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SOME REMARKS ON ψ-PARTICLES

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Recently MIT - BNL [1] and SLAC [2] groups reported the discovery, confirmed by the Frascati group [3], of a new particle ψ(3105) with leptonic and hadronic decay modes. The outstanding characteristics of this particle is its narrow width much less than the widths of ordinary hadronic resonances.

In the framework of the papers published before as well as after the discovery, it is natural to interprete the new particle either as a boson, in some way connected with the weak neutral current, or as an hadron, associated with the existence of a new quantum number (we have in mind charmed and coloured quarks). Although it is likely that the last hypothesis turns out to be correct, in this note we express a different point of view. It is quite improbable that the speculations given below turn out to be true; nevertheless there is definite physical meaning in them, since some of their consequences may be experimentally checked.

It is very important from our point of view that a second ψ-particle with mass 3695 MeV and similar decay properties has been discovered [4]. Accordingly we assume that a family of new particles might exist. This suggests the existence of some kind of symmetry reminding us the symmetry in hadron matter. And yet the relatively narrow widths of the ψ-particles may point out essential differences between them and usual hadrons. In order to facilitate our further discussion we shall call them new-hadrons, and the corresponding bosons we shall denote by ψ. The experiments indicate that the coupling of the new-hadrons to hadrons and leptons is "semiweak" (of course, we do not state here that the ψ-particles are connected with the weak interactions; this important point can be checked only by experiments, for example, by a search for decay $\psi \to \nu + \bar{\nu}$).

Naturally the following question arises: should not there exist plenty of new-hadronic resonances analogous to usual hadron resonances? Yes, probably there should be many such resonances, but only a few of them, namely those with relatively small masses, will decay directly into leptons and ordinary hadrons. Most of new-hadronic particles should decay with large widths into other new-hadrons.

The existence of the new-hadronic matter should manifest itself in multiplicity phenomena, i.e., in the multiple production of ψ-particles, just as it happens for hadronic matter, where there is the multiple production of hadrons, say pions. This leads to the ''unusual'' situation where the production of two or more ψ-particles is of the same ''semiweak'' order as the production of only one ψ-particle. This is illustrated by the diagrams in fig. 1.

From the above speculations it follows that:

1. The ''semiweak'' processes

$$\psi(3.7) \to \psi(3.1) + e^+ + e^- ; \quad \psi(3.7) \to \psi(3.1) + \mu^+ + \mu^-$$

could take place. The signature of these decays is quite clear. Since $\psi(3.1)$ can decay with the emission of a (nearly collinear) leptonic pair, two leptonic pairs in the final state will be present.

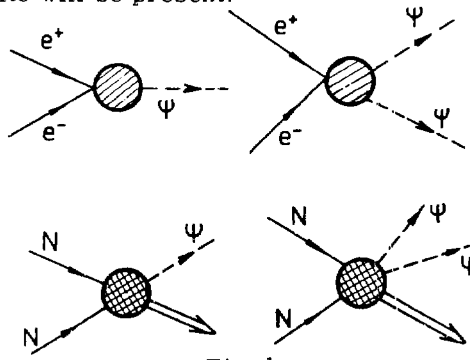

Fig. 1

2. In collisions of the type $e^+ + e^-$, $N + N$, etc., at sufficiently high energies *the multiple* ψ-particle production should take place (in the order of g_ψ). Practically this can be observed through the detection of leptonic pairs, for example, of two $\mu^+ - \mu^-$ pairs if at least two ψ-particles are produced.

3. If the energy of the colliding $e^+ e^-$-particles is greater than the total mass of two ψ-particles, processes of the type

$$e^+ + e^- \to \psi + \psi + \ldots ,$$

i.e., a new (annihilation) channels of hadron production (from the hadron decays of ψ) are opened. The opening of new nonresonance channels could be connected with the well known 'anomaly'' [5] in the energetic dependence of the $e^+ + e^- \to$ hadrons cross section.

4. In the scheme under consideration the decay

$$\psi(3.7) \to \psi(3.1) + \pi^+ + \pi^-$$

should be characterized by the ''semiweak'' coupling constant g_ψ. There is some information that the SLAC-group in fact observed this decay and that its width is 15-20% of the total $\psi(3.7)$ width. Such a width would correspond to an effective coupling constant which is too large for our scheme. Nevertherless, we would like to stress that a large effective coupling constant for this decay would arise in our scheme if the pair $\pi^+ - \pi^-$ were emitted in the decay of a light new-hadron (of course, this can be checked by investigating the mass spectrum of $\pi^+ \pi^-$ pairs).

Let us discuss now the possibility of interaction of ψ-particles with neutrinos. The existence of such an interaction would give strength to our arguments. There are contradictory rumors concerning the angular asymmetry in the process $e^+ + e^- \to \mu^+ + \mu^-$ at $E = 3105$ MeV. The observation of such an asymmetry, of course, would indicate the connection of ψ-particles with the weak interactions. The opposite is not true, because there is no experimental evidence in favour of parity nonconservation in neutral currents [6].

We wish to underline here that the existence of a neutrino decay mode of $\psi(3.1)$ could be checked by investigating the decay $\psi(3.7) \to \psi(3.1) + \pi^+ + \pi^-$. For this purpose it is necessary to select the events of $\psi(3.1)$ production by the missing mass method (i.e., by measuring the momenta of the two pions) and to compare then the number of lepton pairs($\psi(3.1) \to e^+ + e^-$; $\psi(3.1) \to \mu^+ + \mu^-$) with the number of events without complementary visible tracks ($\psi(3.1) \to \nu + \bar{\nu}$) .

If it would turn out that the decay $\psi \to \nu + \bar{\nu}$ takes place, the production of $\mu^+ - \mu^-$-pairs by neutrinos

$$\nu + N \to \nu + \psi + \dots$$
$$\psi \to \mu^+ + \mu^-$$

could be observed (fig. 2).

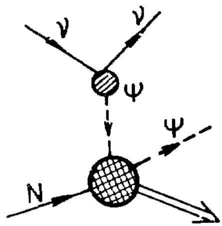

Fig. 2

As L.B.Okun noticed, the above scheme has common features with the ideas developed in papers [7-9] and recently in the investigation of theoretical groups of ITEF [10] .

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