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A MAGNETON THEORY OF THE STRUCTURE OF THE ATOM

(With Two Plates)

BY
A. L. PARSON

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PART I. INTRODUCTORY

§1. General Remarks

The non-electrical bond between atoms, such as may be supposed to exist in the Hydrogen molecule, is an important factor in chemical union; but no plausible suggestion as to its nature has ever been made, and the failure to account for this bond is one of the greatest defects of the electronic theory of matter as it now stands.

Now the present theory is the outcome of an attempt made some years ago to remedy this defect even at the expense of a considerable departure from accepted fundamental ideas: it seemed then to the author that the idea of replacing the classical electron by the magneton here described, which makes the bond in question magnetic, was less revolutionary than any other that could definitely attain the end in view; and the contents of this paper bear witness to its subsequent fertility.

In postulating this magneton for chemical reasons, the phenomena of magnetism and radiation were of course not lost sight of. In the field of magnetism, the magneton has been at once and automatically as strikingly successful as in chemistry—as indeed we ought to require it to be. As regards its application to the phenomena of radiation, not much can be said at present; but the magneton seems *à priori* a promising conception here, and its possibilities have been looked into already by Dr. D. L. Webster in a paper on "Planck's Radiation Formula and the Classical Electrodynamics" (Amer. Acad., Jan., 1915).

As might be expected of a theory that had such an origin, the special considerations which led to the theory of Rutherford and Bohr, for example, were not taken into account; and thus any representation that it has been or will be able to give of the phenomena of α-particle scattering, of spectrum series, of the Röntgen ray spectra, or of the mass of the atom, are necessarily of a supplementary nature: but the theory does not, I believe, exclude the possibility of such representation for any of these phenomena (see the note in §16).

The properties of atoms fall into two distinct classes, the nature of this distinction having been clearly defined by J. J. Thomson, who points out that the atom behaves as if it were made up of a few electrons in an "outer shell" which are responsible for the chemical and light-absorbing properties of the atoms, surrounding a dense central mass made up of other electrons and positive electricity which might be called the "core" of the atom and is the seat of the strictly additive properties such as the mass, the Röntgen ray emission, and the radioactivity: in the properties of the outer shell there is a periodicity, in those of the core not. To this brief sketch might be added the magnetic properties as obviously being due to the behavior of the outer part of the atom.

Now there is no theory that is able to explain, to any appreciable extent, both sets of phenomena. Nor even is there any that shows much promise in connection with the properties of the outer shell alone—especially the chemical and magnetic properties of the atom: most of the recent work (by Rutherford, Moseley, and others) has emphasized the other part of the problem—the properties of the core, or nucleus of the atom. Bohr's theory, based upon the conception of the nuclear positive charge, gives an interesting treatment of the problem of spectrum series, but its chemical application is very meager indeed (see §8). On the other hand, the present theory, since it originated in a study of the simpler aspects of chemical affinity, emphasizes the properties of the outer shell, though not necessarily at the expense of the other set of properties.

The essential assumption of this theory is that the electron is itself magnetic, having in addition to its negative charge the properties of a current circuit whose radius (finally estimated to be 1.5×10^{-9} cm.: see §16) is less than that of the atom but of the same order of magnitude. Hence it will usually be spoken of as the *magneton*. It may be pictured by supposing that the unit negative charge is distributed continuously around a ring which rotates on its axis (with a peripheral velocity of the order of that of light: §§5, 6); and presumably the ring is exceedingly thin. It might at first sight be supposed that if the electron were really thus magnetic, this property would have been detected in the behavior of kathode rays, but it will be shown later (§18) why it could not.

This rotation of a ring-shaped negative charge is intended to replace the usual conception of rotating rings of electrons in providing that orbital motion of electricity which is required by all theories of the magnetic and optical properties of atoms. No attempt will be made, however, to discuss the internal structure of the magneton.

With regard to the positive part of the atom, it will be necessary to avoid Rutherford's conception of a nucleus of very small dimensions—while fully recognizing the value of the evidence upon which he bases it—because it could not allow magnetons to take up the configurations that are essential to this theory, while the uniformly charged sphere of the Kelvin or Thomson "atom" is particularly well adapted to the purpose. As for the possible intersection of positive spheres, since any great amount of intersection, or coalescence, of the model atoms of this or of any other theory must abolish their individuality, and since the positive sphere is little more than a simple mathematical expression of the coherence and individuality of the atom (see also §7), it is consistent, as well as very necessary, to assume that positive spheres cannot intersect. It will also be assumed that the volume of the positive sphere is normally proportional to its charge, that is, to the number of magnetons in the atom, but that it is compressible; and that the normal radius of the magneton is about half that of the positive sphere of the Hydrogen atom:[1] that the volume of the positive sphere of an atom is usually very different from the total space occupied by the atom, and a way to account for this, will be made clear later (§15).

Some reasons for believing that the electron is this magneton may be enumerated now, and discussed more fully afterwards. They are:

1. It seems to be the only satisfactory way of securing valence electrons which are at rest, or vibrating within narrow limits, near the surface of the atom—a great desideratum from a stereochemical standpoint—without abandoning the very essential idea of orbital motion in the atom.

2. Even if the orbital motion is abandoned, and we suppose that the atom does contain electrons of the usual type in positions of equilibrium near its surface, the purely electrostatic nature of their action would be altogether inadequate from a chemical point of view. The additional magnetic forces furnished by the magneton are exactly what the phenomena of chemical action require.

3. It alone can give the atom a structure that accords closely with what is known about the magnetic properties of matter.

A general discussion of these points is given in §§2, 3, 4, the last being considered first. In §5 there is a brief study of the forces between two magnetons. In §6 it is argued that a number of magnetons within a sphere of uniform positive electrification must *tend* to arrange themselves in groups of eight. This suggests structures for the atoms (§7) that are in good accord with the general relations in the Periodic Scheme. A model which partially illustrates the behavior of the group of eight magnetons is also described, and the accompanying plates (1 and 2) show photographs of it. In §8 these results are compared with what is known about the number of

[1] The diagrams in this paper are drawn to scale on this basis.

electrons in the atom, especially in reference to the hypothesis of atomic numbers, with which they conflict to a certain extent. Then follows a detailed application of the theory to the problems of valence (§§9, 10, 12, 13), with a discussion of the residual magnetic and electric forces due to different groupings of magnetons (§11). §§14, 15 deal with the volumes of atoms, and after this (§16) it is convenient to recapitulate the assumptions of the theory, which is at that stage fully developed. §§17, 18 deal with the moment of the magneton and a few questions connected with it; and §§19-23 contain a full treatment of magnetic phenomena.

§2. Considerations of Magnetism

The arguments for the substitution of the conception of the magneton for that of the classical electron in orbital motion, in explaining magnetic phenomena especially, are principally concerned with the radiation difficulties involved in the latter conception, although conclusive arguments of another kind (pp. 9, 10) are also available. The radiation difficulties have of course been a matter of common knowledge, but since on account of the apparent impossibility of avoiding them they have largely been ignored, it is worth while to make a critical study of them as they occur in applications of the electron theory to magnetism.

Of all the theories so far suggested, the present magneton theory is the only one that allows the existence of orbital motion and so of steady magnetic forces in the atom without the accompaniment of radiation processes. Disturbances or irregularities of any kind in the rotation of the magneton's annular charge will give rise to radiations certainly, but these will be non-essential to the chemical and magnetic individuality of the atom, and will be set up always by chance external stimuli, just as all the radiation processes in atoms (not including the emission of α and β " rays ") are known to be in actual fact.

The contrary is the case with the classical electron. Every system of such electrons that has as yet been devised to explain magnetic phenomena either permits of continuous radiation or precludes the possibility of the atom giving radiations of at all the same kind as are observed: this will be made clear in what follows.

To begin with, it has long ago been pointed out by Sir J. J. Thomson that it is out of the question to consider orbits containing