5471
12	235	Cen	6(180)	26	2	S	28	20	4(m)	3.50	3.70	4(m)	3.70	3.41	5190
13	236	Cen	6(180)	26	42	S	29	20	4(m)	3.50	3.70	4(m)	3.70	3.04	5193
14	237	Cen	6(180)	27	52	S	28	0	4	4.00	4.00	4(m)	3.70	3.83	5248
15	238	Cen	6(180)	29	2	S	26	30	4(m)	3.50	3.70	4(m)	3.70	4.36	5285
16	239	Cen	7(210)	5	32	S	25	15	3	3.00	3.00	3	3.00	2.31	5440
17	240	Cen	7(210)	10	12	S	24	0	4(m)	3.50	3.70	4	4.00	3.13	5576
18	241	Cen	7(210)	0	42	S	33	30	3	3.00	3.00	2(m)	2.70	2.55	5231
19	242	Cen	7(210)	0	22	S	31	0	5	5.00	5.00	5	5.00	4.34	5260
20	243	Cen	6(180)	29	32	S	30	20	5	5.00	5.00	5	5.00	3.87	5249
21	244	Cen	6(180)	24	52	S	34	50	5	5.00	5.00	5	5.00	3.00	0
22	245	Cen	6(180)	21	42	S	37	40	5	5.00	5.00	5	5.00	4.71	4940
23	246	Cen	6(180)	18	52	S	40	0	3	3.00	3.00	3	3.00	2.17	4819
24	247	Cen	6(180)	17	42	S	40	20	5	5.00	5.00	4	4.00	3.86	4802
25	248	Cen	6(180)	15	22	S	41	0	5(m)	4.50	4.70	5	5.00	3.91	4743

26	249	Cen	6(180)	15	22	S	46	10	3	3.00	3.00	3	3.00	2.60	4621
27	250	Cen	6(180)	16	12	S	46	45	5	5.00	5.00	4	4.00	3.96	4638
28	251	Cen	7(210)	1	2	S	40	45	5(s)	5.25	5.30	4	4.00	4.65	5172
29	252	Cen	6(180)	29	2	S	43	0	3	3.00	3.00	2	2.00	2.30	5132
30	253	Cen							-	-	-	-	-	-	5141
31	254	Cen	6(180)	22	42	S	51	10	2	2.00	2.00	2	2.00	1.63	4763
32	255	Cen	6(180)	28	2	S	51	40	2	2.00	2.00	2	2.00	1.25	4853
33	256	Cen	6(180)	59	2	S	55	10	3(s)	3.25	3.30	4	4.00	2.80	4656
34	257	Cen	6(180)	23	52	S	55	20	2	2.00	2.00	2	2.00	0.83	4730
35	258	Cen	7(210)	21	2	S	41	10	1	1.00	1.00	1	1.00	0.01	5459
36	259	Cen	7(210)	6	52	S	45	20	2(m)	1.50	1.70	2	2.00	0.61	5267
37	260	Cen	6(180)	27	22	S	49	10	4(s)	4.25	4.30	4	4.00	3.28	4898
1	261	Lup	7(210)	10	42	S	24	50	3	3.00	3.00	3	3.00	2.68	5571
2	262	Lup	7(210)	8	32	S	29	10	3	3.00	3.00	3	3.00	2.30	5469
3	263	Lup	7(210)	13	42	S	21	15	4(m)	3.50	3.70	4	4.00	3.22	5695
4	264	Lup	7(210)	16	52	S	21	0	3(s)	3.25	3.30	4	4.00	2.78	5776
5	265	Lup	7(210)	15	42	S	25	10	4(m)	3.50	3.70	4	4.00	3.37	5708
6	266	Lup	7(210)	12	52	S	27	0	5	5.00	5.00	5	5.00	4.05	5626
7	267	Lup	7(210)	13	12	S	29	0	5	5.00	5.00	5	5.00	4.72	5605
8	268	Lup	7(210)	17	22	S	28	30	5	5.00	5.00	5	5.00	4.27	5683
9	269	Lup	7(210)	16	22	S	30	10	5	5.00	5.00	5	5.00	3.87	5646
10	270	Lup	7(210)	18	22	S	33	10	4(s)	4.25	4.30	5	5.00	3.41	5649
11	271	Lup							-	-	-	-	-	-	5453
12	272	Lup	7(210)	4	32	S	30	30	4(s)	4.25	4.30	4	4.00	3.55	5354
13	273	Lup	7(210)	5	42	S	29	20	5	5.00	5.00	4(k)	3.70	4.35	5396
14	274	Lup	7(210)	21	32	S	17	0	4	4.00	4.00	4	4.00	3.41	5948
15	275	Lup	7(210)	22	2	S	15	20	5	5.00	5.00	4(m)	3.70	4.23	5987
16	276	Lup	7(210)	18	22	S	13	20	5(m)	4.50	4.70	4	4.00	3.95	5883
17	277	Lup	7(210)	19	22	S	11	50	5(s)	5.25	5.30	4(m)	3.70	5.12	5925
18	278	Lup	7(210)	10	2	S	11	30	6	6.00	6.00	4	4.00	4.91	5660
19	279	Lup	7(210)	12	12	S	10	0	5(s)	5.25	5.30	4(m)	3.70	4.34	5686
1	280	Ara	8(240)	10	22	S	22	40	6	6.00	6.00	5	5.00	4.59	6537
2	281	Ara	8(240)	13	2	S	25	45	4	4.00	4.00	4	4.00	3.66	6743
3	282	Ara	8(240)	8	52	S	26	30	4(k)	3.75	3.70	4(k)	3.70	2.95	6510
4	283	Ara	8(240)	3	22	S	30	20	5(s)	5.25	5.30	5	5.00	4.06	6295
5	284	Ara	8(240)	7	52	S	34	10	4(s)	4.25	4.30	4(m)	3.70	3.34	6462
6	285	Ara	8(240)	7	42	S	33	20	4	4.00	4.00	4	4.00	2.85	6461
7	286	Ara	8(240)	3	32	S	34	0	4	4.00	4.00	4	4.00	3.13	6285
1	287	CrA	8(240)	21	52	S	21	30	4	4.00	4.00	4	4.00	3.51	6897
2	288	CrA	8(240)	24	22	S	21	0	6	6.00	6.00	5	5.00	5.49	7062

3	289	CrA	8(240)	25	52	S	20	20	6	6.00	6.00	5	5.00	5.36	7122
4	290	CrA	8(240)	27	32	S	20	0	5	5.00	5.00	4	4.00	4.75	7188
5	291	CrA	8(240)	28	52	S	18	30	5(s)	5.25	5.30	5	5.00	4.59	7242
6	292	CrA	8(240)	29	42	S	17	10	5	5.00	5.00	4	4.00	4.11	7259
7	293	CrA	8(240)	29	32	S	16	0	5	5.00	5.00	4	4.00	4.11	7254
8	294	CrA	8(240)	29	12	S	15	10	5	5.00	5.00	4	4.00	4.94	7226
9	295	CrA	8(240)	27	52	S	15	20	6	6.00	6.00	6	6.00	4.86	7152
10	296	CrA	8(240)	27	22	S	14	50	6	6.00	6.00	6	6.00	5.38	7129
11	297	CrA	8(240)	24	32	S	14	40	5(s)	5.25	5.30	5	5.00	5.13	7021
12	298	CrA	8(240)	22	22	S	15	50	5(s)	5.25	5.30	5	5.00	5.16	6942
13	299	CrA	8(240)	21	52	S	18	30	5	5.00	5.00	5	5.00	4.64	6951
1	300	PsA	10(300)	18	22	S	20	20	4	4.00	4.00	1	1.00	1.16	8728
2	300	PsA	10(300)	18	22	S	20	20	4	4.00	4.00	4	4.00	4.29	8576
3	301	PsA	10(300)	16	52	S	22	15	4	4.00	4.00	4	4.00	4.21	8720
4	302	PsA	10(300)	18	12	S	22	30	4	4.00	4.00	4	4.00	4.46	8695
5	303	PsA	10(300)	17	2	S	16	15	5	5.00	5.00	4	4.00	4.17	8628
6	304	PsA	10(300)	7	52	S	19	30	6(s)	6.25	6.25	5	5.00	4.50	8431
7	305	PsA	10(300)	13	52	S	15	10	5	5.00	5.00	4	4.00	6.43	8570
8	306	PsA	10(300)	11	32	S	14	40	5	5.00	5.00	4	4.00	5.43	8478
9	307	PsA	10(300)	7	52	S	15	5	5(k)	4.75	4.70	4	4.00	5.42	8386
10	308	PsA	10(300)	4	32	S	16	30	4	4.00	4.00	4	4.00	5.01	8326
11	309	PsA	10(300)	3	42	S	18	10	3(s)	3.25	3.30	4	4.00	4.34	8305
12	310	PsA	10(300)	8	42	S	22	15	3(s)	3.25	3.30	4	4.00	3.01	8353
13		PsA										3(s)	3.30	5.53	8069
14		PsA										3(s)	3.30	4.82	8151
15		PsA										3(s)	3.30	5.29	8229
16		PsA										5	5.00	5.77	8180
17		PsA										4	4.00	4.90	7965
18		PsA										4	4.00	4.67	8039

8.2 Excerpts of translation of Poem by al-Ṣūfī's Son

This is a Poem on the fixed stars. It is called "*al-Urjūza li Ibn al-Ṣūfī*" which means "The Poem by Ibn al-Ṣūfī". It is composed of 495 verses which are divided into 48 stanzas, one for each constellation. Every stanza describes the constellation in a simple and easy to understand language. The style is not exactly a literally poetic style; therefore it is called *Urjūza, which* means "Prose" rather then a poem. The writer was trying to compose an easy to memorize poem and not a scientific piece of work; therefore it does not include much detailed scientific information in many of the constellations.

Al-Qifṭī attributed this poem to al-Ṣūfī; however this poem was written by the son of al-Ṣūfī and not by al-Ṣūfī himself. The first 6 verses from this poem clearly identify the person who wrote this poem and to whom it was attributed. The second verse explains that this poem was written by Abū ʻAlī the son of Abū al-Ḥusaīn al-Ṣūfī. The fourth verse states that this poem was dedicated to Shāhenshāh Abū al-Maʻali Fakher al-Dīn, who was the second son of Rukn al-Dawla. Fakher al-Dawla took power in Rayy in A.D. 976 after his father's death. He took the title of Shāhenshāh in A.D. 984 until his death in A.D. 997; therefore this poem must have been composed some time between A.D. 984 and A.D. 997 and most probably after al-Ṣūfī's death in A.D. 986. However another reference (Kunitzsch, Encyclopedia Iranica) identifies Shāhenshāh Abū al-Maʻali Fakher Din Allah as the *Artuqid* ruler in A.D. 1143; thus Kunitzsch rejects the claim that this poem was ever written during the time of al-Ṣūfī or by his son. However the final verses of this poem state that the information on the stars was taken from the book of al-Ṣūfī. Therefore it would be a strange coincidence that this Ibn al-Ṣūfī also has a father who was called Abū al-Ḥusaīn al-Ṣūfī who wrote a book on the stars from which the son composes a poem in this subject. A copy of this poem is to be found at the end of the below-mentioned manuscripts of al-Ṣūfī's Book of the fixed stars". This is why there was sometimes a little confusion as to who wrote the poem. This also explains another confusion, which is the name of al-Ṣūfī because he was referred to as Ibn al-Ṣūfī in many historical reference works.

- Vatican Library, Manuscript: MS Rossi 1033, Copy dated A.H. 621/A.D. 1224
- Paris Bibliotheque Nationale, Manuscript: Arab 979, Copy date unknown
- Munich library , Manuscript: Arab 870, Copy date unknown

I have translated below a few lines from *al-Urjūza* (Poem) by al-Ṣūfī's son. The first couplet forms the introductory to this poem. The second couplet is for the constellation Ursa

Minor. The last is the final excerpt from the last constellation Piscis Austrinus and the conclusion of this poem.

In the name of God the just the one   and God’s Mercy on Muḥammad
This is a treatise written by Abū ‘Alī   the son of Abū al-Ḥusaīn al-Ṣūfī
Describing the stars and their orbits   written for the king of kings
The king of the nation, Shāhenshāh   Abū al-Ma‘ali Fakher al-Dīn
God made him the king of his time   and did not take away his domain
Those who ask me about the stars   and what they hold of wonders
I took it from one who knows   adding my literary knowledge to it
Behold the depiction of the great sphere   and all it holds of the stars

Know that the closest to the pole   are stars in the image of a bear
They are seven if you count them   drawn with the pole on the same spot
There are two stars in this constellation   the distance between them is 2 *Shibr*
The Arabs call them *al-Farqadain*   under the brighter of the two
A small dim star not drawn   the Arabs of the desert call it *Fa’s al-Raḥā*
Yes and a star used to find the *Qiblah*   it is above the tail of the bear
Called *al-Juday* by the Arabs   from those close and far
It is close to the pole   other stars known by the Arabs
Called also *Banāt Na’es*h   together with *al-Fared* the old star

They are followed by stars in the south   some with light and others dim
They are called *al-Ḥūt* by the Romans   and those which are called astronomers
None of the Arabs mentioned them   nor were they mentioned by other names
These are the stars which   you find in the history books
They are known   by the scholars from *al-Kūfa*
Some by scholars of *al-Shām*   also by other well informed persons
There are other stars in the sky   nobody has heard of their names
The Arabs call them *al-Suhūla*   they are known by unpleasant names
Our father mentioned them in his book   so every one should be aware of them
Finally may God always pray   for the Prophet of his righteous religion
Muḥammad the selected one   and the chosen at the Day of Judgment
Then on his disciples and family   as long as the days and nights exist

8.3 Arabic Transliteration:

The Arabic language has a number of phonemes that have no equivalent in English. Therefore several different transliteration standards have been used to represent certain Arabic characters such as the ISO, DIN and the British BS standard. However I have tried to follow the Library of Congress transliteration rules in this thesis.

Dates:

Unless mentioned, all dates in the thesis use Anno Domini system (i.e. A.D. and B.C.). When Hijri dates (Islamic calendar) are noted, they will be indicated by the suffix A.H. (i.e. A.H. 657). When double dates are mentioned A.D. dates are preceded by Hijri Dates and separated by a slash (i.e. 657/1261 is A.H. /A.D.).