

QUASARS AND THE CALTECH-CARNEGIE CONNECTION

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Abstract: A collaborative relationship existed between the California Institute of Technology (Caltech) and the Carnegie Institution of Washington (Carnegie) beginning in 1946, when a formal agreement was signed between the two groups of trustees. This agreement was designed to integrate Mount Wilson Observatory and the new unfinished Palomar Observatory into a single scientific entity. During the period from 1946 to 1979, much astronomical research was done at both institutions as a direct result of this collaboration. Part of this research included the first identification of a radio source with an apparently stellar object by Allan Sandage of Carnegie and Thomas Matthews of Caltech in 1960, and the first identification of spectral lines at large redshift from a radio source associated with such an object by Maarten Schmidt of Caltech in 1963. This paper examines how the discovery of these objects—which came to be known as quasars—and subsequent research on them, indirectly had an impact on the relationship between Caltech and Carnegie by leading to an environment of increased competitiveness that eventually resulted in the formal dissolution of the relationship in 1980. In this paper, the controversy surrounding the discovery and the interpretation of quasars is examined to provide further understanding about the working relationship when the two institutions were formally collaborating. Some of the data used in this paper were drawn from personal correspondence and interviews with the researchers themselves, and this research forms part of a dissertation for a Ph.D. degree in the Centre for Astronomy at James Cook University, Townsville, Australia.

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1 THE CARNEGIE INSTITUTION OF WASHINGTON AND ITS OBSERVATORIES

1.1 The Beginning

The Carnegie Institution of Washington was founded on 4 January 1902 when its Articles of Incorporation were signed. The institution was reincorporated by an act of the Congress of the United States, approved 28 April 1904, under the title of the *Carnegie Institution of Washington* (Carnegie Year Book No. 47, 1948: xi). Andrew Carnegie, a multi-millionaire steel baron and philanthropist, financed the institution with an endowment of registered bonds with a par value of ten million dollars, in order "... to encourage, in the broadest and most liberal manner, investigation, research, and discovery, and the application of knowledge to the improvement of mankind." (ibid.). Mr Carnegie made an additional contribution of two million dollars to this fund on 10 December 1907, and he contributed a further ten million dollars on 19 January 1911 (ibid.).

Carnegie gave the Board of Trustees "... full power to decide how the institution would meet its mandate, and even to amend his mandate ..." (Sandage, 2004: 30). Accordingly, the Board selected a seven-man Executive Committee to formulate research methods in a variety of fields, and these were presented to the Board from time to time. The first move of the Executive Committee was "... to canvass the state of knowledge in seventeen different fields of human endeavor ..." (ibid.), and to select leaders in each field to form Advisory Committees, which would write position papers outlining where major advances were likely to be made in their respective disciplines. Edward C. Pickering, Director of the Harvard College Observatory, was appointed Chairman of the Advisory Committee for Astronomy.

In 1904, George Ellery Hale (Figure 1), seeking clearer skies than existed near Chicago, obtained support from the Carnegie Institution to found the Mount Wilson Solar Observatory in the mountains near Pasadena, California. Hale, who had invented the spectroheliograph and discovered solar magnetism, wanted to understand the physics of the Sun and stars.

In pursuit of this goal, the initial complement of solar telescopes at Mount Wilson was followed by the 60-inch Reflector and then the 100-inch Hooker Telescope, which was the largest in the world at the time of its construction (Carnegie Observatories, 2006). Hale's motivation came from an enduring goal "... to solve the problem of stellar evolution." (Sandage, 2006a).

The Observatories of the Carnegie Institution at Mount Wilson transformed astronomy and astrophysics with a succession of major breakthroughs, including Harlow Shapley's mapping of the globular clusters of our Galaxy, Edwin Hubble's extragalactic studies and his redshift-distance relation, and Walter Baade's recognition of stellar populations (ibid.).



Figure 1: George Ellery Hale shown here in his office at Mt Wilson Observatory. This photograph dates to about 1905 (from <http://www.mwoa.org/hale.html>).

From the success of the Mt Wilson telescopes, Hale was determined to build a 200-inch or even larger telescope that would enable astronomers to see farther into space and to attack problems ranging from the structure of the Universe to the evolution of stars and the composition of stellar matter (Goodstein, 1991). In February 1928 Hale asked the editor of *Harper's* to send an advance copy of "The Possibilities of Large Telescopes", which he had written, to Wickliffe Rose,

the General Education Board President at the Rockefeller Foundation. When Hale called on Rose on 14 March, Rose asked him, "Do you want a 200-inch or a 300-inch?" Hale replied "A 200-inch telescope." (ibid.). Rose wanted to put the proposed telescope into the hands of a school, not the Carnegie Institution or the National Academy of Sciences, as Hale had initially proposed. Rose's suggestion that Caltech would make better use of the new telescope if it belonged to them infuriated John Merriam, Carnegie Institution President. This hostility meant that no real progress on a joint Caltech-Carnegie astrophysics program was likely while Merriam remained in office. Nevertheless, Merriam changed his mind, and in the fall of 1928 the International Education Board of the Rockefeller Foundation gave the green light to Hale's \$6 million proposal. This pledge, for which responsibility was later assumed by the General Education Board and which was supplemented by funds from the Rockefeller Foundation, was made to Caltech, of which Hale was a trustee.



Figure 2: Ira Sprague Bowen was Director of the Mount Wilson and Palomar Observatories from 1948 to 1964, and oversaw the completion of the 200-inch Hale Telescope and the 48-inch Schmidt Telescope (from <http://www.oss.org/bios/fellows-bowen.html>).



Figure 3: Robert Bacher joined Caltech in 1949 and remained there for the rest of his career, serving as Chair of Physics, Mathematics, and Astronomy from 1949 to 1962, and as Caltech Provost from 1962 to 1969, and Vice-President and Provost from 1969 to 1970 (from http://en.wikipedia.org/Robert_Bacher).

1.2 Administration

In the fall of 1928, the Observatory Council, with Hale as Chairman, was formed to direct the planning, construction and operation of the 200-inch Telescope. Hale assembled the team of scientists and engineers to build the 200-inch Telescope, choosing John Anderson, a Mount Wilson astronomer, as the Executive Director (Goodstein, 1991: 221). The site was to be on Palomar Mountain, southeast of Los Angeles. This site was chosen to enable very long exposures at the limit of the telescope's reach, which Hale acknowledged might not be possible at Mount Wilson because of the illumination of the night sky from the sprawling development of Los Angeles (Florence, 1995). Title to the Palomar Telescope was given to Caltech, which joined with Carnegie to form the Mount Wilson and Palomar Observatories (Caltech, 1951).

The man picked to head the Mount Wilson and Palomar Observatories was Caltech Professor of Physics, Ira Sprague Bowen (Figure 2), who held the position from 1946 to 1964. Bacher (1981) has credited Bowen with making the 200-inch the best telescope in the world at the time. Equally important was the fact that the joint operation of the two staffs worked well under Bowen's tenure. This success was attributed to a mix of subtlety and power in his personality, coupled with good scientific judgment and wise decision-making in administration (Sandage, 2004). Because of Bowen's outstanding credentials, the Carnegie Institution was willing to allocate up to three million dollars of endowment for the Telescope, and this was to be given as either a single grant or as a series of endowments (see Florence, 1995).

The administration of the two Observatories was affected through an Observatory Committee which comprised Bowen (as Director), Robert Bacher (the Chairman of the Division of Physics, Mathematics and Astronomy at Caltech), plus two additional members from the Observatory and two from Caltech. When Bowen became Director of the Observatories, he also became an employee of the Carnegie Institution, and perhaps this was a contributing factor to "... the observatory problems that developed between Caltech and the Carnegie Institution." (Bacher, 1981).

Robert Bacher (Figure 3) was Caltech's first Provost, from 1962 to 1969, and when asked if there were any problems in administering Palomar he responded as follows:

You know, the two Observatories have now separated. I have a certain sadness over this, because there were forces in this direction even during the period in which I was Provost, and I tried very hard to put the thing together in a way that would work better. But the forces toward separation became very large. When I came out here, one of the ways the operation was carried out was that there was an Observatory Committee and two *ex-officio* members—Bowen as Director of the Observatories, and myself as Chairman of the Division. At that time, I think, there were two additional members from the Observatory and two from Caltech. I used to talk to Bowen a great deal about the fact that we should talk about the research planning in the Observatory Committee, but Bowen never liked to do it that way. He was glad to talk to me about it, but he didn't really like to get into it in a meeting of that sort. And the Observatory Committee became a committee that sort of put the rubber stamp on things to be done and particularly

supervised the allocation of Observatory time. (Bacher, 1981).

Bacher's comment that the Observatory Committee was never used to plan the research programs indicates that at this senior administrative level there was a basic lack of communication between Caltech and Carnegie. Consequently, the concerns of both institutions were never properly addressed, and "... the problems between Caltech and the Carnegie Institution ... became worse as the years went by." (ibid.).

Another interesting comment from Bacher was that he and Bowen got along very well together, except when it came to staffing appointments:

The only problem I ever had with Bowen was that he hated to act on any appointments at Caltech in astronomy. He was responsible, not I, for the research carried on at Caltech in astronomy. Things having to do with teaching reported through the Division, and things that had to do with research reported through the Observatory. But if somebody had to be appointed, connected with research and so on, he'd always say, "Well you do it, you do it." [But] Overall we got along just fine. (ibid.).

Bowen's reluctance to make appointments was somewhat disconcerting to Bacher, and the problem manifested itself later in conflicts which were to have serious repercussions (as reported below).

1.3 Conflict

Despite the agreement between Caltech and Carnegie regarding the equal right of access to all the equipment on either mountain, a letter written in 1969 by Jesse Greenstein (Figure 4) to Allan Sandage (Figure 5) indicated that there were problems:

Your letter brought up anxieties about the relations between the two Institutions. I might feel them also, but I believe it is important to act as if there were no important problems which we could not solve by mutual agreement. Most certainly there are real problems, and they are not all one-sided. We are doing our best to keep our cool, and to work out a rational arrangement with mutual respect. I have completely disinvolved myself in any CARSO [Carnegie Southern Observatory] activities from the beginning; I have been involved in attempts to foster better planning for all of Caltech astronomy, and for the future of Palomar, the possibility of a search for a new location ... (Greenstein, 1969).

However, these relational problems already existed in 1965 when Jesse Greenstein wrote John Bolton that the use of the Caltech and Carnegie telescopes was a delicate issue that impacted on the relations between the radio astronomers and their optical counterparts:

I should point out to you that the question of the use of our telescopes for identification of radio sources and accurate optical positions has been one of the most delicate ones between relations of the radio observers, the optical observers and guest investigators. At the present time a precarious working arrangement exists in which John Wyndham is identifying the sources for which the Caltech Radio Observatory finds positions, quite on his own. Subsequent to the preparation of his manuscript these positions are made available to Sandage and Schmidt. Thus I should warn you that you will be coming into a fairly complicated situation. Sandage is taking direct photographs for accurate optical positions and doing the photoelectric photometry and Schmidt the redshifts. Consequently, where your new data might overlap any from Owens valley or

Green Bank you are going to have direct competition with Sandage. (Greenstein, 1965).



Figure 4: Jesse Greenstein, who collaborated with Maarten Schmidt on the interpretation of quasars in 1963, and helped to instigate the founding of Caltech's OVRO. He became foundation Head of the graduate astronomy program at Caltech at the time of the inauguration of the 200-inch Telescope and the joint operation of the Mt Wilson and Palomar Observatories (from <http://pr.caltech.edu/periodicals/336/articles/Volume%202/10-31-02/greenstein.html>).

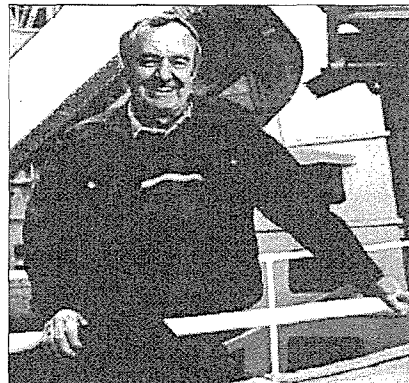


Figure 5: Allan Sandage has been a staff member of the Carnegie Observatories since 1952, and has been involved in researching the evolution of stars, galaxies and the Universe (from <http://www.ociw.edu/research/sandage.html>).

By 1969, there were indications of a possible rift in the relationship between the two institutions, as suggested in the following letter from Olin C. Wilson to Horace Babcock.

... no one here, I feel sure, has the slightest desire to break up the arrangement for joint operation of the Observatories which began in 1948. If there is any interest in such a move it certainly does not come from the C.I.W. staff, but must have originated elsewhere.

But I find another aspect of the matter even more unsettling, namely, what do we mean by the partnership of C.I.W. and C.I.T. in the astronomy business? My understanding is that it consists of an agreement for joint operation and joint use of certain expensive equipment, for the mutual benefit of both partners, but

that in no way implies dominance by one nor the loss of identity and self-determination of either.

If this view is basically correct, then I interpret your statement to mean that one of the partners does not subscribe to it. It seems to me that one partner is attempting to use threats and coercion against the other in order to force the latter to spend a large sum of its own money in a manner it deems deleterious to its own interests. Personally, I feel that such methods have no place in the partnership in question, and are entirely unworthy of either of the members. (Wilson, 1969).

What Wilson appears to suggest is that Caltech was coercing Carnegie into spending money in a manner that was not in its best interests. At the time, Wilson was the person who allocated observing time on the Mt. Wilson and Palomar Telescopes while Babcock (Figure 6), the recipient of his letter, was the Director.



Figure 6: Horace Babcock invented and built many astronomical instruments, including a ruling engine which produced excellent diffraction gratings, the solar magnetograph and microphotometers, automatic guiders, and exposure meters for the 100-inch and 200-inch Telescopes. By combining his polarizing analyzer with the spectrograph he discovered magnetic fields in other stars. He developed important models of sunspots and their magnetism, and in 1953 he was the first to propose adaptive optics. He was the Director of the Mt. Wilson and Palomar Observatories from 1964 to 1978. During this time he founded the Las Campanas Observatory in Chile (from <http://www.phys-astro.sonoma.edu/BruceMedalists/BabcockHW/>).

In a recent interview, George Preston, the Director Emeritus at Carnegie, explained why there was conflict between the Caltech and Carnegie astronomers:

There was a profound asymmetry in the relationship between Carnegie and Caltech by 1980, because we had been contributing, since the end of World War II, to the aging outmoded telescopes on Mt. Wilson—the 60-inch and 100-inch reflectors—in a light-polluted site. Because the telescopes were old and because the site was polluted, nobody was much interested in investing money in them, and they were growing more antiquated and inadequate with every passing year. Caltech was interested in supporting Palomar at that time, and I think that Caltech astronomers felt that we were not pulling our own weight in the joint operation. We were

contributing aged telescopes in a light-polluted site that nobody wanted to use, and we were making demands for the much-coveted telescopes at Palomar (which were) bigger telescopes, more modern and in a darker sky. This led to a kind of estrangement and a feeling on the part of the Caltech astronomers that they were not getting their money's worth. They were giving telescope time and they were not getting anything back. (Preston, 2006).

It seems clear that even in the early 1960s Caltech and Carnegie had a somewhat precarious relationship, despite the contractual arrangement between the two institutions. This is similar to the way in which Maarten Schmidt saw the situation when he became Director more than a decade later.

When Schmidt (Figure 7) assumed the Directorship of the Hale Observatories in 1977, the 'Observatories' consisted of Palomar and the Big Bear Solar Observatory, and on the Carnegie side Mt. Wilson and Las Campanas in Chile. In an interview conducted in 1999, Schmidt commented that

... the relationship between Caltech and Carnegie concerning the observatories had not been overly good. And curiously enough, that didn't apply so much to the astronomers but more to the administrative levels. Jesse Greenstein certainly had his conflicts with the Carnegie administration. (Schmidt, 1999).

Schmidt acknowledged that part of the conflict stemmed from the fact that while the two halves of the Hale Observatories were financially and organizationally independent and the facilities were utilized jointly.

An additional operational difficulty was that the Caltech astronomers had undue influence over the appointment of Carnegie staff, and *vice versa*:

If the Caltech group proposed that a potential faculty appointee become a staff member of the Hale Observatories, that then had to be approved by the Observatory Committee, which consisted half of Carnegie and half of Caltech astronomers. So that meant that the Carnegie side was able to influence, or bias, or perhaps even veto, or make difficult, Caltech's academic appointments. (*ibid.*)

In October 1979 an appointment by the Carnegie side was rejected by the Caltech astronomers, and because of the bitterness that resulted Schmidt felt that the system was not working, so in his capacity as the Director he wrote a letter to the Carnegie and Caltech Presidents proposing that the operational agreement between the two institutions—which had existed since 1948 and been amended several times—should be terminated (*ibid.*). At the same time he tendered his resignation, effective from 1 July 1980 (i.e. in nine months time).

According to Schmidt (*ibid.*), telescope accessibility was not the issue. The problem seemed to be the organizational structure that created awkward relationships that could have devastating decision-making implications. Apparently, Carnegie President, James Ebert, and Caltech President, Marvin L. Goldberger, were very surprised by Schmidt's letter. As it turned out, the Carnegie side opposed the separation, while the Caltech side supported it. In Schmidt's opinion, Carnegie felt that part of their strength was in a solid union with Caltech in astronomy, while access to the 200-inch Palomar Telescope might be jeopardized by separation. However, physicists at Caltech involved in

