ON THE PION-PION RESONANCE IN THE p STATE

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QUITE recently there has been great interest in the question of the existence of a p resonance (isobar) in pion-pion scattering.[1] From a study of the structure of nucleons by the method of dispersion relations, Frazer and Fulco have concluded that an isobar with mass 435 Mev and half-width 10 Mev must exist in the p state of pion-pion systems.[2] Similar results on the presence of a p resonance in pion-pion scattering have also been obtained by other authors.[3] On the other hand, the integral equations for pion-pion scattering have been derived more accurately by means of the ordinary theory of one-dimensional dispersion relations.[4] Preliminary results on the solution of these equations, obtained by means of an electronic computing machine, show that the amplitude of the p wave is very small. It is as yet unknown whether there is another solution with a large p amplitude. Therefore a direct experimental test of the presence of a p isobar in the pion-pion system is of great importance. For this purpose Chew and others[5] have suggested the reactions

$$e^+ + e^- \to \pi^+ + \pi^-, \quad e^- + e^- \to e^- + e^- + \pi^+ + \pi^-, \qquad (1)$$

studies of which could help to provide information about the interaction of pions in the p state. These processes are interesting because the theoretical interpretation of the results is simple and clear. But because of the lack of high-energy clashing electron and positron beams, it is difficult to conduct such experiments at present.

In the present note we suggest the study of the following processes:

$$\pi^\pm + He^4 \to He^4 + \pi^\pm + \pi^0, \qquad (2a)$$

$$\pi^\pm + d \to d + \pi^\pm + \pi^0, \qquad (2b)$$

$$p + p \to d + \pi^+ + \pi^0. \qquad (2c)$$

For all of these processes the initial isotopic spin is I = 1. Consequently, the pair of pions in the final state has the isotopic spin I = 1 and is in a state with odd orbital angular momentum. In the low energy region these pions are mainly in the p state.

Let us assume that there is an isobar with mass 435 Mev and half-width 10 Mev in the p state. Then in the reactions (2) the pairs of pions come from the decay of isobars that have been produced together with nuclei He^4 or d. Because of this it is to be expected that there will be a sharp maximum in the spectrum of the He^4 (or d).

Let us consider, for example, the reaction (2a). Suppose the energy of the incident pion beam is 700 Mev in the laboratory system. (l.s.). Then in the center-of-mass system (c.m.s.) one should observe a maximum in the spectrum of the He^4 at energy 11 Mev and with half-width 2 Mev. In the case of the reaction (2c) with incident beam energy 1.4 Bev in the l.s. the deuteron spectrum in the c.m.s. must have a maximum at energy 36 Mev and with half-width 3 Mev.

If the p isobar does not exist, then the shape of the spectrum of the He^4(d) varies smoothly and is determined mainly by the statistical phase-volume factor. Therefore measurements of the spectra of the nuclei in the reactions (2) will give information about the existence of a p resonance in the pion-pion system.

We note that the process $d + d \to He^4 + \pi^0 + \pi^+ + \pi^-$ is also useful for studying the isobaric structure of pion-pion systems in the iso-scalar state.

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[3] F. Cerulus, Nuovo cimento **14**, 827 (1959).

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