cipal axis $\langle q \rangle = \langle \partial^2 V/\partial z^2 \rangle$, and the angular orientation of this tensor with respect to its static direction. In addition, with temperature there may be some change also in the asymmetry parameter $\eta = |(q_{xx} - q_{yy})/q_{zz}|$. The calculations of Kushida et al.[3] lead to the following dependence of the value of the splitting on the temperature: $\Delta = a(1 + bT + c/T)$. The constants a, b, and c are functions of volume and can be obtained from measurements of the dependence of Δ on pressure for different temperatures. A comparison of the experimental data with theoretical computation should enable one to determine the quadrupole moment of the Sn^{119} nucleus in the excited state.

The dependence found in the present work for the quadrupole splitting as a function of temperature explains the result of Boyle, Bunbury, and Edwards[4] who observed no splitting of the absorption line in the β-Sn crystal. In their work the absorber was at room temperature, in which case the quadrupole splitting does not exceed in magnitude the width of the line in the absorption spectrum even for a thin source. But the width of their source was such that as a result of self-absorption the line width of the radiated line was increased by a factor of two compared to the natural width. Under such conditions of the experiment, the quadrupole splitting could not be observed. (In the work of Picou et al.[5] the quadrupole splitting was also not observed at liquid nitrogen temperature, which is possibly explained by the use in their work of extremely thick source and absorber.)

As we see from the figure, the influence of the temperature shows itself not only in the magnitude of the quadrupole splitting, but also in the location of the centers of the absorption curves in the spectra. The observed line shift with changing temperature exceeds by several factors the value of the so-called "temperature shift"[6] and contradicts the data of the work of Boyle et al.,[7] who found good agreement with the theory. The reason for this discrepancy is difficult to analyze, since these authors do not give all the necessary data; it is possible that in their work there was an influence on the measured effect of the change in line shape with change in temperature, which was not taken into account. One may assume that the change in internal field in the β-Sn crystal with changing temperature not only leads to a change in the value of the quadrupole interaction, but also changes the energy of the γ transition as a whole, which has an effect on the observed shifts in the absorption line.

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RATIO OF $\pi N \to \pi\pi N$ REACTION CROSS SECTIONS OF 290 Mev AND π-π INTERACTION

Yu. A. BATUSOV, S. A. BUNYATOV, V. M. SIDOROV, and V. A. YARBA

Joint Institute for Nuclear Research

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THE process of the production of the second meson in the reaction $\pi N \to \pi\pi N$ at different energies has recently been widely used to obtain information on the π-π interaction. In the collision of a π meson and a proton above the threshold for the production of the second meson ($\sim$170 Mev) the following processes are possible:

$$(1)\ \pi^- + p \to n + \pi^+ + \pi^-,\quad (2)\ \pi^- + p \to p + \pi^0 + \pi^-,$$
$$(3)\ \pi^- + p \to n + \pi^0 + \pi^0,\quad (4)\ \pi^+ + p \to n + \pi^+ + \pi^+,$$
$$(5)\ \pi^+ + p \to p + \pi^+ + \pi^0.$$

In order to explain certain qualitative features of the π-π interaction, it is of interest to establish relations between the cross sections of the above processes. Of these reactions, (1) and (2) have been investigated in detail at an energy of the primary meson of the order of 1 Bev.[1-3] At lower energies only reaction (1) has been studied in detail.[4-6] The cross section for it at 290 Mev was found to be $\sigma_1 = 0.61 \pm 0.13$ mb.[5] The cross section of reaction (2) has not been measured directly.

Zinov and Korenchenko[7] have measured the combined cross section $2\sigma_1 + 0.7\sigma_2$. Combined with the data of Perkins et al.,[4] who have determined σ_1, one can obtain at 317 Mev the estimate $\sigma_2 = 0.2 \pm 1.2$ mb. At 220 Mev there have been observed[8] three events corresponding to reaction (1) and no event of reaction (2) was found. In the present paper we shall estimate the ratio of the cross sections of reactions (2) and (1) at a meson energy of 290 ± 15 Mev.

A search for the reactions (1) and (2) was undertaken in emulsions irradiated in the Synchrocyclotron Laboratory of the Joint Institute for Nuclear Research. The emulsions were area scanned for stopping of secondary π^- mesons. The tracks then were followed back to the point of production. The events where the production took place on hydrogen were decided by the criteria described in reference 5. A total of 1058 stars associated with π^- mesons were found. Amongst them 12 events of reaction (1) and 5 events of reaction (2) were found. Taking into account geometric corrections concerning the probability of registration of π mesons by the emulsion chamber we obtain for the ratio of the cross sections of reaction (2) to (1) the value $\sigma_2/\sigma_1 = 0.3 \pm 0.2$.* With $\sigma_1 = 0.61 \pm 0.13$ mb this gives for reaction (2) at 290 ± 15 Mev a cross section $\sigma_2 = 0.2 \pm 0.1$ mb (see the footnote, however.) If one extrapolates the results of the calculations Goebel and Schnitzer[9] for the statistical model including π-π interaction to 290 Mev one obtains for this ratio the value $\sigma_2/\sigma_1 \approx 0.2$.

At present there do not exist equivalent data for the reaction (3) in the energy region around 300 Mev. The combined cross section for reactions (4) and (5) at 290 Mev is estimated[10] to be ~ 0.1 mb. This way, according to the available experimental information, the largest of the measured cross sections is that for reaction (1), while those for reactions (2), (4) and (5) are small compared to σ_1.

Utilizing charge independence one can obtain relations between the cross sections for reactions (1) — (5) if one assumes that the π mesons interact only in one of the possible isospin states which have $T_\pi = 2, 1, 0$. If they interact only in the state with $T_\pi = 2$ then reaction (4) will have the largest cross section while the cross sections of reactions (1), (2), (3) and (5) will be $1/18$, $1/4$, $1/9$ and $1/4$ of σ_4 respectively. As remarked above, in reality σ_1 has the largest value and the other cross sections, including σ_4 are small compared to σ_1. If $T_\pi = 1$ then $\sigma_3 = \sigma_4 = 0$ while σ_2 and σ_5 cannot both be small compared to σ_1. However, the obtained results and the results of reference 10 indicate that both σ_2 and σ_5 are small compared to σ_1.

Finally, we assume that the π mesons interact only in the state with $T_\pi = 0$ (indeed, such an assumption has been made by Korenchenko[7]). Then from charge independence immediately follows that $\sigma_3 = \sigma_1/2$, $\sigma_2 = \sigma_4 = \sigma_5 = 0$. Experimental data on σ_3 are as yet not available while the values of σ_2, σ_4 and σ_5 are indeed small compared to σ_1.

This way the presently available information concerning the relations between the cross sections of the reactions $\pi N \rightarrow \pi\pi N$ at an energy of 290 Mev indicates that the π mesons interact with themselves in the considered energy range† predominantly in the state with isospin $T_\pi = 0$. Consequently at energies below 300 Mev the most important contribution is due to transitions from an initial state with $T = 1/2$.

In reference 11 it was indicated that there possibly exists a resonance in the π-π system at a low energy (total energy of the system of two π mesons 310 ± 10 Mev) in an isospin state with $T_\pi = 0$ or $T_\pi = 1$. V. V. Anisovich has pointed out to us that such a resonance would have a strong influence on the ratios between the cross sections of the reactions $\pi N \rightarrow \pi\pi N$ at energies of the order 250 — 290 Mev. In this energy range the meson-nucleon interaction cross sections are still small. On the other hand, the mesons are produced at an energy close to the resonance. The data of the present work contradict the assumption that there exists a resonance in the interaction of two π mesons at a total energy of 310 ± 10 Mev in a state with isospin $T_\pi = 1$. The interaction in a $T_\pi = 0$ state seems to predominate. However, the obtained results do not allow to make definite statements about the existence of a resonance in the considered energy range.

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*This value represents an upper limit because for reaction (2) a possible background from production off bound nucleons of the nuclei of the emulsion was not subtracted.

†The total energy of the two π mesons in their center of mass system is contained in the interval 280 — 370 Mev.

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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*

Yu. K. AKIMOV, O. V. SAVCHENKO, and L. M. SOROKO

Joint Institute for Nuclear Research

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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

$$p + p \to d + \pi^+ \tag{1}$$

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

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

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

$$p + p \to \begin{cases} d + \omega^+ \\ n + p + \omega^+ \end{cases} \tag{3}$$

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