LETTERS TO THE EDITOR

Prompt publication of brief reports of important discoveries in physics may be secured by addressing them to this department. Closing dates for this department are, for the first issue of the month, the twenty-eight of the preceding month; for the second issue, the thirteenth of the month. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents.

The Effect of Retardation on the Interaction of two Electrons

The problem of calculating positions of energy levels and probabilities of existing spectroscopic transitions is practically solved by the Dirac equation. As has been pointed out by Dirac even this simple case involves the fundamental difficulty of transitions to states with negative energy. It is hopeless at present therefore to have anything but an approximate treatment for two electrons since even one has not as yet been treated altogether satisfactorily. Nevertheless it seems reasonable to ask for a treatment correct to the order $(v/c)^2$. This is the approximation involved in the discussion of most problems of fine structure in spectroscopy.

In a paper which is to appear soon in this Review such an equation is set up. It is

$$\{p_0+\sum_{k=1}^{3}(\alpha_k^{\mathrm{I}}p_k^{\mathrm{I}}+\alpha_k^{\mathrm{II}}p_k^{\mathrm{II}})+(\alpha_4^{\mathrm{I}}+\alpha_4^{\mathrm{II}})mc+(e^2/2cr)(\sum_{k=1}^{3}\alpha_k^{\mathrm{I}}\alpha_k^{\mathrm{II}}+\sum_{k,i=1}^{3}\alpha_k^{\mathrm{I}}(x_k^{\mathrm{II}}-x_k^{\mathrm{I}})\alpha_i^{\mathrm{II}}(x_i^{\mathrm{II}}-x_i^{\mathrm{I}})/r^2)\}\psi=0$$

where $p_0=-(h/2\pi i)\partial/c\partial t+(e/c)(A_0^{\mathrm{I}}+A_0^{\mathrm{II}})-e^2/cr$; $p_k^{\mathrm{I}}=(h/2\pi i)\partial/\partial x_k^{\mathrm{I}}+(e/c)A_k^{\mathrm{I}}$; $p_k^{\mathrm{II}}=(h/2\pi i)\partial/\partial x_k^{\mathrm{II}}+(e/c)A_k^{\mathrm{II}}$, $r=[(x_1^{\mathrm{II}}-x_1^{\mathrm{I}})^2+(x_2^{\mathrm{II}}-x_2^{\mathrm{I}})^2+(x_3^{\mathrm{II}}-x_3^{\mathrm{I}})^2]^{1/2}$

and where A_0^{I} A_0^{II} are respectively the scalar potentials due to the external field for the coordinates $(x_1^{\mathrm{I}}\ x_2^{\mathrm{I}}\ x_3^{\mathrm{I}})$ and $(x_1^{\mathrm{II}}\ x_2^{\mathrm{II}}\ x_3^{\mathrm{II}})$ of the electrons I and II. The same convention is used for the vector potentials A_k^{I}, A_k^{II}. The above equation is derived in two ways. It is shown that in the configuration space of two electrons the relations between the momenta and the velocities $c\alpha_k^{\mathrm{I}}$, $c\alpha_k^{\mathrm{II}}$ are precisely those found by Darwin[1] for two electrons in the classical theory. It is also shown that the unified quantum theory of electrodynamics and matter recently developed by Heisenberg and Pauli leads to a first approximation in the Coulomb interaction to the same result as the equation just written. From the point of view of the later theory it becomes clear that another restriction should be made. The above equation applies only if the electrons in question are sufficiently close together to make $2\pi r/\lambda \ll 1$ where r is the distance between the electrons and λ is the shortest wave length of the term values of the electrons.

Presupposing the validity of the equation having 16 components it is reduced to a form involving only four. In this form the interactions of electronic spins with each other and with the orbits appear with the correct numerical factors used by Heisenberg in his discussion of the He fine structure. In addition another term of the same order of magnitude as the interaction of the electronics spins is found. It is hoped that its existence can be checked by an exact calculation of the proper functions of the ^2p state of He. For elements of high atomic number the effects of the interaction of electronic spins and of the new term are negligible and only the well known orbital spin interactions remain.

G. BREIT

Department of Terrestrial Magnetism,
Carnegie Institute of Washington,
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[1] C. G. Darwin, Phil. Mag. **39**, 537 (1920).