The Spontaneous Disintegration of the Neutral Mesotron (Neutretto)

From the scattering experiments of Tuve, Heydenburg and Hafstad[1] it is known that the forces between two protons seem to be equal to those between a proton and a neutron. In order to account for this fact Yukawa et al.[2] and Kemmer[3] have extended the mesotron theory of the nuclear forces and have postulated the existence of a neutral particle which has the same rest mass and other properties similar to those of the mesotron. Thus a neutral mesotron or neutretto (denoted by Y^0) can be emitted and absorbed by a proton (P) or neutron (N) as indicated by the equations:

$$P \rightleftharpoons P + Y^0; \quad N \rightleftharpoons N + Y^0. \tag{1}$$

The forces between two protons can then be considered as due to mutual emission and reabsorption of this particle.

The spontaneous disintegration of a charged mesotron into an electron and a neutrino has been discussed theoretically,[1,4] and the lifetime has been found to be in reasonable accord with observations on the mass absorption anomaly for cosmic rays.[5] This would lead to the analogous assumption that the neutral mesotron has also a finite lifetime of the same order of magnitude as that of the charged one and disintegrates spontaneously into a pair of electrons or neutrinos:

$$Y \rightarrow e + \pi; \quad Y \rightarrow n + n'. \tag{2}$$

Here e, π, n and n' denote an electron, a positron, a neutrino and an antineutrino, respectively. We shall, however, point out here that without such an assumption the neutral mesotron is still unstable and transforms spontaneously into photons $(h\nu)$:

$$Y^0 \rightarrow h\nu + h\nu; \quad Y^0 \rightarrow h\nu + h\nu + h\nu; \quad \text{etc.} \tag{3}$$

These processes can be brought about in the following way. First a neutral mesotron is absorbed by a proton which is in the negative energy state and produces a (virtual) pair of a proton and an antiproton. Then this pair disappears with the emission of more than two photons. The transition probabilities of these processes are proportional to $g^2 e^4$, $g^2 e^6$, etc., respectively, where e is the elementary charge and g is the constant, characterizing the strength of the interaction between the neutral mesotron and the heavy particle, which is determined by the magnitude of the proton-proton force. Owing to the largeness of this constant, the lifetime of the neutral mesotron is expected to be far shorter than that of the charged one.

Calculations based on the vector mesotron theory show, however, that transition probabilities of the processes in which even numbers of photons are created vanish identically.[6] Therefore the main contribution to the lifetime comes from the three-quanta disintegration. Though the exact calculation of this process is extremely complicated on account of the complexity of the Dirac-Heisenberg theory of the positron (antiproton in this case), a rough estimation gives the following value for the lifetime of the neutral mesotron at rest:[7]

$$\tau \sim \frac{h^4 c^4}{g^2 e^6} \frac{h}{m_u c^2} \sim 10^{-16} \text{ sec.,} \tag{4}$$

which is about 10^{-10} times as short as that of the charged one. This result seems to account for the failure of the experiments to prove the existence of the neutral mesotron in cosmic rays.[8]

Full details will be published later in Proc. Phys.-Math. Soc. Japan.

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On the Polarization of Electrons by Scattering

It is well known that experiments fail to observe any appreciable polarization by scattering[1] which is sometimes regarded as a failure of the theory. Bethe and Rose[2] have shown in a recent article that this fact cannot be explained by depolarization effects. I wish to point out that the negative result of experiments seems to follow from a much simpler reason, namely from the fact that the scattered electrons observed have got their deflection not in a single act of scattering but as a result of multiple scattering.

The angular width of the beam originated by multiple scattering can be easily calculated. The mean square angle of deflection resulting from a multiple scattering is[3]

$$\langle \theta^2 \rangle_{Av} = 2\pi N (Ze^2/E)^2 l \log [\langle \theta^2 \rangle_{Av}^{\frac{1}{2}}/\theta_0],$$

where N is the number of atoms in a unit volume, Z the atomic number, E the energy of the electrons (more exactly $E = mv^2/2[1 - (v^2/c^2)]^{\frac{1}{2}}$), θ_0 the angle for which effects of screening become important, and l the path which the electrons have traveled. Inserting the values for gold we get for $E = 100$ kv

$$\langle \theta^2 \rangle_{Av} = 2.5 \times 10^3 l \log (5 \times 10^6 l).$$

Even for $l = 7 \times 10^{-6}$ cm (the thinnest foil used by Dymond) we get

$$\langle \theta^2 \rangle_{Av}^{\frac{1}{2}} = 0.23.$$

But this means that most of the deflected electrons observed in experiment were scattered many times on small angles. As the polarization formula given by Mott[4] shows that the polarization falls very rapidly for small angles of scattering, this seems to explain the experimental results.

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