Letters to the Editor.

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Stellar Structure and the Origin of Stellar Energy.

THE generally accepted theory of the internal conditions in stars, due to Sir A. S. Eddington, depends largely on a special solution of the fundamental equations, and according to this a definite calculable luminosity is associated with a given mass. If this were the only solution of the equations it would conflict, as I have repeatedly shown in recent papers, with the obvious physical considerations which show that we can build up a given mass in equilibrium so as to have an *arbitrary* luminosity (not too large) whatever the assumed physical properties of the material. I have recently noticed that the fundamental equations possess a whole family of solutions, corresponding to arbitrarily assigned luminosity for given mass. These solutions show immediately that Eddington's solution is a special solution and corresponds to an unstable distribution of mass. In the stable distributions the density and temperature tend to very high values as the centre is approached, theoretically becoming infinite if the classical gas laws held to unlimited compressibility.

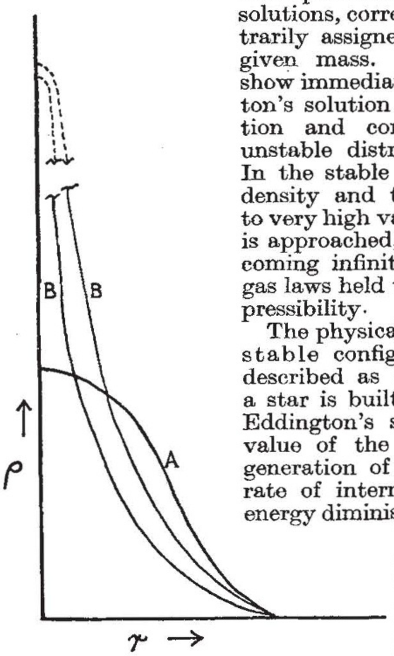

FIG. 1.

The physical properties of the stable configurations can be described as follows. Suppose a star is built up according to Eddington's solution with his value of the rate of internal generation of energy. Let the rate of internal generation of energy diminish ever so slightly. Then the density distribution suffers a remarkable change. The mass suffers an intense concentration towards its centre, the external radius not necessarily being changed. The star tends to precipitate itself at its centre, to crystallise out so to speak, forming a core or nucleus of very dense material. The star tends to generate a kind of 'white-dwarf' at its centre, surrounded of course by a gaseous distribution of more familiar type; the star is like a yolk in an egg. In this configuration the density and temperature are prevented from assuming infinite values by the failure of the classical gas laws, but they reach values incomparably higher than current estimates. For example, it seems probable (though the following estimates are subject to revision) that the central temperature exceeds 10^{11} degrees, in comparison with the current estimates of the order of 10^7 degrees; and the density may run up to the maximum density of which ionised matter is capable.

The unstable density distribution of Eddington's model (curve *A*) and the stable density distribution of actual stars (curves *B*) are indicated roughly in Fig. 1, which is not drawn to scale. It may be mentioned that the instability is of a radically different kind from that discussed by Sir James Jeans. He concluded that perfect-gas stars of Eddington's model were *vibrationally* unstable. In my investigations, the instability of Eddington's model arises from any slight departure of the rate of generation of energy below the critical value found by Eddington. The perfect-gas distribution of my solutions is perfectly stable, but the density necessarily increases until degeneracy or imperfect compressibility takes control.

The consequences amount to a complete revolution in our picture of the internal constitution of the stars. In the intensely hot, intensely dense nucleus, the temperatures and densities are high enough for the transformation of matter into radiation to take place with ease. It is to this nucleus that we must look for the origin of stellar energy, a nucleus the existence of which has previously been unsuspected. The difficulties previously felt as to stellar conditions being sufficiently drastic to permit the evolution of energy largely disappear. Many of the cherished results of current investigations of the interiors of stars must be abandoned; current estimates of central temperature, central density, the current theory of pulsating stars, the current view that high mass necessarily implies high radiation pressure, the supposed method of deducing opacity of stellar material from observed masses and luminosities, the supposed proof of the observed mass-luminosity correlation—all these require serious modification.

The new results are not a speculation. They are derived by taking the observed mass and luminosity of a star, and finding the restrictions these impose on the possible density distributions compatible with this mass and luminosity. By integrating the fundamental equations from the boundary inwards, we are inevitably led to high central temperatures and densities. So long as the classical gas laws persist, the solution is one of the family with a central singularity (infinities in ρ and T), and it is only the ultimate failure of the gas laws which rounds off the distribution with a finite though very large central ρ and T.

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July 29.

Structure of Carbohydrates and their Optical Rotatory Power.

IT would appear from two recent publications by Dr. C. S. Hudson of New York (*J. Amer. Chem. Soc.*, **52**, pp. 1680, 1707; 1930) that the classification of the ring structure of sugars can be decided upon little more evidence than that of the optical rotations which these substances display in a single solvent and for light of one selected wave-length. If this claim could be substantiated, the method might be usefully extended to other groups of compounds and the labours of organic and bio-chemists would be immeasurably simplified.

Dr. Hudson is satisfied, however, with a standard of constitutional proof for the carbohydrates which will not find general acceptance. In no case does he advance evidence which is unequivocal for any sugar, although he attempts to apply definitive formulæ to many. His scheme finds its origin in the assumption that optical rotation is an additive property. At the same time that he is seeking to test this hypothesis he assigns differing structural formulæ to explain the anomalies that arise from it. These are at variance with many of the constitutional formulæ which my co-workers and I have established from a fundamental