Letters to the Editor.

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Stellar Structure.

IT is only with some qualms that an outsider can enter into the discussion of questions of stellar structure, but I feel that Sir James Jeans is speaking more favourably of Prof. Milne's theory than he thinks when he says that it contains little that has not been anticipated either by Sir Arthur Eddington or by himself.[1] A theory that will combine the good points of Eddington's and Jeans's theories is precisely what observers of the progress of astrophysics have long wished to see. Jeans requires a liquid interior to explain binary fission ; Eddington says that owing to ionisation the gas laws must hold through most of the interior. Eddington, assuming that the gas laws hold throughout the interior, infers the mass-luminosity relation, which is verified by observation except for the adjustment of a single constant. Neither theory appears to account for the facts explained by the other, and there must be something that both authors have overlooked. It seems to me that the chief recommendation of Prof. Milne's method of attack is that it foreshadows a means of finding out what this is.

As to Prof. Milne's results, the most striking seems to me to have escaped comment. In his forthcoming paper[2] he gives results for the companion of Sirius, containing an adjustable parameter β. If we take this equal to 0·28, we get :

	Theoretical.	Observed.
Mean density (gm./cm.³) . .	6×10^4	6×10^4
Radius (cm.) . . .	$3 \cdot 4 \times 10^9$	$1 \cdot 9 \times 10^9$
Effective temperature (degrees)	6000	8000–10000

An agreement in order of magnitude for matter so far removed from any state known in the laboratory must be impressive, particularly since, as Prof. Milne indicates, the theory is capable of further development.

The generation of stellar energy has long been an intractable problem. Eddington recognises the difficulty of accounting for it at the temperatures given by his theory. Jeans deals with it by introducing radioactive elements of higher atomic number than uranium. Whether this is an assumption or an inference, mere radioactivity, as usually understood, scarcely seems likely to give so great a secular diminution of mass as the stellar time-scale requires. Mutual annihilation of protons and electrons will do it, but this does not take place in ordinary radioactive processes. The great recommendation of Prof. Milne's theory is that it provides temperatures in the central regions of a star such that this mutual annihilation can be explained without going beyond current physical theories. On the other hand, the amount of generation given still needs quantitative test.

The defect of Milne's and Eddington's theories alike seems to be that they require too high a value of the stellar opacity, as was pointed out by several speakers in the recent discussion at the Royal Astronomical Society. Is it possible that this is because the chief mode of transfer of stellar energy is not by radiation but by vertical convection currents ? All existing theories are against this suggestion, yet two circumstances point towards it. The granular appearance of the surface of the sun, as seen in a photograph taken in monochromatic light, strongly resembles that noticed by Bénard[3] and later workers[4] in the surface

of a thin layer of liquid that has become unstable under a vertical temperature gradient just exceeding the adiabatic ; also that shown in photographs of the upper surface of strato-cumulus clouds. Against this we have the fact that Prof. Milne seems to have shown[5] that the temperature gradient in the photosphere does not reach the adiabatic except possibly inside a sunspot. Secondly, if we *demand* a temperature of the order of 10^{10} degrees for the generation of subatomic energy, the whole of this generation must be in a small sphere about the centre of the star, and radiation may be unable to dispose of it at a gradient under the adiabatic.

Current theories, by assuming generation throughout the star, must give too low a gradient in the central regions. If this suggestion is correct, vertical currents must be generated, and these will redistribute the heat so as to keep the gradient near the adiabatic for a stream of matter carrying its radiation with it. This has been discussed by Prof. Milne, apparently with adverse results, but I am still inclined to think that his discussion may have constructive and not merely destructive value.

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[1] NATURE, Jan. 17, p. 89.
[2] *Mon. Not. Roy. Ast. Soc.*, Nov. 1930.
[3] *Ann. d. Chimie et d. Physique*, **23**, 62-144, 1900; also James Thomson, "Collected Papers", p. 136.
[4] Cf. A. R. Low, NATURE, **115**, 300 ; 1925.
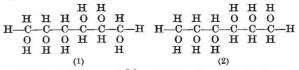[5] *Quart. Jour. Math.*, **1**, 1-20 ; 1930.

An X-Ray Study of Mannitol.

IN NATURE of Jan. 3, p. 11, Miss Thora C. Marwick gives the results of an X-ray examination of mannitol. I have recently completed an investigation of the structure of *d*-mannitol in the Chemistry Department of the University of Edinburgh, and have obtained the following results from the X-ray analysis :

Space-group, Q^4 ; $a = 8 \cdot 66$ A. ; $b = 16 \cdot 58$ A. ; $c = 5 \cdot 50$ A. ; calculated density, 1·522 gm. per c.c. ; 4 molecules per cell.

Groth (*Chem. Kryst.*, vol. 3, p. 431) reports on two crystalline modifications of *d*-mannitol ; the β-form which is always obtained by crystallisation from water is the form which was examined.

Irvine and Paterson (*Jour. Chem. Soc.*, **105**, p. 898 ; 1914) have shown that the terminal primary hydroxyl groups of the *d*-mannitol molecule do not appear to possess free rotation, but assume preferentially the fixed positions shown in formula (1). A second possible configuration is shown in formula (2), but a comparison of the reactive powers of the terminal hydroxyl groups made by Irvine and Steele (*Jour. Chem. Soc.*, **107**, p. 1221 ; 1915) proves that the configuration of formula (1) is correct.

$$\begin{array}{ccc} & \text{H} \quad \text{H} & \text{H} \quad \text{H} \quad \text{H} \\ & \text{H} \quad \text{H} \quad \text{O} \quad \text{O} \quad \text{H} & \text{H} \quad \text{H} \quad \text{H} \quad \text{O} \quad \text{O} \quad \text{O} \\ \text{H—C—C—C—C—C—C—H} & & \text{H—C—C—C—C—C—C—H} \\ & \text{O} \quad \text{O} \quad \text{O} \quad \text{H} \quad \text{H} \quad \text{O} & \text{O} \quad \text{O} \quad \text{O} \quad \text{H} \quad \text{H} \quad \text{H} \\ & \text{H} \quad \text{H} \quad \quad \quad \text{H} & \text{H} \quad \text{H} \quad \text{H} \\ & (1) & (2) \end{array}$$

W. T. Astbury and Miss K. Yardley (*Phil. Trans.*, A, vol. 224, p. 221 ; 1924) show that in a crystal belonging to the space-group Q^4, and having four molecules in the unit cell, the molecules must be asymmetric. Of the two possible configurations shown in formulæ (1) and (2), that of the latter possesses a diad axis of symmetry, while that of the former cannot possess any symmetry. The structure of the molecule of *d*-mannitol within the crystal is therefore represented by formula (1). This structure was also assigned to *d*-mannitol by Irvine and his collaborators examining the substance in solution.

An investigation of the crystal structure of *d*-