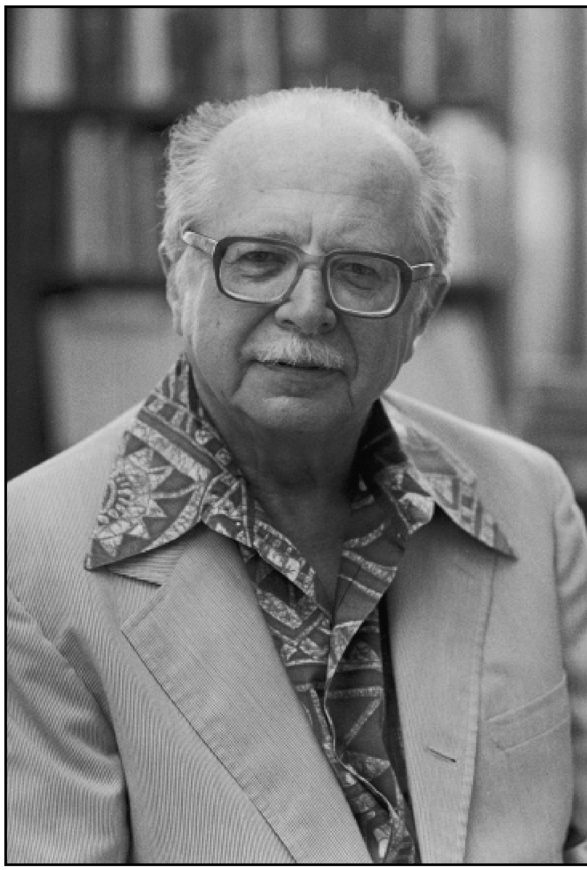
JESSE L. GREENSTEIN



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JESSE LEONARD GREENSTEIN, who died 21 October 2002 in Arcadia, California, added enormously to our knowledge of the structure and evolution of stars, especially faint ones, and built up the astronomy department of the California Institute of Technology from a one-man operation (himself) to one of the half dozen best-known in the world. He will perhaps be remembered longest in the astronomical community for coordinating and largely writing the decadal report *Astronomy and Astrophysics for the 1970s* (the Greenstein report), the first of these to include the full range of ground- and space-based astronomy and arguably the last whose recommendations were fully carried out in a timely fashion. Greenstein also accepted, with great grace, the curious distinction of being the first person ever defeated in a balloted election for the presidency of the American Astronomical Society, whose nominating committee had put forward only a single candidate for the office until 1972–73. He had previously served the AAS as vice president (1955–57) and councillor (1947–50), and the International Astronomical Union as president of Commission 29 (on stellar spectra) from 1952 to 1955. In addition to the American Philosophical Society, he was a member of the U.S. National Academy of Sciences and several foreign academies, and received medals and other honors from the NAS, the Astronomical Society of the Pacific (Bruce Medal), and the AAS (Russell Lectureship).

Jesse was born in New York City on 15 October 1909 and skipped rapidly through the Horace Mann School for Boys to start college at Harvard University at the age of sixteen. While there, he met Naomi Kittay (one of four daughters of a prominent business family in the area), whom he married in 1934. They had two sons, George (also an astronomer) and Peter, and she predeceased him by only a couple of months. Jesse's own paternal grandfather had brought his family to the United States in 1888 and prospered thereafter. Thus the growing boy had access to a wide range of books, a small telescope, a prism spectrograph, and amateur radio equipment. His road to astronomy was, however, an interrupted one. After receiving a Harvard A.B. in 1929 and an A.M. in 1930, and being prevented by illness from taking up a fellowship at Oxford, he returned to the Greenstein family business in manufacturing and real estate. In the process, he learned how to communicate with people from business and industry, a skill that remains rare in academe. It proved invaluable in his service to astronomy and to Caltech.

Greenstein's A.M. thesis attempted to establish the relationship between colors and surface temperatures of hot stars. It had already been noted by Cecilia Payne (later Gaposchkin, the first woman astronomer on the Harvard faculty and one of Greenstein's mentors) that the colors sometimes seemed very red ("cool") in comparison with the larger temperatures required to account for the levels of ionization and excitation in the stellar atmospheres. Sadly, he explained this as seasonal error in taking account of light reddening in the earth's atmosphere. In fact, the cause was scattering and absorption of light by dust in interstellar space, a phenomenon that had been suspected but also doubted for decades, and which was established later that same year by someone else.

Interaction with Payne, including work on variable stars (with which Greenstein kept his hand in astronomy while working in the real world), left him somewhat ambivalent about the role of women in science. Her brilliance was unquestionably underutilized at Harvard, leaving her frustrated and under-rewarded. Greenstein claimed in principle to be opposed to women in astronomy and was the Caltech program director when the first, eventually successful, female applicant for an astronomy Ph.D. was turned down on the grounds that women would not be able to tolerate the long, cold nights observing on mountain tops. But, in practice, four of the first six women to receive Caltech astronomy Ph.D.'s (including the present author) carried out either their second-year research projects or their dissertations under Jesse's guidance.

Returning to graduate school in 1934, Greenstein completed a thesis on the properties of that dust he had just barely failed to discover, both collecting the data and applying what was then the best available physics to interpret it. This mix remained characteristic of his later work.

Greenstein was probably the first conventionally trained astronomer to take radio astronomy seriously. Soon after Grote Reber's 1933 discovery of "cosmic static," he and Fred Whipple coauthored the first attempt at theoretical interpretation, finding that the only emission mechanism they, or anybody else at the time, could think of failed by a factor of 10,000 to match the observed brightness. In the 1940s and 1950s he showed that conventional emission by hot gas failed equally spectacularly to account for the radio waves from sources we now recognize as supernova remnants and radio galaxies, and he was in large measure responsible for the initiation of a radio astronomy group at Caltech, initially bringing John Bolton from Australia to head it.

Greenstein went to Yerkes Observatory operated by the University of Chicago with an NRC fellowship for 1937–39, and remained as a faculty member at Chicago and a staff member of the brand-new McDonald Observatory in Texas until 1948. While there, he participated in the design and use of novel spectrographs, showing that virtually the entire sky glows faintly with light from ionized hydrogen gas (previously thought to be concentrated in clumps), showed that interstellar grains are made of common substances like silicate and ices, and analyzed the second star ever to show a mix of the various chemical elements different from the standard one found in the sun and most stars (as established by Payne in her 1925 thesis). Such studies of anomalous stars were keystones in the 1957 achievement of understanding how all the other elements were produced in stars from hydrogen and helium, the chief architects of which were Geoffrey and Margaret Burbidge, Al Cameron, Nobelist William A. Fowler, and Sir Fred Hoyle.

During World War II, Greenstein worked with other Yerkes astronomers in optical design for gunsights, periscopes, fast lenses, and so forth, needed because U.S. industry had imported most optical components from Germany since the 1920s. There were spin-offs useful in both astronomy and medical imaging, while Greenstein learned how to interact with the military, a valuable skill in the decades after World War II, when much of his and other astronomical research was funded through the offices of scientific research of the navy and air force.

In 1948, Greenstein accepted an appointment as the first professor of astronomy at the California Institute of Technology. (Fritz Zwicky had been there since the 1920s, but with a physics chair.) The responsibilities included creating a graduate school, recruiting faculty for it, and assembling a staff for the newly opened and Caltech-owned observatory on Palomar Mountain. Throughout Jesse's tenure, Palomar retained close relations and interlocking staffs with the older Mt. Wilson Observatory as well as with Caltech. A number of the early appointments also came from Yerkes and Chicago, while the first handful of Ph.D. students were virtually all later very well known astronomers, all of whom have now themselves passed retirement age.

Following the move to Caltech, Greenstein became increasingly polarized between relatively private research and very public administration and service. On the research side, the 1949 discovery of interstellar polarization of starlight by John Hall and William Hiltner led Greenstein and Leveritt Davis to propose that it was the result of scattering by non-spherical dust grains with their spins aligned by magnetic fields along the spiral arms of the Milky Way. This made our Galaxy the third entity, after the earth (in 1600) and the sun (in 1908) to have a magnetic field recognized. Jesse said much later that it had been talks by Enrico Fermi about cosmic ray acceleration, shortly before he left Chicago, that had put magnetic fields in the field of his gunsights.

Other contributions during this period included (a) discovery of which nuclear reaction liberates the neutrons that make possible the synthesis of many elements heavier than iron in the late evolutionary phases of intermediate mass stars, (b) analysis of additional stars with non-standard compositions, especially very old ones that proved to be deficient in all the heavy elements, and (c), most conspicuously, work on white dwarfs and other faint stars with Olin Eggen and others, which increased the known inventories of these objects by a factor of something like one hundred, and our knowledge of their colors, sizes, brightnesses, surface compositions, and so forth by an even larger factor. And you could not reasonably expect me to leave out the measurement of the gravitational ("Einstein") redshifts for the first large sample of white dwarfs, which was my second-year research project with Greenstein.

Greenstein's involvement with quasars was not entirely a happy one. A few high-latitude faint blue objects were already in his collection of presumed white dwarf spectra to be analyzed some day. He later was frequently to be heard saying that his assumption of luminosities for them of a thousandth or less of the sun's brightness was surely a world record error in comparison with the 10^{12} solar luminosity truth, exceeding even the large failures of his early calculations for the radio emission by the Milky Way. But the nadir came with his 200-inch telescope spectrum of a source called 3C 48, an object more or less inherited from Allan Sandage, who had first observed it in 1960. Bluish color, and broad emission lines at what seemed to be the wavelengths of five-times ionized oxygen and singly-ionized helium. And a paper saying so, along with other proposed identifications for the features in the spectra of magnetic white dwarfs and supernovae, based on anomalous compositions for all, had already been submitted when the breakthrough identification of ordinary hydrogen lines in the spectrum of 3C 273 was made in 1963 by Maarten Schmidt. The moment Greenstein saw the lines in 3C 273 as being hydrogen at a redshift of 0.16, he recognized that the 3C 48 features must be the same lines at a redshift of 0.37, and he was coauthor of a paper saying so that appeared as part of the quasar discovery package in *Nature*. A paper by Greenstein and Schmidt the next year showed that the redshifts could not be due to strong gravitation like the white dwarf redshifts, because you couldn't have enough low-density gas at a sufficiently uniform gravitational potential to make the lines as bright as they are.

His later work on white dwarfs included at least two important items: the demonstration that nearly all must be very close to having the same mass (about 60 percent that of the Sun) because of the way they cool, and the recognition of some mysterious lines as ordinary hydrogen (again!) that had gone wandering, because of very strong magnetic fields, rather than gravitational ones. The sum total of these various topics increased his bibliography by about a hundred papers per decade between 1949 and 1979.

During the same period, Greenstein delivered about seventy-five named lectures, served on fifty major committees (peaking at twenty simultaneously), dedicated three buildings in one year, and, of course, coordinated the Greenstein report. He chaired the Caltech faculty board, served on the Harvard Board of Overseers, and participated in the National Academy of Sciences Committee on Science and Public Policy during the same 1965–71 years. Some of his advice was taken—against the use of nuclear weapons in Korea and in favor of siting the NASA Infrared Telescope Facility on Mauna Kea, and the Space Telescope Science Institute in Baltimore. He was also a successful fund-raiser for Caltech, for Harvard, for Palomar (including the reconditioning of the 60-inch with private funds), and for other public institutions, especially the Pacific Asia Museum in Pasadena, which has become the recipient of much of the Greensteins' extensive collection of Japanese art (which he used to rotate on the walls at home, so as never to become tired of any one item).

An attempt to raise Burmese cats was less successful, and resulted in a student being paid for house sitting in Burmese kittens. Jesse's feeling for fast, sporty cars was more a passion than a hobby, and he long held the speed record for trips from Pasadena to Palomar, twelve minutes, set in a Mercedes. The Greensteins regularly invited students and postdocs into their home, and virtually every one of his younger colleagues has some story to tell of an unexpected kindness or sympathy extended. To quote a letter read at his memorial service, "Jesse was, well, Jesse."

Elected 1968

VIRGINIA TRIMBLE
Professor of Physics, University of California, Irvine
Visiting Professor of Astronomy
University of Maryland, College Park

A more extended tribute appears in *Publications of the Astronomical Society of the Pacific* 115 (2003): 890–96.