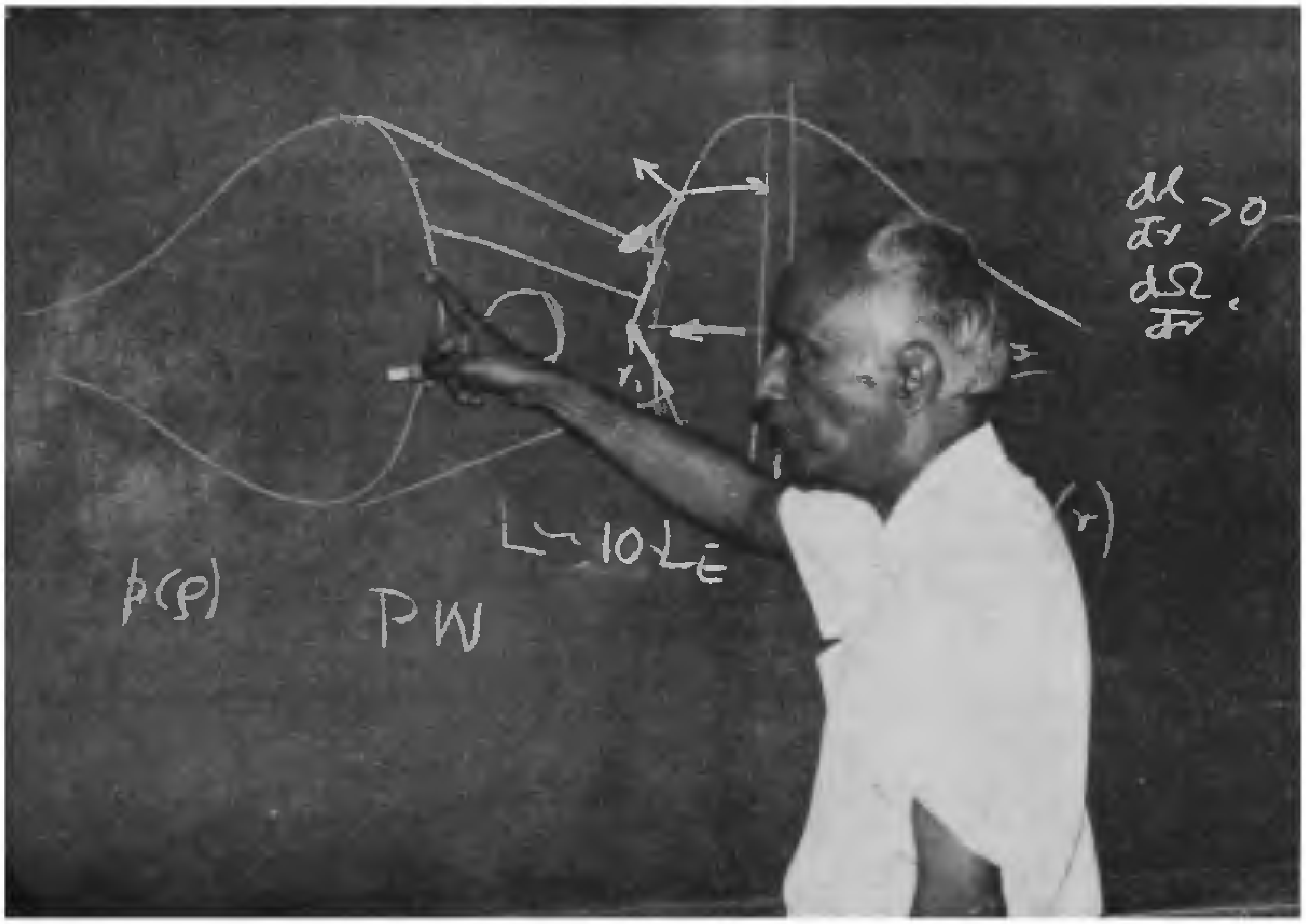
FELICITATION



"The Stars are as they are, because $(hc/G)^{3/2}H^{-2}$ provides a correct measure for their massess".

—S. Chandrasekhar.

The 1983 Nobel Prize for physics has been awarded to Prof. S. Chandrasekhar of the University of Chicago (jointly with Prof. William Fowler) for his outstanding contributions to stellar structure and evolution, particularly the end point of their evolution.

To the positivist philosophers of the eighteenth century it was meaningless to ask what the stars were made of. With the discovery by Fraunhoffer of absorption lines in the spectra of stars, and their interpretation by Kirchoff, the question acquired a meaning. By 1926, a *standard model* for main sequence stars had been developed by Eddington; the hydrostatic equilibrium of stars was to be understood in terms of the force of gravity being opposed by the sum of gas pressure (given by Boyle's law) and radiation pressure. However, the standard model ran into serious difficulty in explaining white dwarfs which are highly condensed stars with masses comparable to the Sun, but of planetary size. In a seminal paper published in 1926 R. H. Fowler argued that the stability of such dense stars must be understood in terms of the *degeneracy pressure of electrons* balancing the gravitational pressure. Interestingly, this was the first application of the newly discovered statistics of Fermi and Dirac. In 1930, young Chandrasekhar was a student at the Presidency College in Madras and this paper by Fowler made a great impression on him. He proceeded to work out a complete theory of white dwarfs along the lines suggested by Fowler. A closer examination revealed, however, that in the interior of white dwarfs of solar mass, the densities were so high that *special relativistic corrections* to the degenerate equation of state were essential. He derived such an equation of state, and using it in conjunction with the theory of polytropic gas spheres, discovered that the model led to a *unique value for the mass of the star*, unlike in the case of the nonrelativistic equation of state where finite equilibrium configuration existed for all masses. Given the chemical composition of the star, this mass was determined solely by a combination of fundamental constants — a truly remarkable result! Many of these results were obtained during his long voyage from India to England in July 1930. A few months after he arrived in Cambridge he published these results, and interpreted this unique value of the mass "*as representing the upper limit to the mass of an ideal white dwarf*". He followed it up by a detailed and rigorous consideration of the equilibrium configuration based on exact equation of state and showed that the radius of a white dwarf will tend to zero as its mass approaches the limiting mass. This limitig mass, ~ 1.4 solar mass, has come to be known as the *Chandrasekhar limit*. Once he had established that stars less massive than 1.4 solar mass could end their lives peacefully as white dwarfs, he turned to the evolution of more massive stars. The first question to be answered was under what conditions will a star, initially gaseous, develop a degenerate core. In a classic paper published in 1932, Chandrasekhar showed that degeneracy cannot set in if the radiation pressure was more than 9.2 percent of the total pressure. Using the highly successful standard model of Eddington, he translated this to a critical mass above which degeneracy cannot set in. It emerged that *stars more massive than* $6.6\ \mu^{-2}$ *solar mass* (where μ is the mean molecular weight) *cannot end up as white dwarfs*, and "*an appeal to the Fermi-Dirac statistics to avoid the central singularity cannot be made*". Though these brilliant predictions were not generally accepted for over two decades, the notion that "*the life-history of a star of small mass must be essentially different from the life-history of a star of large mass*" plays a central role in the current models of stellar evolution and supernova theory.

In 1937 Chandrasekhar joined the faculty of the University of Chicago. Faced with the reluctance of some leading astronomers to accept these compelling results, he turned his attention to the motion of stars in the Galaxy. Unlike other astronomers who were worrying about specific problems, Chandrasekhar approached stellar dynamics as a discipline in itself bringing forth and trying to solve its own theoretical problems. Thus he was able to formulate "certain abstract problems which appear to have an interest for general dynamical theory even apart from the practical context in which they arise". This characteristic style of approaching the subject as a whole has always had the effect of unifying the field and making transparent the connection between the problems under study and others in seemingly unconnected areas in physics. For several years after the publication of his famous book *Principles of Stellar Dynamics* (1942) and his classic paper in *Reviews of Modern Physics* (1943) the subject looked too difficult and esoteric. However, as time passed, several of the seminal ideas introduced by him, such as the principle of *dynamical friction*, became crucial in our understanding of globular clusters, galaxies and, indeed, clusters of galaxies

One of the key problems in astrophysics in the 1940s was the interaction of radiation with matter in the atmosphere of stars. The problem of specifying the radiation field in an atmosphere originated in Lord Rayleigh's investigations in 1871, and Stokes made several important contributions a few years later. But the formulation of the fundamental equations and their solution had to wait till Chandrasekhar turned his attention to it Characteristically, he approached the problem of radiative transfer as a branch of mathematical physics. His research culminated in his book *Radiative Transfer* (1950). In this he developed novel mathematical techniques to exploit certain general *principles of invariance*. Recently, a new branch of mathematics known as Invariant Imbedding has blossomed, inspired by Chandrasekhar's book of twenty years ago.

After learning of the award of the Nobel Prize Chandrasekhar is reported to have commented "I work for my own personal satisfaction on things generally outside of the scientific mainstream. Usually my work has become appreciated only after some length of time". During the 1960s he was engaged in a study of the stability of rotating liquid masses The subject had attracted the attention of many distinguished mathematicians during the last two centuries, though many astronomers were skeptic about the relevance of all this to real stars. Once again, after a decade of research, he published a monumental book entitled "Ellipsoidal Figures of Equilibrium" (1969). In the epilogue of this book he wrote "... But the subject, nevertheless, had been left in an incomplete state with many gaps and omissions and some plain errors and misconceptions. It seemed a pity that it should be allowed to remain in that destitute state. Whether the efforts expended in its rehabilitation was worth the time, the author cannot presume to judge". Yet, fifteen years later it has become a standard text and many of the results obtained by him, and his students, have a bearing on the stability of fast pulsars, such as the recently discovered millisecond pulsar.

Chandrasekhar's research career began with the study of white dwarfs. The fundamental discoveries he made fifty years ago led one, inescapably, to the concept of black holes and singularities. It is to this subject he turned about ten years ago The problem he chose to concentrate on concerned the stability of black holes against external perturbations such as gravitational and electromagnetic waves. His latest book *The*

Mathematical Theory of Black Holes (1983) is a truly monumental piece of work, and has become an instant classic. He has said that this is the hardest project he has worked on, and the one that gave him the greatest satisfaction.

All his books have a definitive character. They reveal his intense dedication, thoroughness, commitment to scholarship, passion for precision, the elegance of his mathematical methods and, most of all, his unique perspective of the subject which, he has often said, is his real motivation for research. After Chandrasekhar has written a book on a subject, it is very difficult to enter that field and do something new. As a distinguished astronomer has said "Don't try to go beyond Chandrasekhar by following the same road. Your only hope is to find a different road".

Chandrasekhar is undoubtedly one of the great pillars of astrophysics. The entire astronomical community rejoices at this long overdue recognition.

Raman Research Institute G. Srinivasan
Bangalore 560 080
October 29, 1983.

(Photograph courtesy of the author)

On the occasion of his attaining the age of 73 and receiving the world's greatest honour to a scientist—the Nobel Prize for 1983, *Current Science* has great pleasure in congratulating Prof. Chandrasekhar and wishing him many more happy years of creative scientific ability.

Editor

ANNOUNCEMENTS

TEXTILE RESEARCH INSTITUTE, PRINCETON, NEW JERSEY

Under the auspices of the Textile Research Institute, Princeton New Jersey, the following conferences will be held: (1) Textile Research Institute 54th Annual Research and Technology Conference, 11 and 12 April 1984, Sheraton Center Hotel, Charlotte, N. C.; (2) Fibre Society Technical Conference, 6-8 June 1984, Philadelphia College of Textiles and Science, Philadelphia, PA; (3) Fibre Society Technical Conference, 10-12 October 1984, University of Tennessee, Knoxville, Tenn.

For details please contact: P. O. Box 625, Princeton, N. J. 08540, USA.

XI ALL INDIA BIOPHYSICS SYMPOSIUM ON 'BIOLOGICAL MACROMOLECULES AND METHODS

The Indian Biophysical Society (IBS) will hold its XI Annual Symposium on 'Biological Macromolecules and Methods' at Hyderabad from Friday 2nd March to Sunday 4th March, 1984. Interested colleagues are invited to participate and contribute papers for the symposium.

The scientific program will include invited lectures, oral presentations and poster sessions, and will focus on the application of physical techniques and models in the study of the structure and function of biological systems.

Invited lectures and oral presentations will be of 20-30 min. duration each. Each poster session is planned for about an hour, following which, there will be a discussion on the posters presented therein.

Further circulars and registration details may be obtained from Dr. A. S. Kolaskar, Centre for Cellular and Molecular Biology, Regional Research Laboratory, Campus, Hyderabad 500 007.