Understanding of Stellar Structure

The H-R Diagram and the Saha Equation (*see* Parsecstone 16) provided the basic tools for classifying stars empirically in terms of their visible surface properties. Questions relating to a deeper understanding of stars, such as: what makes a star shine, what are the forces controlling its equilibrium, how does energy propagate outwards within its interior, etc. could now be meaningfully posed.

It was Arthur Stanley Eddington who pioneered the subject of stellar structure. Eddington's equations of stellar structure basically formulated the physics behind the questions posed above. Solving these equations, Eddington could deduce that the stellar interior would typically be made of hot plasma whose temperature falls outwards from a very high central value of upwards of ten million degrees. Likewise its thermal and radiation pressures decrease outwards, thereby supplying the force necessary to keep it in equilibrium against its own gravity.

It is these high core temperatures that hold the key to the secret of stellar energy. Following the ideas of J. Perrin, Eddington argued that temperatures of such high order would induce thermonuclear fusion, leading to the formation of helium from the fusion of hydrogen nuclei.

In a hot plasma, hydrogen nuclei are stripped of their electrons and move freely. But how could four such positively charged particles overcome their Coulomb repulsion and fuse together? The nuclear physicists were sceptical of Eddington's ideas and felt that even at the high temperatures he was talking about nuclear fusion would not happen. In his classic book, *The Internal Constitution of the Stars,* published in the mid-twenties Eddington poured scorn on his critics: "We do not argue with the critic who urges that the stars are not hot enough for this process; we tell him to go and find a hotter place."

Within a decade, however, the nature of nuclear force whose attractive power at close range dwarfs any Coulomb repulsion, became established and Eddington's conjecture was proved. In 1939 Hans Bethe, a nuclear physicist, constructed solar models in which the then available information on thermonuclear fusion was put in. With this work, it became possible to predict the physical characteristics of a star like its radius, surface temperature and colour, its luminosity, etc., given its mass. For this landmark work, Bethe was awarded the Nobel Prize in 1967. Unfortunately Eddington was long dead by then.