Dwarf star instability

DR Subrahmanyan Chandrasekhar, who shares this year's physics prize with W.A. Fowler (see previous page) for his contributions to the understanding of stellar structure, was born in Lahore (now in Pakistan), educated at Madras and became a graduate student of R.H. Fowler at Cambridge, England, in 1930. His five years at Cambridge were embittered by a dispute with Eddington over the work now singled out by the Nobel committees.

Fowler had already argued that the behaviour of dwarf stars (with no substantial internal source of energy) should be influenced by Fermi statistics, the thermodynamic consequence of the Pauli exclusion principle which among other things ensure that the compressibility of condensed matter should be determined largely by electron exclusion. Chandrasekhar arrived in Cambridge with a solution of the non-relativistic (low-mass star) problem showing that the density of dense matter should vary as the $3/5$ th power of the pressure and be independent of temperature. He extended this to the relativistic case in his PhD thesis in 1933, showing that the density should then vary as the pressure to the power $3/4$.

With or without the relativistic correction, the dominance of Fermi statistics for degenerate matter such as the material of dwarf stars implies that stellar radii decrease as stellar masses increase. In the relativistic case, Chandrasekhar's calculation showed that there must be an upper

limit to the mass of a stable dwarf star calculated as 1.4 solar masses for dwarf stars made of hydrogen and as 1.2 solar masses for iron stars.

The Chandrasekhar limit played an important part in the theory of nucleogenesis chiefly by providing a basis for the argument that in the late stages of the evolution of a massive star, the collapse of the degenerate core should result in the increased production of neutrons required for the r -process. Chandrasekhar's argument also provided from the outset a natural explanation of the small masses of then known dwarf stars (mostly a fraction of the Sun's mass).

For a reason not fully explained, Eddington took against this idea. Chandrasekhar has described (BBC Radio Three) how, "in a very shattering experience for me personally", Eddington had described his work as "obviously false" at a section meeting of the International Astronomical Union in Paris in 1934, and how he had been denied a chance to defend himself by the then secretary of the section on stellar constitution, W.H. Russell. When Chandrasekhar was offered a post at the University of Chicago in 1935, Eddington appears to have advised him to jump at the chance.

During nearly half a century in the United States, Chandrasekhar has earned an outstanding reputation for stamina.

Stung by his experience at Cambridge, Chandrasekhar "stated my views as clearly as I could . . . in a book" (*An Introduction to the Study of Stellar Structure*, 1939) before turning his attention to the study of stellar opacity. In 1952, he became the managing editor of *Astrophysical Journal*, then published by the University of Chicago, and in that role served both as editor and single-handed referee for what the journal published.

In the early 1960s, Chandrasekhar converted himself into a relativist by means of a sabbatical spell at the California Institute of Technology. His monumental book *The Mathematical Theory of Black Holes* (Cambridge, 1982) includes one chapter nearly a hundred pages long to which a footnote apologetically explains that much of the mathematics has had to be omitted, for which reason a number of notebooks and more than 500 handwritten pages of algebra have been deposited with the library of the University of Chicago.

John Maddox

Electron transfer comprehended

THE Nobel Prize for chemistry was awarded to Dr Henry Taube of Stanford University in California for his fundamental studies of inorganic reaction mechanisms. Taube's most far-reaching work on electron transfer processes, cited in the Nobel award, was carried out 30 years ago. This work provided the foundation for an understanding of reaction rates and mechanisms in a wide range of oxidation-reduction reactions.

Taube's own work, however, has concentrated on often very simple inorganic systems, especially transition-metal complexes. From these elegant basic studies, Taube developed rules for predicting the rate of electron-transfer reactions as a function of electronic configuration, solvation and other factors. Colleagues credit him with almost single-handedly transforming inorganic chemistry from a descriptive to a predictive science.

Taube distinguished between two sorts of redox reactions in inorganic systems: "outer sphere" reactions involving the direct transfer of an electron between two molecules, as in the reaction between O_2 and O_2^- and "inner sphere" reactions involving the transfer of an atom, typically a shared ligand between two metals with coordination groups, as in the oxidation of $Cr(II)$ to $Cr(III)$ and the simultaneous reduction of $Co(III)$ to $Co(II)$ by transfer of a chloride atom between the metals.

Although Taube himself has never worked with biological systems, his results have had a profound effect on the understanding of enzyme kinetics. His theoretical work is invoked to explain why different enzyme reactions proceed at different rates and how rates change with changing conditions. Taube's rules also help to explain many chemical curiosities

and many basic features of chemical behaviour that chemists have tended to take for granted (or have shrouded in mystery through the invocation of the magic word "catalysis"). One example: molecular oxygen, from a thermodynamic viewpoint, is a very powerful oxidizing agent; yet kinetically it is a reluctant one. Taube has shown that the addition of the

Henry Taube

first electron to O_2 is into an antibonding level which causes an unfavourable change in geometry, whence the kinetic barrier.

Taube was the first to use isotopically-labelled oxygen in inorganic reaction studies and pioneered the application of nuclear magnetic resonance to the field.

Taube says that he made a conscious decision to concentrate on inorganic chemistry after teaching an advanced chemistry course and seeing the vast opportunities for research in what was — and, relatively speaking, still is — a wide open field. Taube is not well known outside chemistry, but he has for years received recognition from within the ranks of his discipline.

Stephen Budiansky

Subrahmanyan Chandrasekhar

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