WALTER SYDNEY ADAMS
1876-1956

WALSTER SYDNEY ADAMS was born on 20 December 1876, in the village of Kessab near Antioch in Northern Syria, then a province of the Turkish Empire. His father and mother, Lucien and Nancy Adams, were missionaries under the American Board of Commissioners for Foreign Missions with headquarters in Boston. They were both college graduates—Lucien of Dartmouth College and Andover Theological Seminary, Nancy of Mount Holyoke College. Walter was the youngest of the family. In the village in which he lived there were no schools except one for Mohammedan children and one for Armenians, so he received his earliest training in the elements of arithmetic, grammar and geography from his mother. For books he had his father’s library which, apart from theological books, consisted largely of histories and classical text books and treatises. At the age of six he knew more of the history of Athens and Rome, and of the campaigns of Alexander the Great and Hannibal than of the rise and development of the United States. In 1885, when Adams was eight years old, he moved with the family to the United States and settled in the village of Derry, New Hampshire, his father’s old home.

His education was continued at first at the village school and then at Pinkerton Academy, a privately endowed secondary school in the village. In 1890 his father returned to Syria and Adams was sent to St Johnsbury Academy in northern Vermont where he completed his college preparatory course. He then, largely for health reasons, spent a year on a Massachusetts farm and a year at Phillips Academy, Andover. Here his early classical education was followed by study in mathematics, physics and chemistry. He graduated from Andover in 1894 and then entered Dartmouth College where he studied under Frost; he graduated A.B. in 1898. This was followed by two years’ graduate study at the University of Chicago where he worked under Moulton, Laves and Bolza for his A.M. degree. In 1899 he published his first paper on ‘The polar compression of Jupiter’. At the suggestion of Hale and Frost he proceeded in 1900 to Munich to work for a Ph.D. degree under Seeliger and Schwarzschild; but at the end of a year he received from Hale the offer of an appointment as computer and general assistant at the Yerkes Observatory, which offer he accepted and he returned to live in Chicago.

At Yerkes he commenced his study of the radial velocity of stars to which he was to devote much effort in later life, working at first with Frost; he also served for a year as an instructor in astrophysics and as an assistant astronomer,
before he was invited by Hale in 1904 to join him, along with Ellerman and Ritchey, in the task of establishing a new observatory on Mt Wilson in California. Actually Adams went with Hale from Chicago to California before the scheme for the high tower solar telescope and the 60-inch stellar telescope had been approved by the founders of the Observatory, the Carnegie Institution of Washington, and before the necessary large financial grants had been decided upon. Not for the last time was Adams to witness the disappointments and frustration attending successive steps by Hale in pressing forward his schemes for larger instruments for the Mt Wilson Observatory and the ultimate success achieved on each occasion.

Adams accompanied Hale on his second visit to the top of Mt Wilson in 1904 and for the rest of his life he was to be the devoted colleague of Hale and servant of the Observatory. He was to be an Assistant Astronomer 1904-9, Assistant Director or Acting Director 1909-23 (during which period he was frequently actually serving as Director during the absence of Hale for illness or other reasons), and Director 1923-46. He and Hale worked closely together in the building and planning of the observatory. Conditions of life on the mountain were very primitive at first and difficulties of transportation up the mountainside were serious. A foot trail was improved into a mule trail fit for pack transport; this was in turn widened to allow for a mule waggon team and later for a truck. Adams had many amusing tales about the mules and their burdens, both living and material. The early widenings of the trail had to be done by hand; when some ten years later the track was widened again for the transportation of the parts of the 100-inch telescope power shovels and drills were available to help.

It was good that Adams was a fine walker and athletically active. In the early days observers would walk up the mountain—an eight mile trek—adjust or change instruments in the afternoon and observe all night. Adams walked up the mountain trail some 200 times, though, charged as he was with the erection of the buildings on the summit, he naturally stayed up for long spells in the early days. The single log cabin known as the Casino, which was the only available building at first, was replaced by the Monastery for the resident observers. The building for the Snow solar telescope had to be designed and erected and spectrographs installed: and as soon as regular observations had commenced the 60-ft. solar tower telescope had to be erected and preparations made for installing the 60-inch stellar telescope. The transportation, construction and erection of this telescope and its building provided a major problem for nearly two years.

In addition to the supervision of the building programme on Mt Wilson Adams was occupied in designing spectrographs for the 60-inch telescope for use at the primary focus, the Cassegrain focus and the coudé focus: these had to be designed to suit the proposed programme for the telescope; this included radial velocity investigations comparable with those carried out on other large telescopes but extended to fainter stars, and the application to much higher dispersion of the greater light-gathering power of the telescope.
Later a laboratory had to be installed for the use of Gale and King in their study of spectra under varying conditions of temperature and pressure. Optical tests also were carried out by Adams, for instance on Ritchey's 30-inch mirror for the Helwan Observatory, and later a comparison of the optical performance of the 60-inch and 100-inch mirrors.

With all this administrative work on his hands and while waiting for the erection of the 60-inch telescope, which was to be used to continue his studies of stellar radial velocities, Adams carried out with Hale investigations on the spectra of sunspots, paying especial attention to the lines widened or doubled in sunspots, and to those which were intensified or weakened. Hale's discovery of magnetic fields in sunspot dealt largely with the first group of lines. Work in the laboratory with Gale showed that the lines which varied between spot and disk also varied in arcs carrying currents of differing strength and also in different parts of the arc. Hale, Adams and Gale identified the source of these changes as differences in temperature. Alfred Fowler carrying out simultaneously in London work on condensed spark discharges regarded electrical excitation as the main factor concerned. As Fowler developed the modern theory of ionization, thus opening a new epoch in the rational interpretation of spectra, it became clear that the 'enhanced lines' which were weakened in spots were lines due to ionized atoms. Their greater strength in the chromosphere was not understood at first but was explained subsequently by Saha as a result of diminished pressure.

The work on the spectra of sunspots was carried out at first with the Snow telescope and spectrograph mounted horizontally; the erection of the 60-ft. tower telescope with its improved seeing and the higher dispersion given by the 30-ft. spectrograph greatly improved the quality of the spectrograms available. Adams with Hale and others was able to identify titanium oxide bands in spots, to examine the differences in intensities and wave-lengths of lines between the spectra of the centre of the solar disk and the limb, to study the flash spectrum without an eclipse and to verify the presence of convection currents in the solar atmosphere. Before the 60-inch telescope was erected the Snow telescope and the tower telescope were used to obtain high dispersion spectra of one or two stars. But the long exposure times required, 29 hours spread over four nights for Arcturus, prevented this work from being continued.

One other important investigation by Adams on the sun must, however, be mentioned, his classic investigation of solar rotation. His initial study with the Snow telescope was followed in 1908 by one using the tower telescope and the 30-ft. Littrow spectrograph. He confirmed his earlier result that higher levels in the sun's atmosphere showed a higher rate of rotation. He showed that the best fit for the equatorial acceleration was given by Faye's equation and that the equatorial acceleration was less marked for the higher levels in the atmosphere. He noted also that, when sunspot vortices were close to the limb, he got discordant results agreeing with a counterclockwise rotation in the northern hemisphere.
With the completion of the 60-inch telescope, Adams took charge of the stellar radial velocity programme, working in particular with Joy, Sanford and Strömberg. The selection of stars to be examined was based on varying considerations; some brighter stars were chosen for comparison with those examined at Lick and Victoria with a view to a select list of standard velocity stars; some were chosen at the request of Kapteyn, mostly A and B stars of known proper motions; others chosen were faint dwarfs, spectroscopic binaries, long-period and Cepheid variables, stars with bright hydrogen lines. Altogether Adams was concerned with producing lists of radial velocities for some thousands of stars; before he ceased to be Director of Mt Wilson Observatory R. E. Wilson had commenced the preparation of the General catalogue of stellar radial velocities for 6739 stars of which Mount Wilson had contributed data for half.

Adams's early experience on radial velocity measures with Frost at Yerkes, his detailed study of the lines in the high dispersion spectra of the sun's disk and sunspots had enabled him to make the best possible use of the spectra of high dispersion that he obtained with the 60-inch and of the still higher dispersion available with the 100-inch telescope when it in turn became available.

In addition to the fuller studies that will be discussed later he published a whole series of short notes and papers on special points of interest in the spectra of individual stars; a great many of these were written jointly with Joy with whom he worked in the closest contact for years; in some cases he took advantage of the high dispersion spectra available to discuss points of interest in the special researches of others and he published joint papers with Shapley and Schwarzschild on Cepheids, with Humason on the red shift and on white dwarfs, with Greenstein on $\nu$ Sagittarii, a star with a nebulous envelope and a number of unexplained spectroscopic features, with Merrill on $\tau$ Scorpii, a star with discordant radial velocities, and with Russell and Mrs Moore-Sitterly on the calibration of Rowland's scale of intensities and on a method of analyzing stellar spectra for abundance of elements. Among his many papers on individual stars mention must be made of those in which he made valuable contributions to our knowledge of the following: $\alpha$ Orionis, $\gamma$ Cygni, $\alpha$ Boötis, $\alpha$ Canis Majoris, $\alpha$ Canis Minoris, $\beta$ Capricorni, $\epsilon$ Aurigae, $\circ$ Ceti near minimum, Boss 46, Boss 1517. Adams took advantage of the fine lines in the high dispersion spectra of $\alpha$ Boötis to make a determination of the solar parallax.

Adams published a number of papers on the spectra of novae, examining most of those that appeared from 1901 to 1936. At first he was inclined to attribute to some kind of dissociation the displacements of successive hydrogen absorptions, which he noticed to be in the ratio of 1:2:3. But when in the spectrum of Nova Aquitae 1918 he recognized an $\alpha$ Cygni absorption spectrum apparently displaced by a simple Doppler effect, he adopted the idea of an expanding shell or of a succession of shells as being the simplest explanation of the earlier spectra of a nova. With the great light-gathering power available
at Mt Wilson he was able with Pease to photograph a nova spectrum to a late stage in the fading of the star and could follow it through the nebular stage to the Wolf Rayet stage and explain puzzling changes in colour in terms of the bright bands present at any stage. He was also able to secure interesting details of the changes in the spectrum of *Nova Herculis* 1934 during its deep minimum and again during the subsequent slow fading. The discovery with Joy of coronal lines in the spectrum of *Nova (RS) Ophiuchi* 1901 at its outburst in 1933 should be mentioned as one of the many details of changing nova spectra that Adams secured for the use of the students of novae.

A dramatic element enters into the story of the next piece of research to be described. In 1918 Adams had attempted to examine the spectrum of the companion of Sirius, obtaining a spectrum at the 80-ft. focus of the 60-inch telescope. He secured almost certainly a line spectrum of the star identical with that of Sirius and he was clear that the colour indices of the two stars were the same. This led Eddington to predict that the companion was a white dwarf of extremely high density and to estimate a displacement of the lines of the spectrum to the red in accordance with the theory of relativity. In 1925 when the International Astronomical Union was meeting in Cambridge Eddington gave a lecture on relativity in the course of which he announced that he had just received a telegram from Adams: with the 100-inch telescope at the Cassegrain focus (135 ft. focal length), with a 40 minutes' exposure and a separation of the two stars of 10", Adams had secured a spectrum of the companion and had found, after allowing for the velocity of Sirius and an orbital correction, a displacement to the red of 21 km/s; Eddington's theoretical value was +20 km/s at A4500. Subsequently, using an improved orbit for the binary Adams altered his relativity displacement to +19 km/s, but the confirmation of the theory of relativity held good and has remained as, perhaps, the most striking instance of the skill of Adams in his study of high dispersion spectra obtained with the 100-inch telescope.

A further case where Adams had to pay careful attention to the delicate matter of slight changes in a spectrum in the presence of a strong overlying spectrum was in his search with Dunham for evidence of oxygen and water vapour in the atmospheres of Mars, Venus and Mercury. Confirming the results of St John and Nicholson they found no indication of either in the spectra of Venus and Mercury. In the case of Mars spectrograms taken at the coude focus of the 100-inch gave for oxygen an upper limit of less than 1 per cent (and probably less than one-tenth of 1 per cent) of the amount in the earth's atmosphere above equal areas of surface, while for water vapour there was no evidence and an upper possible limit could be given as 5 per cent of the amount in the terrestrial atmosphere above Pasadena.

Reading Adams's papers one feels that one is reading a chapter in the history of practical astro-physics. To appreciate his greatest contribution to astronomy, the development of the method of spectroscopic parallaxes it is necessary to go back to the last century. Ritter and Homer Lane had worked out a theory of the condensation of a contracting mass of gas, steadily rising
in temperature to a maximum and then cooling again. Norman Lockyer followed these views in his stellar classification which contained red stars, now described as giants and dwarfs, at the two ends of the scale of evolution. He pointed out differences in the spectra of these two groups, but there was at that time no physical observations nor theory to support his views and, after a period of controversy, opinion hardened in favour of a simple line of evolution down the main sequence of stars from hot to cool stars. It was not long, however, before Hertzsprung and Russell, with increasing observational data of the brightness and parallaxes of stars found convincing evidence that the red or cool stars fell into two widely separated groups of giants and dwarfs; one or two tentative suggestions were made by Schwarzschild and Hertzsprung that differences in spectral details might be directly linked with a star's luminosity.

Meanwhile Adams in his detailed work on sunspot spectra and on the behaviour of 'enhanced lines' in the laboratory had been applying his spectroscopic experience to stellar spectra. Working at first with Kohlschütter, who had developed a quantitative method of stellar classification by inter-comparison of sharp and diffuse lines in the spectrum, he used material gathered together for a study of radial velocities of stars with large and small proper motions and stars of known parallax. They found that stars with small proper motions but of the same spectral type showed an obvious weakening in the continuous spectrum in the ultra-violet, rightly interpreted as inter-stellar absorption. But they also noticed that the stars with small proper motions—on the whole more distant and intrinsically brighter—had abnormally strong hydrogen lines (not to be ascribed for various reasons to interstellar absorption) while other pairs of lines showed relative intensities varying with proper motion. Applying these differences, measured on a simple quantitative scale, to stars of known parallax, they found simple relations between luminosity and spectroscopic differences. Thus the spectroscopic method of determining a star's parallax had been discovered: an examination of its spectrum gave its absolute magnitude; its apparent magnitude then gave its distance. The first joint paper appeared in 1914 and Kohlschütter was shortly afterwards recalled to Germany on the outbreak of World War I.

It fell to Adams in a series of valuable papers to develop fully this most important method of extending our distance probe into the surrounding stellar universe. He widened the scope of the method to include stars of various spectral types, he developed more accurate scales for the quantitative measurement of spectroscopic differences, on which the method entirely depended. As more and more accurate trigonometrical parallaxes were published by Yale, Leander McCormick, Yerkes and Mt Wilson Observatories he checked and rechecked his scales. The work of A. Fowler in the laboratory coupled with the theoretical researches of Saha, Milne and R. H. Fowler gave a physical meaning to the differences in the spectra which had been lacking for Lockyer's earlier work; it was indeed atomic dissociation.
that was involved but not of the type Lockyer had postulated. Ultimately Adams published with Joy, Humason and Miss Brayton a catalogue of 4179 stellar parallaxes, essentially complete for the stars north of $-20^\circ$ in Boss's Preliminary general catalogue, with other stars from Kapteyn's selected areas, and a number of visual binaries, and stars with known trigonometric parallaxes, and large proper motions.

One further major contribution of Adams's must be mentioned—the study of clouds of interstellar gas. Beals had discovered in the spectra of several stars a doubling of the interstellar lines H and K of ionized calcium, and his observations had been confirmed with moderate dispersion by Sanford at Mt Wilson. Adams used high dispersion with the 100-inch telescope and found double or multiple interstellar lines for 80 percent of the stars examined. He found that there were two classes of cloud: (a) with CN, CH, CH+ prominent and H and K of moderate strength; and (b) with H and K strong, CN and CH faint or absent and with neutral sodium, calcium, iron and potassium and ionized titanium well marked. In four cases four clouds were found moving with different velocities in the line of sight ranging up to 100 km/s. The larger and thicker clouds moved more slowly, the thinner and smaller clouds with the higher velocities; CN generally appeared with CH, which was found less frequently than CH+.

Reference has been made to the tasks that fell to Adams in the early days on Mt Wilson preparing for the Snow telescope, the tower telescope and the 60-inch stellar telescope. Similar responsibilities were largely his in the case of the 100-inch telescope for which the road up the hill had to be widened once more. Adams again had to take his share in the design of spectrographs for the 100-inch telescope; the change from prismatic to grating spectrographs with specially blazed gratings by Wood and Babcock, the application, with Dunham, of Schmidt optical principles, all called for his attention. From 1909 onwards he frequently carried the load of duties as Director. He has recorded the shock when with a party including Hale he attended the first optical test of the 100-inch Hooker telescope after the mirror had been mounted: six or seven images of Jupiter partly overlapping each other were to be seen. It transpired that the workmen had been letting direct sunlight fall upon the mirror; by 3 a.m. the same night the mirror had returned to normal.

After Adams became Director in 1923 he was responsible for the annual report of the Observatory, a document eagerly read at other observatories to find the latest discoveries and developments in work in progress. One of these reports gave his views of the organization of a research observatory and the need to apply to every suitable field all progress made in any one field. His co-ordinating power in the work of the observatory is reflected in the number of papers that he wrote jointly with the members of his staff.

Adams again took an active part in the realization of Hale's pipe-dream—the 200-inch telescope now on Mt Palomar. In 1926 he took Mr Thorkelson of the General Education Board of the Rockefeller Foundation up to the
Mt Wilson Observatory; it was Thorkelson's report that led to a subsequent visit of Wickliffe Rose and Thorkelson and to the grant of $6,000,000 from the Rockefeller Board. Adams was also involved in the further negotiations that led to the approval of the final scheme. He always as Director attended the Observatory Council, which was the executive body making the final decisions upon major questions affecting the 200-inch telescope. There were two other committees, which reported to the Observatory Council—a policy committee, dealing with such general questions as the functions of the telescope and the auxiliary instruments, and a construction committee, dealing with technical questions of design and engineering. In 1934 Adams must have revived old memories of the Toll Road on Mt Wilson when he drove up the Nigger Trail on to Mt Palomar to assist in the selection of the site for the new observatory. The dome, details of the mounting, the drive and control system were all finished or settled before Adams retired in 1946, a retirement delayed for two years on account of World War II.

He did not sever his long connexion with the Observatory, continuing to work as a Research Associate of the Carnegie Institute of Washington, 1946-8, and of the California Institute of Technology, 1947-8. He thus maintained his link with the Mt Wilson Observatory throughout its whole history from 1904 to 1947 when it was merged with the Mt Palomar Observatory under the joint control of the Carnegie Institution of Washington and the California Institute of Technology. It was natural that he should be the guest of honour at the Jubilee Dinner at Pasadena on 20 December 1954. He had also naturally been chosen by the National Academy of Sciences as one of the delegates to the Royal Society’s celebrations of the Newton Tercentenary in 1946. He gave an address on ‘Newton’s contributions to observational astronomy’ illustrated by the great developments that had sprung from Newton’s discovery of the spectrum and invention of the reflecting telescope. Adams continued active to the end, a very typical paper ‘Notes on the Shell lines and the radial velocity of Alpha Orionis’ appearing in the last number of The Astrophysical Journal before his death.

Many honours came his way. He was awarded the Gold Medal of the Royal Astronomical Society in 1917, the Draper Medal of the National Academy of Sciences in 1918, the Prix Janssen of the Société Astronomique de France in 1926, the Bruce Medal of the Astronomical Society of the Pacific in 1928 and the Janssen Medal of the Paris Académie des Sciences in 1935. He was an honorary doctor of Chicago, Columbia, Dartmouth, Pomona, Princeton and Southern California. He was a Foreign Associate or Member of the Royal Astronomical Society, 1914, the Royal Swedish Academy, 1935, the Institut de France, 1945, and the Royal Society, 1950. He was a member of the National Academy of Sciences and of the American Philosophical Society; he was President of the Astronomical Society of the Pacific, 1923, of the American Astronomical Society 1931-4 and of the Pacific Division of the American Association for the Advancement of Science in 1929.
He was a Vice-President of the International Astronomical Union, 1935-48, and acted as General Secretary 1940-5 to keep the Union alive during the war years, when the General Secretary, Professor Oort, was cut off from participation in international activities. He was also the first President of the Commission of the Union on the Spectral Classification of Stars, President of the Commission on Radial Velocities and a member of five other commissions. In his connexions with the Union he showed himself, as ever, a valuable adviser, willing to co-operate and help when called upon.

Adams was twice married. His first wife, Lilian M. Wickham, died in 1922. His second wife, Adeline L. Miller, survives him with two sons. He died on 11 May 1956 of a cerebral thrombosis after a short and painless illness.

F. J. M. Stratton

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