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263

SEARCH FOR ANOMALIES IN THE ENERGY DEPENDENCE OF THE CROSS SECTION OF THE REACTION $p + p \to d + \pi^+$ *NEAR THRESHOLD OF PION PAIR PRODUCTION*

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RECENTLY in a number of papers (cf., e.g., reference 1) there has been a broad discussion of effects associated with anomalies in the energy dependence of a reaction near thresholds for inelastic processes. No one has as yet succeeded in observing effects of this sort at high energies, and therefore the problem of testing the results of the theory is now of considerable interest. We have made an attempt to detect near-threshold singularities in the reaction

$$p + p \to d + \pi^+ \qquad (1)$$

at proton energies from 574 to 648 Mev, where the following processes of π-meson pair production are possible:

$$p + p \to \begin{cases} p + p + \pi^0 + \pi^0, & Q = 579.03 \text{ Mev} \\ d + \pi^+ + \pi^0, & Q = 587.48 \text{ Mev} \\ n + p + \pi^0 + \pi^+, & Q = 592.53 \text{ Mev} \\ p + p + \pi^+ + \pi^-, & Q = 600.08 \text{ Mev} \\ n + n + \pi^+ + \pi^+, & Q = 606.06 \text{ Mev} \end{cases} \qquad (2)$$

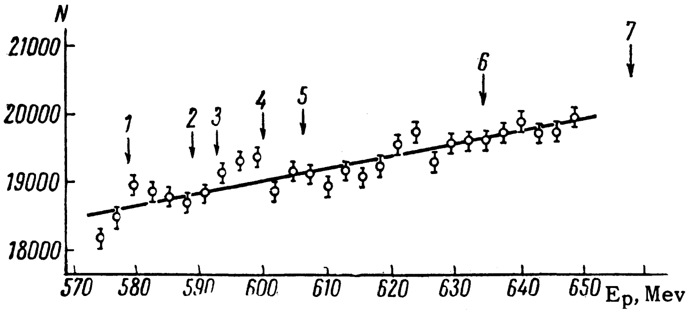
Furthermore, in this energy range one can expect anomalies near the threshold for production of the hypothetical ω particle, which has been discussed in reference 2 as one of the ways of explaining the experimental data. In p-p collisions the ω particle can be produced in the reactions

$$p + p \to \begin{cases} d + \omega^+ \\ n + p + \omega^+ \end{cases} \qquad (3)$$

The range of proton energies from 574 to 648 Mev corresponds to a range of masses for the ω particle from 275 to 305 Mev.

The choice of the reaction (1) for the observation of near-threshold singularities was made for the following reasons. First, the total and differential cross sections of the reaction (1) change only by small amounts in the range of energies of the incident protons from 574 to 648 Mev,[3] and this to some extent facilitates the search for anomalies near the thresholds of other reactions. Second, we may suppose that owing to the small cross section of the reaction (1) possible anomalous effects may be most clearly marked in just this reaction. Finally, the method that we have used to measure the differential cross section of the reaction (1) may give greater sensitivity to near-threshold anomalies than would be obtained in measurements of the total cross section.

We have measured the yield of deuterons in the low-energy branch of the reaction (1) for a single angle in the laboratory coordinate system (l.s.) as a function of the energy of the incident protons over the range 574 — 648 Mev. The proton beam of intensity 10^{11} sec^{-1} was focused with magnetic quadrupole lenses on a polyethylene target 5 mm thick. The secondary particles produced in the target were separated out by a brass collimator placed at an angle of 5.8° with the axis of the beam, were deflected by an electromagnet through an angle of 27°, passed through a steel collimator in the concrete shielding wall, and were registered by a telescope made up of five scintillation counters. The charged particles were identified by their momentum, specific ionization, and range,[4] which



Energy dependence of the differential cross section of the reaction $p + p \rightarrow d + \pi^+$ for the angle 5.8° in the l.s. The straight line drawn in the diagram was obtained by the method of least squares. The arrows 1, 2, 3, 4, 5 show the positions of the thresholds of the reactions (2); the arrows 6 and 7 show the positions of the thresholds of reaction (3) for masses 295 and 305 Mev for the ω particle.

made it possible to distinguish deuterons reliably against the background of photons coming from the target.

The energy of the proton beam was varied by means of polyethylene blocks placed in front of the magnetic quadrupole lenses. The proton energy was determined within an interval of 2.8 Mev, which was approximately the energy dispersion of the proton beam.[5]

The kinematics of the reaction (1) are such that for an angle of 5.8° in the l.s. the momentum of the deuterons of the low-energy branch varies by only 3 percent as the proton energy is decreased from 650 to 570 Mev. This decidedly simplifies the measurements and makes it possible to determine the energy dependence of the differential cross section for the reaction (1) by measuring the deuteron yield at the maximum of the resolution curve, instead of finding the area under the resolution curve at each proton energy. At each proton energy a determination was made of the value of the current in the deflecting magnet that corresponded to the position of the peak of the deuterons from the reaction (1); this was calculated from calibration curves of the resolving power, with half-width about 2 percent, measured at three energies: 574, 607, and 657 Mev. With this procedure the inaccuracy in supplying the required current through the deflecting magnet could not cause an error of more than 0.3 percent in the results.

The averaged results of two series of measurements, without subtraction of the background of deuterons from the carbon target, which was about 15 percent, are shown in the diagram. The data were approximated by a straight line, constructed by the method of least squares. If we take into account only the statistical errors of the measurements, amounting to 0.7 percent, the χ^2 test indicates that the experimental data are not consistent with this straight line. If, however, we suppose that besides the statistical errors there is an additional dispersion in the measurements which amounts to 0.5 percent, the χ^2 test gives a 10-percent probability for the fit of the linear dependence to the experimental data. Since the results of a comparison of the separate series of measurements do not allow us to exclude such an amount of instability of the apparatus, the spread of the experimental points which is seen in the diagram cannot be ascribed to real anomalies in the energy dependence of the differential cross section for the reaction (1).

It follows from the results of this work that if the near-threshold anomalies predicted by the theory do exist in the reaction (1), their magnitude does not exceed 2 percent of the average differential cross section of reaction (1) over the proton-energy range 574 — 648 Mev.

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264

SEARCH FOR ANOMALIES IN THE SPECTRUM OF THE H^3 NUCLEI EMITTED IN THE REACTION $p + d \rightarrow H^3 + \pi^+ + \pi^0$ AT A PROTON ENERGY OF 670 Mev

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THERE has recently been much discussion of the problem of the resonance interaction of two π mesons with the isotopic spin $T_{\pi\pi} = 1$. The only