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Remarks on the Theory of Protons and Neutrons

In a recent paper[1] the author attempted to write the equations of the proton and the neutron (considered as two quantum states of one heavy particle) in close analogy with Dirac's equations for the electron and Pauli's equations for the neutron.[2] Eight values of the spin-variable were used and two additional terms in the Hamilton-operator were introduced. These latter represented (1) the interaction of the tensor of the electromagnetic field with the electric and magnetic moment of the particle and (2) the interaction of the heavy particle with the quantized field of electrons and neutrinos. (This second interaction is analogous to that introduced by Fermi[3] in his theory of β-rays.)

We write:

$$(p_0 - H/c)\psi = 0,$$

where

$$H = H_{PN} + H' \qquad (1)$$

and H_{PN} is the Hamilton-operator of the heavy particle:

$$\frac{1}{c}H_{PN} = \frac{e}{c}A_0\gamma - \alpha_4 Mc - \Sigma\alpha_k\left(p_k - \frac{e}{c}A_k\gamma\right) - \frac{e\hbar}{Mc}\Sigma\epsilon_{kl}\frac{\partial A_e}{\partial x_k}. \qquad (2)$$

Here ϵ_{kl} represents the components of the antisymmetrical tensor of the magnetic and electric moment of the heavy particle: $\epsilon_{23} = i\alpha_2\alpha_3\alpha_4\cdots$, $\epsilon_{01} = i\alpha_1\alpha_4\cdots$. γ is a matrix introduced in our previous paper in such a manner that the potentials A_k do not appear in the equations for a neutron. H' represents the interaction between the heavy particle and the electrons and neutrinos. It must be written so that the conservation laws of the energy and of the spin are respected; that is, every transition of a neutron into a proton must be accompanied by the emission of an electron and a neutrino (as by Fermi[3]). In the present paper we remark that the values of the magnetic moment of the proton ($3e\hbar/2Mc$) and of the neutron ($2e\hbar/2Mc$), which we obtain from (2) by introducing only one numerical factor $e\hbar/Mc$ (as a coefficient of ϵ_{kl}), are both in a satisfactory agreement with the values recently deduced by G. Kruger (2.7 and 1.75 nuclear magnetons) and with the measurements of the magnetic moment of the proton.

It seems also noteworthy that the interaction of the heavy particles with the electrons (represented, for instance, by the Dirac "density matrix") and neutrinos makes it possible to understand the oriign of the exchange forces between the proton and the neutron (considered by Heisenberg and E. Majorona).

A more detailed account of this question will be published shortly.

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[1] Lincei R. (in press).
[2] J. F. Carlson and J. R. Oppenheimer, Phys. Rev. 41, 63 (1932).
[3] Fermi, Zeits. f. Physik 88, 162 (1934).