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OLIN CHADDOCK WILSON
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A Biographical Memoir by

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January 13, 1909–July 13, 1994

BY HELMUT A. ABT

OLIN C. WILSON was a stellar spectroscopist who spent his entire research career (1932-82) observing at the Mt. Wilson and Palomar observatories. He is known for being the first person to derive activity cycles in other stars analogous to the 11-year solar cycle. He also showed that the widths of the chromospheric Ca II emission lines in late-type stars provide accurate measures of their luminosities—the Wilson-Bappu effect. He is known for showing the complex internal motions in planetary nebulae and the Orion nebula; the latter shows evidence of shock waves and turbulence that is non-Kolmogoroff. He also demonstrated that many Wolf-Rayet stars are members of double stars and that they are under-massive. He also showed that the chromosphere of the supergiant zeta Aurigae consists of sheets or clumps, not a smoothly varying density gradient.

Olin Wilson was born in San Francisco, California, on January 13, 1909. His father was a lawyer who had moved to California in 1904, and his mother came from Iowa. They lived just south of Golden Gate Park. Fortunately they were not seriously affected by the earthquake and fire of 1906. His father worked downtown and rode the streetcars; they did not have a car. Their income was only moderate. Olin was an only child and his parents were kind to him and were supportive of his interests.

Olin went to the San Francisco public schools and showed an interest in the physical sciences. In high school when the substitute general science teacher showed her lack of knowledge about astronomy, Olin developed the habit of learning by himself at the public library. He also attended the lectures in Golden Gate Park that were organized by the Astronomical Society of the Pacific. For instance, he remembered hearing Sir Arthur S. Eddington, probably in 1924, when Eddington received the Bruce Gold Medal of the Astronomical Society of the Pacific. Olin, at 15, remembered that the talk was all about relativity and he did not understand it, but Eddington later became one of Olin's heroes. Because it was foggy in San Francisco nearly every night, he never looked through a telescope until he was at the university.

There was not much doubt that Olin would attend the University of California in Berkeley, partly because his family supported his desire for more education, partly because he had heard that Berkeley had an excellent astronomy department and partly because he could commute there by ferry. In addition, the university was cheap then; there was no tuition and the fees were only approximately $25 per semester. Olin graduated from high school in December 1925 and started at the university in January 1926 at the age of nearly 17.

In Berkeley Olin became disappointed with the astronomy department's concentration on celestial mechanics, because he was much more interested in the nature of stars and in the applications of physics to astronomy. Therefore he majored in physics but he did take courses under C. D. Shane, A. O. Leuschner, William H. Williams, Raymond T. Birge, and Donald H. Menzel. He helped support himself by grading mathematics papers (at 50 cents per hour). He also worked for a while for Birge, who was then determining the best values of the fundamental constants. That led Olin to write one of his first individual scientific papers (1932) on the constancy of the speed of light. He demonstrated that the reported constancy to six decimal places of the length of the meter was inconsistent with the reported variation in the third decimal place in the speed of light.

Donald Menzel came to Lick Observatory in 1926, having been a student of Henry Norris Russell at Princeton. He had a great influence upon Olin because both were interested in applying physics to astronomical objects, or what we now call astrophysics. Menzel first worked on measuring the Lick flash spectra of the Sun taken at eclipses from 1900 through 1908. Menzel employed Olin to measure the strengths of the chromospheric lines, and Olin received credit in the publication. That work was published in the *Publications of the Lick Observatory*, Vol. 17, 1931.

Olin's heroes in astrophysics were Ünsold, Menzel, Bowen, and Eddington. Bowen's explanation for the "mutilated multiplets" in nebular spectra in terms of a fluorescent mechanism impressed Olin and contributed to his selecting Caltech for graduate work.

Olin's father died in 1929, leaving little for his wife and son. His father's brother helped out for a half year until Olin could support his mother and himself. Olin visited Caltech in 1929 and talked with Bowen and J. A. Anderson, who was then in charge of the 200-inch project. Olin was strongly tempted to do his graduate work at Caltech, partly because of the facilities at Mt. Wilson and partly because of the caliber of the Caltech staff. He was offered a teaching fellowship that paid $75 per month for 10 months, and he and his mother managed to live on that amount. People like Olin who had to struggle financially during the depression never forgot that experience and it affected their outlook throughout their lives.

Caltech did not have an astronomy department in 1930; that did not occur until 1948 after the dedication of the Hale 200-inch, when Jesse Greenstein was brought from Yerkes to organize such a department. Therefore Olin was in the physics department; he took all the required physics courses or passed them by exam, but was allowed to do an astrophysics project for his thesis. In 1934 he received Caltech's first Ph.D. in astrophysics. His thesis was done under the supervision of Paul W. Merrill on the Mt. Wilson staff and was entitled "Comparison of the Paschen and the Balmer Series of Hydrogen in Stellar Spectra." Characteristic of the policies of the time, the lead author was Merrill.

In his second year at Caltech Olin was offered a full-time position, which had just been vacated by Nicholas U. Mayall at the Mt. Wilson Observatory. However, he had to give up his studies for one year. He worked for several of the staff astronomers mostly measuring plates for radial velocities. That position allowed him to buy his first car (for $200). Before the end of that year J. A. Anderson told Olin that he was going to teach an astronomy course the next year and asked Olin to be his teaching fellow, an offer that he readily accepted. With the approval of Director Walter S. Adams, Olin worked half-time for the Mt. Wilson Observatory, took courses at Caltech, and worked as a teaching fellow for Anderson. He also did some observing on Mt. Wilson that led to several of his first publications.

After graduation in 1934 Director Adams offered Olin a position at the Mt. Wilson Observatory as a computer. In those days computers were people, not machines. His duties were the same as before, namely to assist staff astronomers.

That same summer Donald Menzel invited Olin to come to the Harvard summer school. Olin drove east with David Thackeray, who was in this country as a commonwealth fellow, in Thackeray's car. Also in attendance were Otto Struve, Harlow Shapley, and graduate students Leo Goldberg and Jesse Greenstein. Thackeray then returned to Europe and Olin took the train west. Struve invited him to stop off at Yerkes Observatory, where Olin had dinner with the Struves before returning west.

After returning to Pasadena Olin received an offer from Struve to join the staff at Yerkes. Olin thought much about this, weighing his respect for Struve as a stellar spectroscopist against their lack of high-dispersion equipment. At that time the McDonald Observatory was under construction. Finally Olin showed the offer to Director Walter Adams. Adams, basically a very parsimonious person, hemmed and hawed, said he didn't want to lose Olin, and offered a staff position at $100 a year less than Struve's offer of $2,500. Olin decided that the difference was less than the increased home heating cost in the winters, and he became a staff astronomer.

His initial papers were often with astronomers Paul W. Merrill, Roscoe F. Sanford, and William H. Christie, but gradually they gave way to individual papers. He became well acquainted with and learned from the other astronomers, especially the stellar and solar ones who worked when the Moon was bright. Although he worked well with them, his political views were diametrically opposed to those of Merrill, and they avoided that topic. Merrill was staunchly Republican while Olin was liberal. In fact, Olin's political views were conservative on financial issues (due to his experiences during the Great Depression) and liberal on social problems, a combination that I have seen in others but for which I have not heard a label. More importantly, Merrill's philosophy for doing astronomy was to collect enough observations until they made sense, emphasizing unusual stars, while Olin's was based more on a physical understanding, particularly of normal stars.

When America entered World War II in December 1941, Olin was disgusted, because he did not like war. However, he felt that he should do something to help, so he asked Ira Bowen at Caltech who referred him to William A. Fowler, who had a war-related project and welcomed Olin's help. Olin was not told, for secrecy reasons, what they were doing but he quickly surmised. They took him to Goldstone Lake, where they were testing solid-fuel rockets. The rockets were about 2.5 inches (6 cm) in diameter and a yard (1 m) long. Most of them exploded because they were designed incorrectly; hence the remote location.

The solid fuel (propellant) was a mixture of nitrocelluloid plus nitroglycerine. To fit it into the rockets, it was often turned on a lathe. One day Olin missed by one minute being killed in an explosion when an assistant was shaping the propellant on a lathe and it exploded.

In the course of his work Olin made an invention that is still used in rockets to this day. He saw that the support for the rocket fuel could be improved, so he designed a new one that was easier to install and increased the throughput by 5 percent. Olin also operated a school for Navy personnel, teaching them the construction and use of rockets. Other astronomers who worked on the rocket project were Bowen, Robert King (of later laboratory transition values fame), Horace Babcock, Franklin Roach, Gerald Kron, and Nick Mayall.

In 1944 Olin left the rocket project because he did not think it was progressing. Instead be went to work for the aircraft torpedo project on Green Street in Pasadena. The challenge was that an anti-submarine torpedo launched from a plane often had its steering mechanism disturbed upon impact with the water. Therefore they had a torpedo-launching tube aimed at a reservoir behind Morris Dam in Azusa Canyon east of Pasadena to simulate the airplane launches. It was known that the Japanese air-to-submarine torpedoes were far superior, which was one reason for their success in Pearl Harbor.

One important personal benefit came from his war work, and that was in meeting Katherine E. Johnson, a secretary who also worked at Caltech, mostly in publications and later in its radio astronomy group under John Bolton. She and Olin were married on September 3, 1943, and enjoyed 50 years of happy life together. They complemented each other. Olin enjoyed his work, his home life, and an occasional friend or two over. Katherine was far more outgoing and loved social occasions. She kept Olin "connected" with the outside world. She acquiesced to his wishes but sometimes guided him farther into the world of other people than he would have ventured himself. She loved to talk with people while he liked to read a book. They raised two wonderful children. Nicole, born on December 24, 1945, eventually married chemist Dave McMillan, who joined the Purdue University faculty in West Lafayette, Indiana. They have two children. After the children were somewhat self-sufficient Nickie worked as the secretary to the mayor of West Lafayette. Randy Wilson married Erin and they also have two children. Randy became a high school counselor in Encinitas, California, just north of San Diego.

Olin returned to the Mt. Wilson Observatory in January 1946 at the same time Bowen became director in place of Walter Adams. Olin relished the freedom of being able to talk with others about what he was doing. He became acquainted with Walter Baade, who joined the Mt. Wilson staff in 1932, a year after Olin came, and he was impressed with Baade's abilities and insights. Baade once invited Olin to join the nebular group, but after some thought Olin decided to stay where his training had led him.

Except for his work during World War II, he remained at the Mt. Wilson Observatory (later successively called the Mt. Wilson and Palomar observatories, the Hale Observatory, the Mt. Wilson and Las Campanas observatories, and the Carnegie Observatories) for the remainder of his career. He continued with high-dispersion stellar and nebular spectroscopy until his retirement in 1974. He aided Sinclair Smith, Ira S. Bowen, and others with some of the new instrumentation and had equipment built for his use, but generally he did not design it or do much laboratory work. He lived through the times of sole dependence upon prism spectrographs, then grating spectrographs, and finally electronic detectors.

In accord with Carnegie Institution policies at the time he had to retire at age 65. However, he obtained an emeritus position for several more years beyond that to complete work on stellar activity cycles. His last observing was done in 1980. Later he was persuaded to sell his house in Pasadena and move with Katherine to West Lafayette, Indiana, to be near their daughter and her family. I last saw the Wilsons in March 1994, where they enjoyed the frequent company of Nickie and Dave and their children. Olin bought a pool table; astronomers used to play pool on cloudy nights, but now most of them watch television. Olin missed his astronomical friends. After a short illness he died on July 13, 1994, at age 85. Katherine was increasingly bothered with retinitis pigmentosa (tunnel vision) during the last three to four decades of her life to the point that she could not walk unassisted. After Olin's death she moved to California to be close to Randy and his family. She died on December 2, 2000.

Olin rarely traveled, even during vacations. He loved his pipe, reading, watching football on television, playing poker, and long walks on Friday evenings. He hated pretense and egotism in people but respected honesty. He always spoke his mind, often in salty language. He epitomized a good scientist in being skeptical, honest, modest, generous, and never arrogant.

With regard to research, Wilson called himself an "opportunist." That label was realistic for him and others because with the new tools of astrophysics, astronomers could for the first time draw far-reaching conclusions from stellar spectra. For instance, the identities and strength of certain spectral lines told them, through the use of atomic theory and laboratory transition values, the atomic abundances and nuclear processes that have occurred in the stars. The widths and shapes of the spectral lines told them about stellar rotation and atmospheric turbulence. The presence of sharp non-stellar absorption lines in the spectra told them about the amounts, temperatures, and random motions in the foreground interstellar matter. The presence of emission lines told them about chromospheric matter and excited matter around the stars. It must have been a strong temptation to observe one spectrum after another and discuss each special case. It was, and still is, a great and productive time for stellar spectroscopists. Whereas a few spectroscopists concentrated upon one class of stars for decades, Olin's technique was to study a class of objects for several years until he had learned as much about them as seemed possible at the time.

Olin's initial research was governed partly by the interests of his collaborators at the Mt. Wilson Observatory. For instance, Christie got him interested in the nearly unique opportunity furnished by zeta Aurigae for exploring the nature of the chromosphere of a supergiant (or perhaps bright giant) star. Every two and two-thirds years a relatively small (5-solar-radii) B star is eclipsed by the 300-solar-radii K supergiant. The latter has a very extensive outer atmosphere or chromosphere such that it takes a week for the light from the B star to pass through successive layers of the K chromosphere. Each night for a week the atmospheric absorption lines superimposed on the B star spectrum yielded abundances, temperatures, pressures, turbulent velocities, and large-scale mass motions. Because of the period, not every eclipse is favorably placed in the sky for observation.

Christie and Wilson (1935) explored the 1934 eclipse and Wilson analyzed the spectra from the 1939-40 eclipse (1948). The weather during the 1947-48 eclipse was excellent, and Wilson obtained coude spectra every night during ingress (into totality) and egress (coming out of totality). By that time Olin obtained the assistance of Helmut A. Abt, one of the first four graduate students (with Allan Sandage, Morton S. Roberts, and James Parker) in the new astronomy department started at Caltech in 1948. The resulting analysis was published as the first *Astrophysical Journal Supplement* (1954). Of particular interest was the result that the whole chromosphere should have been ionized by the B star's radiation unless the material is concentrated in a dozen or so (along the line of sight) thin dense sheets or clumps. Thus, the assumption of a smoothly varying density gradient in the outer atmosphere is far from the truth.

Olin joined astronomers Adams, Merrill, Sanford, and later Deutsch, Kraft, and Preston in the study of the interstellar lines that appeared in the spectra of early-type (or distant) stars. In each star's spectrum the interstellar lines had their own strength and radial (line-of-sight) motions. They soon realized that there was a pattern of radial velocities that depended upon galactic longitude. Thus, they attached a large (2- x 4-foot) graph to the hallway wall and each person added the position on the graph of the radial velocity of the interstellar matter for each star newly observed. Gradually it was found that these interstellar velocities showed a double-wave pattern that yielded the constants of galactic rotation. Various members of the team published the results. Merrill and Wilson published lists of unidentified interstellar lines, and Sanford and Wilson discussed the doublet ratio for calcium and sodium. Wilson (1939), having the tools of radiative transfer, could discuss the abundances and significance of a doublet ratio that showed saturation with increasing line strength.

Observations of the spectra of novae (exploding stars that become about 100 times brighter within two days) persuaded Olin to compute the line profiles of an expanding star, again using the tools of radiative transfer (1935). Further, the recent work relating interstellar line strengths with mean distance for stars could be used to determine approximate distances to several novae. This allowed Olin to obtain luminosities (absolute brightnesses) of novae at maximum light (1936). This reasoning was also applied by Sanford and Wilson (1939) to obtaining luminosities of Wolf-Rayet stars.

Olin started to become intrigued with the nature of Wolf-Rayet stars, ones that show extremely broad emission lines characterized by high temperatures. He soon found that many of them are in spectroscopic binaries with normal O or B stars, allowing a determination of their masses. Actually, the discovery of the first Wolf-Rayet binary (HD 193576) was serendipitous. He was looking for objects in which both the Ca II H and K interstellar lines could be measured without interference from Hε of hydrogen that is found in most early-type stars. He looked at two plates taken of HD 193576 on a spectra comparator and was surprised to see that if the interstellar lines were aligned, the emission bands moved. That meant that he had discovered the first Wolf-Rayet binary, and he could therefore determine its mass. The Wolf-Rayet stars were found to be under-massive for their luminosities (1940). Another strange characteristic of such stars is that their mean radial (line-of-sight) velocities are consistently nearly 100 km s^{-1} larger than for the companions. Could this be due to an expanding atmosphere as in the case of novae?

Olin suspected that Wolf-Rayet binary HD 193576 was also eclipsing and persuaded Sergei Gaposchkin to find out. Gaposchkin found that it was eclipsing and Gerald Kron obtained a photoelectric light curve. This allowed Wilson (1942) to show that the Wolf-Rayet star is larger and brighter than the B star. He explored the expanding-envelope hypothesis for the broadened emission lines. That hypothesis led to a prediction of a transit time effect, a difference between the observed times of eclipses and the predicted times based on the spectroscopic orbit. The observations led to constraints on the ejection velocity, and he showed that the emission line widths could not be produced simply by an expanding envelope. No satisfactory final model was produced.

After the interruption due to World War II his observing concentrated on the spectra of planetary nebulae. He finished previous work on interstellar lines and Wolf-Rayet stars, but he started to explore the internal motions of planetaries with "slitless" spectra. Guiding on a nearby star, he allowed the light from the planetary to go through the spectrograph without being partitioned with a slit. Because the spectra of planetaries consist of a few emission lines with a very weak continuum from the central star, he obtained a velocity "picture" of the planetary at each emission line. In addition, the nuclear star has absorption lines whose velocities vary with excitation and ionization potentials. The highest excitation lines are formed deepest in the atmosphere and the lowest are formed farthest out. Meanwhile the nebular lines show the presence of previous ejections. However, not all the line widths were understood. Some of this work was done together with Lawrence Aller at the University of California, Los Angeles, and Aller is continuing this work to the present day.

Olin could not resist doing some "neat" projects for which the facilities allowed solutions. For instance, the coude spectrograph of the Hale 200-inch allowed him to obtain spectra of 15 red giants in the globular cluster M92. The scatter in the radial velocities for constant-velocity stars is a direct result of the mass of the cluster. Wilson and Coffeen (1954) obtained the reasonable mass of 3.3 million solar masses and a mass-to-luminosity ratio of 2.0 in solar units.

A more difficult project, funded by the Office of Naval Research, was to determine the internal motions in the Orion nebula (1959). To do so by setting the spectrograph slit successively on each of many strips in the nebula would have been too wasteful of observing time on the 200-inch. Instead Olin devised a multiple slit of 31 slits, each separated by 1.3 seconds of arc, which is approximately the seeing size. They measured thousands of points in the nebula, each in several lines of different elements on 25 spectrograms. The lines showed some asymmetries and occasional doubling, indicating "bubbles" of 25 km s^{-1}. The velocities indicated internal turbulent velocities averaging 5-7 km. However, the velocities are not characteristic of a Kolmogoroff law but rather of shock waves producing subsonic eddies.

Another "neat" project was to ask if the redshift of a distant galaxy is proportional to wavelength, as it must be if it is due to a Doppler motion. Minkowski and Wilson (1956) measured the redshift in Cygnus A from 3830 to 6472 angstroms and also compared the results with radio measures. They found the redshift to be constant within 3 parts in 10^9

per 1000 angstroms, giving good support to the interpretation of the redshift in terms of motion.

In the late 1950s Olin did several projects to relate the spectral characteristics of late-type dwarfs with their photoelectric colors. In obtaining high-dispersion spectra he noted several unusual things. Some (1957) had emission lines in the bottoms of their deep broad Ca II H and K lines. He first saw that before World War II in the spectrum of Arcturus when he was just learning to use the 100-inch coude spectrograph. The H and K lines have such a high opacity that at their centers one is seeing only the outermost part of their atmospheres, namely their chromospheres. This is another example of a serendipitous discovery. He knew from solar research that the H and K emission was seen only in active regions and thus showed a strong variation during the 11-year solar cycle. He reasoned that if he followed the strength of the Ca II emission in other stars, he might discover "stellar cycles" in them too. Would they be 11 years long also, or shorter or longer? Would they depend on the age of the stars, their chemical makeup, or their temperatures?

In spectra placed on the spectra comparator he noticed that 61 Cygni (a dwarf) had narrow emission lines but the supergiant Betelgeuse (α Orionis) had very broad emission lines. He found that very interesting and baffling, but he couldn't do anything further about those observations, because he was preoccupied with planetary nebulae. An invitation to speak in a conference on stellar atmospheres in Bloomington, Indiana, in 1954 persuaded him to organize his material and announce the dependence of emission line widths upon luminosity (1954).

About that time Vainu Bappu was at Mt. Wilson Observatory as a Carnegie fellow, and Olin asked him if he were interested in getting some more spectra. He added about 5 percent to the collection and then returned to India without becoming involved with the measurements or discussion. Olin found that when he plotted the logarithm of the emission line widths against the absolute visual magnitudes, which are also on a logarithmic scale, he obtained a straight line over 15 mag. of luminosity. This straight-line relation holds only for visual absolute magnitudes for stars of various spectral types, G to M, not for bolometric magnitudes or other systems. Olin was frustrated that theoreticians were unable to explain this drastic effect. He could only calibrate it for the values of the parallaxes available at that time for the Sun, Hyades, and Pleiades. However, he found that the calcium line widths in visual pairs agreed well with their magnitude differences.

Olin and Sir Richard Woolley also looked at calcium line strengths and found that they were strong in young stars, weakened with age, and showed that galactic orbital eccentricities and inclinations increased with age as stars suffered encounters.

The project that took most of his time until retirement was to measure the strengths of the calcium K emission line to get the stellar analogs of the solar cycle. The observations were started in 1966 and his last observations were made in 1978. He selected 91 main sequence stars between F5 and M2. The emission lines become more prominent in the later-type stars, because the photospheric continuum is decreasing. He found that nearly all stars show slow variations and in 12 years he found periodic cycles for about 10 of them. This work is being continued by Sallie L. Baliunas of the Harvard-Smithsonian Center for Astrophysics, using a spectrograph designed by Arthur Vaughan with NASA funds.

Olin Wilson published approximately 94 papers, primarily in the *Astrophysical Journal* and the *Publications of the*

Astronomical Society of the Pacific. These extended for 50 years from 1932 to 1982.

Olin Wilson was president of the Astronomical Society of the Pacific during 1954-56. He received the society's Bruce Gold Medal in 1984 for a lifetime of outstanding astronomical research. He was elected to the National Academy of Sciences in 1960. He was chosen to give the 1977 Russell Lecture of the American Astronomical Society.

Olin assisted Ira Bowen in installing the coude spectrograph at the 200-inch Hale telescope in the early 1950s. He also made up the observing schedules for the light time on the Mt. Wilson and Palomar telescopes for more than 20 years until 1973. He did not teach courses at Caltech, feeling that his position at Mt. Wilson allowed him the freedom to do research, which should not be diluted by other activities.

Few people realized his effectiveness behind the scenes. Administrative members of the Carnegie Institution trusted him for his honest and carefully considered recommendations. For instance, he seems to have been the first person to persuade (in his letter to Merle Tuve of March 15, 1963) the Carnegie Institution to build a southern observatory. He pointed out that Mt. Wilson had lost its preeminence among Northern Hemisphere observatories, but the Southern Hemisphere was fertile ground for research.

I AM INDEBTED to Randy Wilson and David DeVorkin for use of a transcript of DeVorkin's long interview with Olin in July 1978. I thank Donald E. Osterbrock for his notes on a phone conversation in 1986 with Olin about his early life and for his review of an early draft of this memoir. George Preston's warm, sincere obituary for Olin (*Proc. Astron. Soc. Pac.* 107[1995]:97) was helpful and is a model for obituaries. The frontispiece, photographed in 1974, is reproduced with permission from the Carnegie Observatories.

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