from the nucleus, so that the screening of the nuclear charge by the other electrons in the atom will have different effects. This screening effect will, however, be the same for a pair of levels which have the same K but different J's and correspond to the same orbital shape. Such pairs of levels were, on the older theory, labelled with values of k differing by one unit, and it was quite impossible to understand why these so-called "relativity" doublets should appear separately from the screening doublets. On our view, the doublets in question may more properly be termed "spin" doublets, since the sole reason for their appearance is the difference in orientation of the spin axis relative to the orbital plane. It should be emphasised that our interpretation is in complete accordance with the correspondence principle as regards the rules of combination of X-ray levels.

The assumption of the spinning electron leads to a new insight into the remarkable analogy between the multiplet structure of the optical spectra and the structure of X-ray spectra, which was emphasised especially by Landé and Millikan. While the attempt to refer this analogy to a relativity effect common to all the structures was most unsatisfactory, it obtains an immediate explanation on the hypothesis of the spin electron. If, for example, we consider the spectra of the alkaline type, we are led to recognise in the well-known doublets regular spin doublets of the character described above. In fact, this enables us to explain the dependence of the doublet width on the effective nuclear charge and the quantum numbers describing the orbit, as well as the rules of combination.

The simplicity of the alkaline spectra is due to the fact that the atom consists of an electron revolving round an atomic residue which contains only completed electronic groups, which are magnetically inert. When we pass to atoms in which several electrons revolve round a residue of this kind we meet with new features, since we have to take account of other directing influences on the spin axis of each electron besides the couple due to its own motion in the electric field. Not only does this enable us to account for the appearance of multiplets of higher complexity, but it also seems to throw light on the so-called "branching" of spectra, which usually accompanies the adding of a further electron to the atom, and for which hitherto no satisfactory explanation has been given. In fact, it seems that the introduction of the concept of the spinning electron makes it possible throughout to maintain the principle of the successive building up of atoms utilised by Bohr in his general discussion of the relations between spectra and the natural system of the elements. Above all, it may be possible to account for the important results arrived at by Pauli, without having to assume an unmechanical "duality" in the binding of the electrons.

So far we have not mentioned the Zeeman effect, although the introduction of the spinning electron was primarily suggested by the analysis of the anomalous Zeeman effects shown by the components of multiplet structures. From the point of view of the correspondence principle, this effect shows that the influence of a magnetic field on the motion of the atom differs considerably from that to be expected if the electron had no spin. In fact, from the well-known theorem of Larmor we would expect the effect on any spectral line to be of the simple Lorentz type, quite independently of the character of the multiplet structure. Therefore the appearance of the anomalous Zeeman effects has hitherto presented very grave difficulties. However, these difficulties disappear at once when, as assumed, the electron has a spin and the ratio between magnetic moment and angular momentum of this spin is different from that corresponding to the revolution of the electron in an orbit large compared with its own size. On this assumption the spin axis of an electron not affected by other forces would precess with a frequency different from the Larmor rotation. It is easily shown that the resultant motion of the atom for magnetic fields of small intensity will be of just the type revealed by Landé's analysis. If the field is so strong that its influence on the precession of the spin axis is comparable with that due to the orbital motion in the atom, this motion will be changed in a way which directly explains the gradual transformation of the multiplet structure for increasing fields known as the Paschen-Back effect.

It seems possible on these lines to develop a quantitative theory of the Zeeman effect, if it is assumed that the ratio between magnetic moment and angular momentum due to the spin is twice the ratio corresponding to an orbital revolution. At present, however, it seems difficult to reconcile this assumption with a quantitative analysis of our explanation of the fine structure of levels. In fact it leads, in a preliminary calculation, to widths of the spin doublets just twice as large as those required by observation. It must be remembered, however, that we are here dealing with problems which for their final solution require a closer study of quantum mechanics and perhaps also of questions concerning the structure of the electron.

In conclusion, we wish to acknowledge our indebtedness to Prof. Niels Bohr for an enlightening discussion, and for criticisms which helped us distinguish between the essential points and the more technical details of the new interpretation.

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HAVING had the opportunity of reading this interesting letter by Mr. Goudsmit and Mr. Uhlenbeck, I am glad to add a few words which may be regarded as an addition to my article on atomic theory and mechanics, which was published as a supplement to NATURE of December 5, 1925. As stated there, the attempts which have been made to account for the properties of the elements by applying the quantum theory to the nuclear atom have met with serious difficulties in the finer structure of spectra and the related problems. In my article expression was given to the view that these difficulties were inherently connected with the limited possibility of representing the stationary states of the atom by a mechanical model. The situation seems, however, to be somewhat altered by the introduction of the hypothesis of the spinning electron which, in spite of the incompleteness of the conclusions that can be derived from models, promises to be a very welcome supplement to our ideas of atomic structure. In fact, as Mr. Goudsmit and Mr. Uhlenbeck have described in their letter, this hypothesis throws new light on many of the difficulties which have puzzled the workers in this field during the last few years. Indeed, it opens up a very hopeful prospect of our being able to account more extensively for the properties of elements by means of mechanical models, at least in the qualitative way characteristic of applications of the correspondence principle. This possibility must be the more welcomed at the present time, when the prospect is held out of a quantitative treatment of atomic problems by the new quantum mechanics initiated by the work of Heisenberg, which aims at a precise formulation of the correspondence between classical mechanics and the quantum theory.

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Copenhagen, January 1926.