On the Existence of Light
Nuclear Mesons

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Recent investigations on cosmic-rays by Lattes and others require that the range of nuclear forces must be taken shorter than that usually adopted. Although this alteration will not give remarkable influence to the problem of nuclear forces, the situation will be different, when we take into consideration the simultaneous interaction with electromagnetic field, where the extension of the charged body affects the results.

The quadrupole moment of the deuterons, for instance, is greatly reduced with decreasing force range. To ascertain this we have made the calculation, employing the nuclear potential proposed by Watanabe,(1) which is characterized by Möller-Resenfeld Schwinger type mixture of pseudoscalar and pseudovector mesons. This type of potential has an advantage, on the contrary to Schwinger's potential, in that it gives considerably large tensor force and consequently we can expect large quadrupole moment. However, even in this case, the results gave too small values for short range force as is seen from the Table.

<table>
<thead>
<tr>
<th>Mass of ps-mesons</th>
<th>Mass ratio</th>
<th>Quadrupole mom. ($\times 10^{-2} \text{cm}^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>313 m.</td>
<td>1.6</td>
<td>0.85</td>
</tr>
<tr>
<td>313 m.</td>
<td>1.0</td>
<td>1.34</td>
</tr>
<tr>
<td>177 m.</td>
<td>1.6</td>
<td>3.4</td>
</tr>
</tbody>
</table>

Concerning to the photo-disintegration of deuterons, its dependence on force range is not so remarkable as quadrupole moment, also decreasing interaction cross section with decreasing force range. Recent investigation by Wilson, Collie and Halban(2) reported that their experimental results favour light mesons (of mass~196 m.) to the mesons of heavier mass~296 m.

Deuteron problems have already been solved almost consistently with long range forces (range = 2 to $2.8 \times 10^{-10}$ cm). Together with the above discussions and the facts that in the Berkeley cyclotron experiments there are observed light and heavy mesons with equal probability and some light mesons give rise to star type disintegrations of nuclei, it seems better to introduce light nuclear mesons. And so we propose as a working hypothesis that:

1. The nuclear meson field is composed, besides $\pi$-mesons, of light nuclear mesons with the mass nearly equal to that $\mu$-mesons, which we shall call $\beta$-meson.

2. $\beta$-mesons decay into electrons and neutrinos with short lifetime $\sim 10^{-8}$ sec. or shorter.

To explain that no, or very few, $\beta$-mesons are found in the hard component of cosmic-rays, 2. must be added. Our interaction scheme is written as follows:

\[
(N, P) \rightarrow (\pi^\pm, \nu) \rightarrow (\mu^\pm, \bar{\nu}) \rightarrow (e^\pm, \nu)
\]

The introduction of $\beta$-mesons may be favourable to explain the following fact in the cosmic-ray phenomena. As many authors have pointed out, the intensity of
electrons in the lower altitude can not be explained as the product of $\pi$-mesons only. These excess electrons are to be attributed to N-radiation. Now we might insist that the substance of N-radiation is $\beta$-mesons, which are produced by nucleon component and immediately disintegrate into electrons. The intensity of excess electrons, deduced by this process, is proportional to $x \cdot \exp (-a x)$, where $x$ is the depth of atmosphere. This intensity curve agrees very well with the altitude dependence of the excess electrons. The ratios of two sorts of electrons, one produced by ordinary mesons and the other by N-radiation, are calculated to be 0.8 at 6m water depth, which again shows good agreement with experimental results.

Although our hypothesis explain fairly well the known phenomena on nuclear forces and cosmic-ray evidence, there exists one defect: that is, $\pi$- and $\beta$-mesons interact with nucleons strongly and thus $\pi$-mesons decay into $\beta$-mesons with considerably large probability and no $\pi$-mesons could exist in the cosmic-rays. As is well known, the similar difficulty also occurs in the $\gamma$-decay of neutral mesons. Both difficulties are, however, the same in their nature and we may say that they will be got over simultaneously in the future; for instance, by assuming that there exist no anti-particles for nucleons, or that we consider the complex constitution of protons and neutrons as Klein. But in the present stage of our knowledge on the elementary particles, we must not be too hasty to solve this problem.

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