Letters to the Editor.

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The Difference between Series Spectra of Isotopes.

PROF. P. EHRENFEST and Prof. N. Bohr, in their letters to NATURE of June 10, have raised the interesting question of the difference to be expected between the spectra of isotopes. Much confusion, as their letters clearly indicate, exists on the subject, and while not in disagreement with any of their conclusions, I should like to make a few remarks which may tend to elucidate the matter somewhat further.

Prof. Ehrenfest raised the question in relation to the spectra of the isotopes of lithium—the subject of an investigation by Prof. Zeeman—and pointed out that the factor $M/(m+M)$ in the Rydberg constant was only deduced by Bohr—and subsequently used by Fowler to obtain the best estimate we have for the ratio m/M, in his Bakerian lecture—for the case of an atom with a *single* electron. He justifiably rejects any conclusions founded on its application to atoms with more than one electron, and Prof. Bohr entirely concurs. Ehrenfest's illustration of an atom in which the mass of the nucleus, on account of symmetry, does not enter into the spectrum at all, is perhaps a sufficient indication of the difficulty of the problem, if such symmetrical atoms can exist, a matter which appears improbable.

The spectra of the lithium isotopes are at present peculiarly interesting since the announcement that Prof. M'Lennan has isolated them and found a difference which is greater than that calculated by the Bohr formula, and in fact three times this value, while 3 is the accepted atomic number of lithium. The quantum theory is unable to explain this large separation, and its exponents must doubt the fact that M'Lennan's new series is the spectrum of an isotope. There are two alternatives—it may be a combination series or a spark series. In an investigation which the present writer made a year ago, on some of the simpler possible orbits in a lithium atom with only two electrons, a specially simple class of orbits was found. Although the work is not yet published, it is possible to state that its result gave, as the principal spark-line of lithium, a value very close to λ 6708, the red line shown in the ordinary spectrum. This line had already been suspected, by several spectroscopists, to have a spark component.

In these simple orbits of a lithium atom positively charged, the two electrons are behaving very differently. The orbit of one of them is only about $\frac{1}{10}$ the linear dimensions of that of the other, so that the Bohr formula for one electron is nearly applicable. In fact, the orbits are very closely analogous to those now generally accepted for the neutral helium atom, which can take two forms, in both of which the orbit of one electron is very small compared with that of the other; the orbits differ mainly in the fact that in ortho-helium they are practically coplanar, and in parhelium practically perpendicular.

I have found it possible by a choice of the simpler orbits, and by the supposition made by Sommerfeld and others as to the invariability of the energy W for all possible orbits, to show that the inner orbit has a radius only about $\frac{1}{10}$ of that of the outer. Thus the Bohr formula is again nearly true, and the Rydberg constant in the ordinary helium series is not very different from its value in the Pickering series. Such results are suggestive, and appear to indicate that when there are many electrons in an atom, a ratio roughly of order $\frac{1}{10}$ exists between the orbital radii of the two outer consecutive electrons. An immediate consequence is that the Bohr formula would never be very far wrong in its use for a rough determination of the separation to be looked for in the spectra of isotopes. If the correspondence with these results does not, however, extend to heavier atoms, we are precluded from making any prediction without the knowledge of the general position—on the average—of the centre of mass of an atom. In a problem of this nature no general treatment is possible, and no general simple law of separation down the Periodic Table is to be expected.

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Balliol College, Oxford, June 12.

A Possible Reconciliation of the Atomic Models of Bohr and of Lewis and Langmuir.

BROADLY speaking, the merits of Bohr's atomic model lie in its very accurate explanation of the reaction of atoms and molecules with radiation, while those of the Lewis-Langmuir model lie in its very satisfactory representation of the mechanism of chemical combination, but the merits of either model are lacking in the other. Both must therefore possess properties which are accurate representations of the truth, and the problem remains to devise a third model which will incorporate those properties in its structure. The following considerations lead to a modification of the Lewis-Langmuir model, which appears to be a satisfactory solution of the problem—so far as I am aware it is new.

Consider first the well-known Lewis-Langmuir model for any atom. It is built up of the central nucleus and its surrounding electrons the mean positions of which are fixed with respect to one another and to the position of the nucleus. Now in order to account for the reaction between the atom and radiant energy it is necessary to assume that these electrons possess acceleration of some kind. The particular kind most agreeable with the results of experiment is the orbital acceleration assumed by Bohr. But since the electrons are fixed (or can be assumed to move but very slightly from their fixed mean positions) in the Lewis-Langmuir model, orbital acceleration is impossible.

Now, apparently, a way out of this difficulty is to assume that the electron shells are fixed and the nucleus rotates on an axis.

By the Theory of Relativity it is immaterial whether—viewing a given atom—we regard the electrons as describing orbits around a fixed nucleus (not fixed in position only) or whether we regard the nucleus as rotating inside the electron shell or shells with each electron fixed relatively to the others. That is, the nucleus possesses acceleration with respect to the electrons, or what is the same thing, the electrons possess acceleration with respect to the nucleus in spite of the fact that they are fixed relatively to outside systems such as other electron shells. Therefore this model when viewed with respect to the electron shells is precisely the same as the Lewis-Langmuir model, and, furthermore, with respect to the whole atom it possesses all the merits of Bohr's model. That is, it appears to be a satisfactory reconciliation of the two atomic models.

Furthermore, the proposed model possesses the further merit that by its aid we can predict the existence of isotopes. Thus if the nucleus of a given atom possesses more than one stable axis of rotation with respect to itself, or to its surrounding shells of elec-