Biographical Encyclopedia of Astronomers

Chandrasekhar, Subrahmanyan

Born Lahore, (Pakistan), 10 October 1910

Died Chicago, Illinois, USA, 21 August 1995

Indian-American theoretical astrophysicist S. Chandrasekhar shared the 1983 Nobel Prize in Physics (with William Fowler) for work done in the 1930s, which established an absolute upper mass limit, now called the Chandrasekhar limit, for an astronomical object in which the pressure support comes from electrons being crowded together as closely as quantum mechanics permits. This limit applies to white dwarf stars, such as the Sun will eventually become, and to the cores of more massive stars that then collapse into neutron stars or black holes

Chandrasekhar came from a scientific background, being the nephew of Nobel Prize winner (Physics: 1930) C. V. Raman. He received a first degree in 1930 from Presidency College, Madras (now Chennai), India, by which time he had published his first paper, on Compton scattering of energetic photons by stationary electrons. A government of Madras scholarship enabled him to go to Cambridge University, and some of the calculations leading to his most famous result were actually carried out on the long journey from India to England

Working under Ralph Fowler, Chandrasekhar wrote a dissertation on the structure of stars (in a particular approximation called a polytrope) when they were distorted by rotation or the close proximity of another star, receiving his degree in 1933. A fellowship at Trinity College, Cambridge, followed. He returned briefly to India in 1936 to marry a fellow physics student from Madras, Lalitha Doraiswamy, and one might reasonably have expected them to remain indefinitely in Cambridge. The later years there were, however, shadowed by a serious controversy with Arthur Eddington.

In 1937, the Chandrasekhars moved to the University of Chicago, where he was initially a research associate, then assistant professor, and He retired as the Morton D. Hull Distinguished Service Professor in 1985, but remained scientifically active until his last year. For the first couple of decades of his association with Chicago University, Chandrasekhar was at its Yerkes Observatory in Williams Bay, Wisconsin, where many of the astrophysics students worked, but he commuted weekly to Chicago to teach there as well, finally settling at the university in 1964.

The disagreement with Eddington arose when Chandrasekhar folded both special relativity and general relativity into his considerations of the internal structure of white dwarfs, leading to a different relationship between pressure and density, called relativistic degeneration, the existence of which Eddington simply denied. He therefore also refused to accept that there would be an upper limit to the possible mass of such dead stars, beyond which something else must happen (which we now call gravitational collapse). The two remained on good terms until Eddington's death, but it would not have been easy for them to work in the same institution, even if Cambridge University had been more hospitable than it then was to dark-skinned scholars

At Chicago, Chandrasekhar turned his attention sequentially from one major area of theoretical astrophysics to another. It is sometimes difficult to determine just how much input his students and other colleagues contributed to these programs (most of which ended with a single-author book). Norman Liebowitz is fully credited in the 1969 *Ellipsoidal Figures of Equilibrium*,

which deals with the stability and oscillations of rotating fluid spheres (one way of approximating complex stars), but that is not the case with Guido Munch, who co-authored several of the papers leading up to the 1949 *Radiative Transfer*, dealing with how energy works its way from the center of a star to the layers we see. Munch wrote several of the chapters in the book, yet is acknowledged only by indirection and as the person who prepared many of the drawings in the text.

Some of Chandrasekhar's important results from these many investigations were:

(1) a rigorous description of the relationship between matter and radiation inside stars (Stellar Structure, 1939);

(2) an upper limit to the mass possible in the inert core of a star before another nuclear reaction must start, the core begins to contract, or the star becomes a red giant (the Schoenberg-Chandrasekhar limit of 1942, with student M. Schoenberg);

(3) the concept of dynamical friction (*Principles of Stellar Dynamics*, 1942) in which a star moving in a cluster is slowed down by its own tidal wake;

(4) an instability in hot, magnetized gases that turns out to be important in the structure of accretion disks around white dwarfs, neutron stars, and black holes (*Hydrodynamic and Hydromagnetic Stability*, 1961); and

(5) a number of theorems concerning the mathematical structure of black holes with rotation and electric charge (Kerr and Riessner-Nordstrom black holes) and the stability of these structures (*The Mathematical Theory of Black Holes*, 1983, which Chandrasekhar himself suspected he might be writing for later generations, the concepts and mathematics being too dense for many of his contemporaries to penetrate).

During the last few years of his life, Chandrasekhar became interested in the work of Isaac Newton and the methods used in deriving the results in Newton's Principia. He recast many of Newton's propositions in modern notation, publishing the results as Newton's *Principia for the Common Reader* (1995). Consistent with the end, Chandrasekhar greatly overestimated what "common readers" were likely to be able to cope with

Chandrasekhar was the Ph.D. advisor of 46 students at Yerkes Observatory and the University of Chicago, including Margaret Krog-dall, Marjorie Harrison, Merle Tuberg, and other women (an unusually large number for the time), and at least two men who became, in due course, directors of major observatories: Donald Osterbrock (Lick) and Guido Munch (Calar Alto). He served as councilor of both the American Physical Society and the American Astronomical Society, but his most impressive contribution to the community was unquestionably his 19 years as managing editor of the *Astrophysical Journal*, an important publication when he took it over in 1952, but the world leader in the field by 1971, when he handed it over to Helmut Abt

In addition to the Nobel Prize, Chandrasekhar received more honorary degrees than he himself cared to tabulate. He was presented with medals from the United States National Academy of Sciences, the Royal Society (London), the Indian National Academy of Sciences, the Polish Physical Society, and many others, and was a member or fellow of the academies of science in the United States, United Kingdom, India, and Sweden. His nonscientific interests included classical music (especially Mozart) and Shakespeare, and he had a modest repertoire of light verse, brought out only on special occasions.

Roy H. Garstang

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