Letters to the Editor.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, nor to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

Spinning Electrons.

I UNDERSTAND that in the newly proposed spinning electron the periphery is supposed to move faster than light, and the question has arisen in some minds whether such a motion can be allowed by the relativity theory. I think an assurance can be given that the relativity theory raises no objection.

It must be remembered that the mass and energy of an electron are considered to reside in the electromagnetic field outside its boundary. Whether the electron spins or not, this field is steady, so that there is no question of any transport of mass or energy with speed faster than light. It is only when *energy* or *signals* are alleged to go faster than light that the relativity theory is moved to intervene. Further, the spinning electron represents a state of the world-distribution of charge-and-current vector—which, while differing from that of an electron at rest, is nevertheless equally static and unchanging. It seems almost an abuse of language to apply the term velocity in connexion with a structure which is perfectly stationary; but the description in terms of spin may be held to serve its purpose since it leaves no doubt as to the structure intended.

The mathematical definition of velocity (dx/dt) contains no special reference to motion in a dynamical sense; x is merely the co-ordinate of a selected succession of world-points, and there is in the definition no guarantee that dx is traversed by anything except the thought of the mathematician. In describing the electron as spinning, what happens is that, faced with a hitherto unimagined structure, we make our thought skip faster than light round its boundary, and by so doing succeed in seeing a correlation with a more familiar structure, namely, that of an electron at rest. The correlating velocity has no more physical existence than has the factor $\sqrt{-1}$ used to correlate the structure of the four-dimensional world to the more familiar structure of a four-dimensional Euclidean space. In a deeper analysis we should not speak of a moving charge-element but of a charge-and-current vector, motion being attributable only to boundaries or analogous features of charge distribution —not to *charge*, but to *a charge*. When in the cruder description the charge moves faster than light, the charge-and-current vector J^{μ} becomes *space-like*. (In ordinary macroscopic phenomena J^{μ} is always *time-like*.)

It may be interesting to recall that the conclusion that the electron contains a space-like J^{μ} was already reached tentatively from a study of the interrelation of the electromagnetic and gravitational fields (see my "Mathematical Theory of Relativity," p. 211). It is deduced from Weyl's action-principle. So far as I can make out, Weyl himself reached a different conclusion, but it seems a straightforward result from his theory. From the action-principle a formula was obtained connecting mass-density with the electric vector ($\rho_0 = -(\beta^2/12\pi)J^{\mu}J^{\mu}$) and the conclusion was—"Since the density of matter is always positive, the electric charge-and-current inside an electron must be a *space-like* vector, the square of its length being negative. It would seem to follow that the electron cannot be built up of elementary electrostatic charges but resolves itself into something more akin to magnetic charges." A. S. EDDINGTON.

Observatory, Cambridge,
April 24.

I FEEL that there are serious arguments against the two objections raised by Mr. Kronig (NATURE, April 17, p. 550) to the view that the electrons in the atom possess an inherent magnetic moment, a view which Uhlenbeck and Goudsmit have shown to have important spectroscopic consequences. I will consider first the second objection, which seems to me to involve implicit assumptions about the structure of the atomic nucleus which go far beyond our present knowledge of the facts or even of the probabilities. I am prepared to follow Mr. Kronig to the extent of believing that if an electron has a quantised spin when in a Bohr orbit, an electron which has the privilege of taking part in the building up of an atomic nucleus will have the same property of possessing one or more units of angular momentum or of magnetic moment. But it seems to me improbable that the electron after it has entered into the composition of the nucleus will be able, as an individual electron, to retain this angular momentum. The 'dimensions' of the nucleus are not very much greater than those of an electron, and as the nucleus may contain a very considerable number of electrons and protons, it must be a highly interlocked structure of a kind which scarcely seems likely to afford opportunity for the ordered spinning contemplated.

I suggest that what is more likely to happen is that the electron gets rid of this angular momentum in the process of nucleus formation either by passing it on to the nucleus as a whole or else by radiating it away. If the angular momentum is transferred to the nucleus as a whole, its magnetic effect becomes negligible owing to the much higher moment of inertia of the rotator; so that in either event the nucleus would have no appreciable magnetic moment. That the nucleus as a whole does possess a quantised angular momentum is shown by the mechanical gyromagnetic anomaly, as I showed in 1922 (*Roy. Soc. Proc.*, A, vol. 102, p. 538), and also, though less directly, by the corresponding and similar spectroscopic anomaly. In any event the magnitude of the mechanical gyromagnetic anomaly makes it necessary to admit the existence of a quantised spin of the nucleus, a structure the 'dimensions' of which are not much greater than those of an electron.

As regards the first objection, the statement as to the foundation of the Bohr magneton resting on the orbital motions of electrons which can be treated solely as point charges moving with velocities small compared with that of light, seems to be too narrow. If it is assumed that an electron is a sphere of radius R carrying a charge e and that the inertia is entirely electromagnetic (these are the simplest assumptions which can be made), the application of the quantum condition $\int pdq = nh$, where p is the angular momentum, requires that for any rotation the magnetic moment of a spinning electron should be $n \cdot eh/4\pi cm$ where n is an integer and the other factor is the magnitude of the 'Bohr magneton.' O. W. RICHARDSON.

King's College,
Strand, W.C.2.
April 19.

IN view of the letters recently published in NATURE upon the subject of rotating electrons, it may be of interest to mention some attempts made four years ago to use this idea in explaining the stability of the nucleus. It is common knowledge that the fact that