the favour bestowed by second-order effects on the spin with the greatest number of states) seems to be effective in making even numbers of neutrons and of protons have zero moments. But for protons this preference for opposite spins is opposed by the effect of the exclusion principle on the average repulsive electrostatic energy. If the spins are parallel, the particles avoid very small separations, thus decreasing the average Coulomb energy. Since the binding-type energy is apt to have no singularity at coincidence[2], the Coulomb energy may predominate at small separations and be relatively more important in determining spins than in questions of stability.

Although the actual states of the nucleus are probably an intricate mixture of the states of a representation of single-particle quantum numbers, their energy should be affected by the same trends as determine the order of states in a simple representation. If we consider a representation which includes orbital moments, the magnetic spin-orbit coupling (which is apt to be very strong, especially in heavy nuclei) introduces another tendency toward smaller moments for neutrons than for protons. If the spin gyromagnetic ratio is positive for protons and negative for neutrons, as seems likely from deflection data, this tends to make spin and orbital mechanical moments parallel for protons and opposite for neutrons.

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[1] NATURE, **135**, 620, April 20, 1935.
[2] Majorana, *Z. Phys.*, **82**, 137; 1933.

Production of Electron Pairs and the Theory of Stellar Structure

IN the discussion of problems of stellar structure, only the deviations from the perfect gas laws arising from degeneracy due to the exclusion principle for the electrons have so far been considered. In fact, as has recently been shown by one of us[1], these deviations involve far-reaching limitations on the possible stellar configurations under given conditions. Thus, it can be deduced from the form of the equation of state of a degenerate gas, taking due account of relativity, that in order that degeneracy should develop in any part of a star, the ratio β of gas pressure to total pressure at that point must satisfy the condition

$$\frac{960}{\pi^4} \cdot \frac{1-\beta}{\beta} < 1\,; \qquad (1)$$

and on the standard model, in which β is assumed to be constant throughout the star, this implies the existence of a critical mass

$$\mathfrak{M} = 6 \cdot 6 \odot \mu^{-2}, \qquad (2)$$

($\odot$ denoting the mass of the sun and μ the molecular weight) above which degeneracy cannot set in at all. A study of the equilibrium of completely degenerate gas spheres leads further to the result that there is an upper limit

$$M_3 = 5 \cdot 7 \odot \mu^{-2} \qquad (3)$$

to the masses of such configurations; this affords the possibility, for stars of mass $\leqslant M_3$, of a course of evolution leading to complete degeneracy through intermediate stages comparable to the observed white dwarf configurations.

Quite another type of deviations from the perfect gas laws, however, arises from the existence of a definite distribution of positrons as well as electrons in equilibrium with temperature radiation, and in this note we desire to point out the bearing of this fact on the theory of stellar structure, and especially to indicate to what extent the conclusions summarised above have to be modified.

In the first place, no effect of the latter type can take place if the electron assembly is completely degenerate; for in that case all the states of negative energy will necessarily be occupied, which on Dirac's well-known picture implies the total absence of positrons. For the theory of stellar structure this obvious remark has the consequence that, under white dwarf conditions, the influence of pair production on the configuration will be entirely negligible, and the possibility of evolution mentioned above, for stars of mass $\leqslant M_3$, can be upheld without modification.

More generally, the presence of an equilibrium distribution of pairs in addition to the 'excess' of electrons, which is proportional to the material density, will give rise to a correction term in the equation of state, and the effect of this term on the stellar structures may conveniently be surveyed on the standard model. It is found that for a fixed value of the ratio β, the correction increases with temperature, tending to a finite limit as the temperature tends to infinity. When the condition (1) is fulfilled, the maximum deviation from the perfect gas law is less than 2 per cent, which means that the effect is altogether negligible for stars of mass $< \mathfrak{M}$, in which degeneracy of the electron assembly is able to occur. For more massive stars, however, the correction term becomes increasingly important. Thus already when $1 - \beta = 0 \cdot 2$, corresponding on the standard model to a mass of $12 \cdot 6 \odot \mu^{-2}$, the maximum effect amounts to 7 per cent. For very massive stars, say, of mass greater than $30 \odot \mu^{-2}$, equilibrium configurations analogous to the white dwarf configurations for masses $< M_3$—but differing from the white dwarfs in that the deviations from the perfect gas laws now arise from the production of pairs and not from degeneracy—are therefore formally possible, and the question suggests itself: Do such configurations exist in Nature?

A detailed derivation of the results here summarised is to be published elsewhere.

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[1] S. Chandrasekhar, *Mon. Not. R.A.S.*, **95**, 207–260; Jan., 1935.

Formation of Mercury Molecules

IT has long been known that mercury vapour is ionised by photons having energies considerably less than that corresponding to the ionisation potential of the mercury atom. Rouse and Giddings[1] showed in 1926 that mercury vapour is ionised by its resonance radiation, 2537 A. To explain this effect, Houtermans[2] suggested that an excited atom in the 2^3P_1 state of $4 \cdot 9$ volts energy may combine with a metastable atom in the 2^3P_0 state of $4 \cdot 7$ volts energy to