Letter to the Editor

A Consistent Theory of the Nuclear Force
and the β-Disintegration

In spite of many an attempt to develop the so-called "β-hypothesis of the nuclear force",[1] there still remains the inconsistency between the small probability of β-disintegration and the large interaction of the neutron and the proton. About two years ago[2] the present a possible solution of this difficulty which was proposed by the present writer about two years ago[2]

First, we consider the a field describing which is responsible for the short range exchange force between the neutron and the proton. just as the ordinary electromagnetic field is responsible for the ordinary Coulomb force.[1] The most simplest possible assumption may be that which such that can be derived from two scalar potentials conjugate complex to each other satisfying the field equations $U, \tilde{U}$ in the presence of a heavy particle

$$\left\{ \Delta - \frac{1}{c^2}\frac{\partial^2}{\partial t^2} - \lambda^2 \right\} U = -4\pi g \,\tilde{v}\, u \quad \text{or} \quad 0 \qquad (1)$$

$$\left\{ \Delta - \frac{1}{c^2}\frac{\partial^2}{\partial t^2} - \lambda^2 \right\} \tilde{U} = 0 \quad \text{or} \quad -4\pi g\, \tilde{u}\, v \qquad (2)$$

according as it is initially in the neutron state u or in the proton state v where g is a constant with the dimension of the electric charge.

From these equations we can easily deduce the exchange force between the neutron and the proton with the potential

$$g^2 \frac{e^{-\lambda r}}{r}$$

between the neutron and the proton. This force was found to be of Heisenberg's type, but the Majorana force can also be obtained by a little more complicated assumptions. assuming the potentials with a space vector, vector character

Next, this field interacts, on the other hand, with the light particles, and leads to the transition between the neutrino state and the electron state. Thus, similar terms as above should be added but with another constant g' instead of g, it follows that the probability of β-disintegration the probability of β-disintegration can be calculated as due to the interaction between the light and heavy particle by means of the U-field, found that the result is essentially the same as that of Fermi if

slight modifications are necessary of the theory

The modification of the theory in order to ~~fit~~ be in ac~~cord~~ with the mathematical formulation of the ~~theory~~ ~~result~~ although the exact ~~couple~~ becomes rather troublesome on account of ~~the~~ the presence of the electromagnetic field. to show the result

we put

$$\frac{4\pi g g'}{\lambda^2} \quad \text{equal to Fermi's } g.$$

Hence, three constant λ, g, g' can adjusted so as to give correct magnitudes both for mass defect and the probability of β-disintegration. If we take, for example, $\lambda = 5 \times 10^{12} \text{cm}^{-1}$ and $g \simeq 2 \times 10^{-9}$, g' should be about 10^{-8} times smaller than g. ~~Premuggaith~~ Kronig and Uhlenbeck, can be obtained by necessary modification by a slight modification, the theory can of the interaction necessarily terms.

~~The immediate~~ A noticeable result which follows ~~immediately~~ is that the above field should be accompanied by quanta with the elementary charge $+e$ or $-e$ and the proper mass obeying Bose's statistics $m_U = \frac{\lambda \hbar}{c}$, which is about 200 times as large as the electronic mass, if we take the above value for λ, We can expect, however, the creation of notes such quanta by ordinary nuclear reactions, ~~for which~~ the ~~needs~~ as the energy it needs at least ~~the~~ an energy of the order $m_U c^2 \gtrsim 10^8 eV$. On the contrary, if they ever exist, their tracks ~~could~~ should ~~can~~ be found in the cloud chamber photographs of cosmic ray and it is not altogether impossible that the anomalous tracks ~~obtained~~ of the curvature discovered by Anderson and Neddermeyer ~~with the larger than the proton~~ recently[3] are really due to such quanta, the range-curvature relation of these tracks ~~can is~~ being not in contradiction with such a hypothesis. Further discussions ~~and~~ ~~Detailed Account of~~ ~~mathematic~~ formulations ~~of~~ will be made in the later issue of the Proc. Phys.-Math. Soc. Japan.

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See, for example, Bethe and Bacher, Rev. Mod. Phys. 8, 82, 1936.

1) ~~Detailed~~ discussion of the subject was made, for ~~example~~, and ~~also~~ further, v. Weizsäcker, Zeits. f. Phys. 102, 572, 1936 ~~Ivanenko~~ and Sokolow, Zeits. f. Phys. 102, 119, 1936;

2) ~~Yukawa~~ Proc. Phys.-Math. Soc. Japan, 17, 48, 1935.

3) Phys. Rev. 50, 263, 1936.

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