ON THE INTERMEDIATE BOSON IN WEAK INTERACTIONS

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The question as to whether weak interactions processes are mediated through a vector B-boson has already been raised[1]. The small probability of the process $\mu \to e + \gamma$ can hardly be conciliated with the intermediate boson assumption if in nature there exists only one type of neutrino-antineutrino pairs[2]. However, if "electron" (ν_e) and "muon" (ν_μ) neutrinoes are different particles, there are no arguments against this assumption. Even more, it can be said that the existence of the B-boson would practically prove that muon and electron neutrinoes are different particles.

According to Lee and Yang[3], the non-locality of the μ-decay connected with the B-boson affects the Michel parameter and the μ-decay rate. However, the accuracy of the measurements is entirely insufficient to determine possible limits on the B-meson mass. Below are discussed some consequences of the B-particle assumption.

If there exists a B-meson, all the known weak interaction processes will be of the second order in the constant g_B coupling the B-meson field with various fermion pairs. The Fermi constant G $\left(G \simeq \frac{10^{-5}}{M^2}, \hbar = c = 1, M-\right.$ nucleon mass) is then a phenomenological constant: $G \sim g_B^2/m_B^2$ (m_B is the B-meson mass). Assuming, e.g. $m_B \sim M$, we get $g_B^2 \sim 10^{-5}$, which is only thousand times less than e^2. It is hardly possible to get some information on the existence of the B-meson by studying ordinary weak interaction processes in which virtual B-mesons are involved. Consequently we turn our attention to the processes involving the production of <u>real</u> B-mesons.

It is clear that B-mesons will decay, in particular, as follows:

$$B \to \mu + \nu \quad , \quad B \to e + \nu \quad , \quad B \to \pi + \pi .$$

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x) This paper was reported at the IX Conference on High Energy Physics, Kiev, 1959. (See discussion after the report of Alikhanov and also the report of Marshak).

The decay rate of the B-meson is of the order of $10^{18}\,sec^{-1}$. As the mean life is relatively short, the collisions in which real B-mesons are generated will simulate stars with apparent production of muons and electrons, although these leptons are emitted with a characteristic time uncomparably greater than the collision time. Therefore, the B-particle existence implies that processes apparently accompanied by lepton emission become relatively probable when the collision energy in the c.m.s. is greater than the B-meson mass: in high-energy stars there will be emitted muons and electrons with a probability only five or six orders of magnitude smaller than the emission probability of pions, a fact which might help to prove experimentally the B-particle existence. Putting aside the processes of B-meson production by strong interacting particles and B-meson photoproduction processes (the cross-section of which contains a factor $g_B^2 e^2$), we will consider some processes of first or zero orders in g_B, especially attractive from the experimental point of view.

1. "Electromagnetic" production of B-meson pairs:

$$\gamma + A \to B^+ + B^- + A$$
$$\pi + A \to B^+ + B^- + A$$

The cross-sections contain the factors $Z^2 e^6$ and $Z^2 e^4 g_\pi^2$ respectively.

2. The production of a B-meson by neutrinoes in the field of a nucleus:

$$\nu + A \to \begin{cases} B + e + A \\ B + \mu + A \end{cases} .$$

Clearly the processes 2 are the only first order processes in g_B, which may be induced by neutrinoes. The probability of such processes is relatively suppressed because of the large value of m_B. Dimension arguments suggest that the cross-section for neutrino induced processes 2 is $\sim Z^2 g_B^2 e^4 m_B^{-2}$. At neutrino energies of a few BeV the cross-section for B-meson production in collisions with lead nuclei attains a value $\sim 10^{-34}$ cm^2, which is quite a reasonable value from the point of view of people wishing to plan experiments on the subject. Events of B-meson production will simulate, for example, the generation of electron, muon and μe pairs. In the experiment an attempt must be undertaken to observe (let us say with a xenon bubble chamber or by means of electronic methods) individual events induced by very hard neutral radiation from an accelerator, under such conditions of shielding, that effects produced by other neutral radiation either are negligible or can be evaluated.

Eventually it may be noted that quite a part from the possibility of parity non-conservation in strong interactions, the real production of B-mesons with their subsequent disintegration into pions will simulate parity non-conservation in strong interactions at high energies (in $\sim 10^{-5}$ of the total number of events).

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References

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3). T.D. Lee and C.N. Yang, Phys. Rev., 108, 1611, (1957).