STUDY OF THE MECHANISM OF INELASTIC (π-p)-INTERACTION FOR Aπ-MESON KINETIC ENERGY OF 344 MeV

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The present work determines the contribution of the isobar 3/2, 3/2 to the cross section for inelastic (π^-p)-interaction at a primary π^- meson beam energy of 344 MeV for the reactions:

$$\pi^- + p \to \pi^- + \pi^+ + n; \qquad (1)$$

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

For processes of the type $\pi N \to \pi_1 \pi_2 N'$ we analyzed the difference in the differential cross sections

$$\Delta = \frac{d\sigma}{d\omega_{\pi_1 N'}} - \frac{d\sigma}{d\omega_{\pi_2 N'}}, \qquad (3)$$

where $\omega_{\pi 1 N'}$ and $\omega_{\pi 2 N'}$ are, respectively, the total energies of $\pi_1 N'$ and $\pi_2 N'$ in their center-of-mass system. Representing the matrix element of the process $\pi N \to \pi_1 \pi_2 N'$ as a sum $= M_{\pi N} + M_{\pi\pi}$ (where $M_{\pi\pi}$ and $M_{\pi N}$ represent the contributions of pion-pion and re-

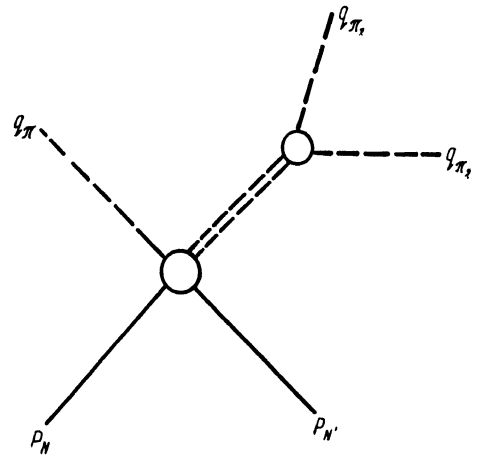

Fig. 1. Matrix element describing the contribution of pion-pion and resonance pion-nucleon interaction.

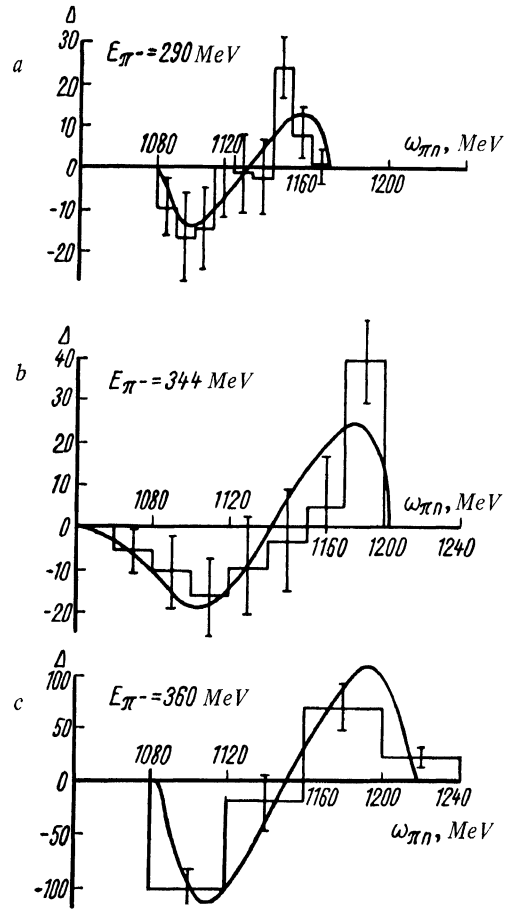

Fig. 2. Δ as a function of $\omega_{\pi n}$. The smooth curves were calculated according to the formula $(\sigma_{\pi^- n} - \sigma_{\pi^+ n})$ $(|f_1|^2 - |f_2|^2$. Plots *a* and *c* are based on data of [3, 4], respectively.

sonance pion-nucleon interactions), and assuming that $M_{\pi\pi}$ is described by the diagram shown in Fig. 1, it can be shown that the contribution of pion-pion interactions to the difference Δ is due only to interference between $M_{\pi\pi}$ and $M_{\pi N}$.

In particular, at low energies, when the parities of $M_{\pi\pi}$ and $M_{\pi N}$ are different, their interference is equal to zero due to the orthogonality of the angular parts of the corresponding wave functions. Let us introduce the functions $|f_1|^2$ and $|f_2|^2$, the first of which describes the distribution over the total energy in the center-of-mass system of the π meson and nucleon resulting from the disintegration of the isobar, and the second of which describes the distribution over the total energy in the center-of-mass system of the the nucleon and π meson, which forms simultaneously with the isobar. Normalizing these functions

$$\int |f_1|^2 d\omega_{\pi N} = \int |f_2|^2 d\omega_{\pi N} = 1 \qquad (4)$$

and denoting the total cross sections for the formations of isobars which disintegrate into $\pi_1 N'$ and $\pi_2 N'$ by $\sigma_{\pi_1 N'}$ and $\sigma_{\pi_2 N'}$ respectively, we have

$$\frac{d\sigma}{d\omega_{\pi_1 N'}} - \frac{d\sigma}{d\omega_{\pi_2 N'}} = (\sigma_{\pi_1 N'} - \sigma_{\pi_2 N'})(|f_1|^2 - |f_2|^2). \qquad (5)$$

The function $|f_1|^2$ was calculated with the help of a formula given in [1]

$$|f_1(\omega_{\pi n})|^2 = \sigma(\omega_{\pi n}) F(\omega_{\pi n}, m_\pi), \qquad (6)$$

where $\sigma(\omega_{\pi n})$ is the total cross section of the $(\pi^+ p)$-interaction [2], and $F(\omega_{\pi n}, m_\pi)$ is a statistical factor. The function $|f_2|^2$ was calculated under the assumption that the disintegration of the isobar is isotropic in a system in which it is at rest.

Fig. 2*b* shows the experimental distribution of $\Delta(\omega_{\pi n})$, plotted on the basis of 324 cases of the reaction (1). Dividing $\Delta(\omega_{\pi n})$ by $|f_1|^2 - |f_2|^2$, we obtain seven values of $\sigma_{\pi^- n} - \sigma_{\pi^+ n}$. The weighted mean value of this difference was found to equal 126 ± 27 cases, which amounts to 39 ± 8% of the total number of analyzed cases.

Similarly, curves of $|f_1|^2 - |f_2|^2$ were used to process the data for π^- meson energies of 290 MeV [3] and 360 MeV [4]. The corresponding histograms and calculated curves are given in Fig. 2*a* and 2*c*. The numerical results for the different energies are given in the table.

For an incident π^- meson energy of 344 MeV, the angular distribution of the secondary π^+ mesons from reaction (1) is almost isotropic. From the conservation laws for parity and total angular momentum it can be easily established that the cross-section difference found refers to the transition $D_{3/2} \rightarrow sp_{3/2}$, the analysis of which makes it possible to obtain information on the scattering lengths of a π meson by a π meson.

Energy of the incident π^- mesons, MeV	No. of cases of the reaction (1)	$\sigma_{\pi^- n} - \sigma_{\pi^+ n}$ (in cases)	$\frac{\sigma_{\pi^- n} - \sigma_{\pi^+ n}}{\sigma_{\pi^- \pi^+ n}}$, %	$\sigma_{\pi^- \pi^+ n}$, 10^{-27} cm^2	$\sigma_{\pi^- n} - \sigma_{\pi^+ n}$, 10^{-27}
290 [3]	300	78±27	26±9	0.61±0.13	0.16±0.06
344	324	126±27	38±8	1.50±0.10	0.57±0.12
360 [4]	573	255±38	44±7	1.93±0.16	0.85±0.15

Expanding the cross sections σ_{π^-n}, σ_{π^+n}, σ_{π^-n} in terms of the amplitudes $A^{3/2}_{3/2}$ and $A^{1/2}_{1/2}$ (the upper indices denote the total isotopic spin of the initial system, the lower indices the total isotopic spin of the secondary πN-systems), and setting $A^{3/2}_{3/2} = 0$, we obtain

$$\sigma_{\pi^-n} = \frac{1}{3}|A^{1/2}_{3/2}|^2, \quad \sigma_{\pi^+n} = \frac{1}{27}|A^{1/2}_{3/2}|^2, \quad \sigma_{\pi^0p} = \sigma_{\pi^-p} = \frac{2}{27}|A^{1/2}_{3/2}|^2.$$

From the relation $\sigma_{\pi^-n} - \sigma_{\pi^+n} = 126 \pm 27$ cases we find that $|A^{1/2}_{3/2}|^2 = 425$ cases.

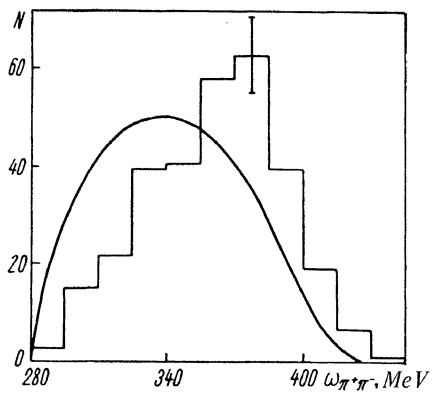

Fig. 3. Distribution of cases of the reaction (1) over the total energy in the center-of-mass system of $(\pi^+\pi^-)$. The smooth curve was calculated by the statistical method.

Strong $\pi\pi$-interaction in a state with $T = J = 0$ does not contribute to the cross-section of reaction (2), and therefore it is natural to assume that the cross section of reaction (2) is the approximately equal to $\sigma_{\pi^-n} + \sigma_{\pi^0p} = \frac{4}{27}|A^{1/2}_{3/2}|^2 = 63 \pm 14$ cases. This value is close to 51^{+9}_{-15} – the value found in the present work.

If we assume that the transition under consideration takes place only in a state with $T = 1/2$, then the sum of the cross sections of isobaric channels amounts to 50% of the total cross section of reaction (1) at 344 MeV. A definite role in this reaction is also played by pion-pion interaction. The influence of pion-pion interaction on the distribution over the total energy in the center-of-mass system of $(\pi^+\pi^-)$ is clearly evident from Fig. 3. The most realistic account of the deviation of the experimental histogram from the phase curve can be given if one allows for the effects of the interaction [5] of the meson formed when the isobar disintegrated and the meson which formed simultaneously with the isobar.

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