Letters to the Editor

SPIN OF THE ρ MESON

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IT has been shown previously[1] that for the process

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

with incident π^--meson momentum $p_0 = 2.8$ BeV/c, the angular distribution of the resonant mesons (with energy $4\mu \lesssim \omega \lesssim 6\mu$, where μ is the meson mass) in the barycentric frame of the two mesons is not isotropic relative to the initial direction but instead is well described by the function $\cos^2\varphi^*$.

In the present work we obtained the angular distribution of π^--mesons in the barycentric frame of the mesons (Fig. 1), for the previously[2] investigated reaction

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

This distribution is also in good agreement with the $\cos^2\varphi^*$ curve, which is shown in the figure as a dashed line. Analogous results were obtained by Aĭnutdinov et al[3] for reaction (2) with $p_0 = 7.2$ BeV/c. It is interesting that the distribution of π^- mesons obtained by us in the case of π^0 production on quasi free protons in the freon mixture $C_2F_5Cl_3$ (Fig. 2) differs only slightly from that shown in Fig. 1, indicating that it may be possible to study reaction (2) in collisions with nuclei. The histograms for the forward hemisphere are not shown in Figs. 1 and 2 since, within the experimental error, they coincide with the distribution in the backward hemisphere.

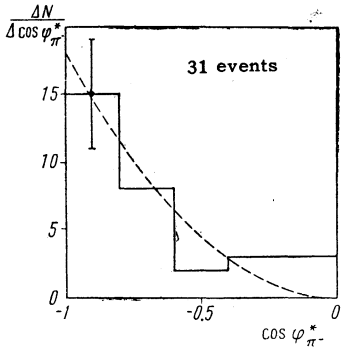

FIG. 1

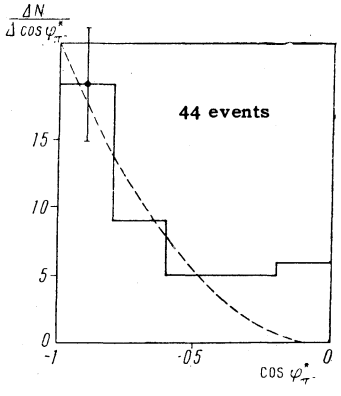

FIG. 2

The angular distributions here obtained are in fact the first direct experimental measurement of the angular momentum of the two-pion resonant state with $\omega \approx 5\mu$ ($J = 1$). This resonance may also be interpreted as the production and subsequent decay of the vector ρ meson* according to the scheme

$$\pi^- + p \to p^{0,-} + (n, p) \to \pi^- + \pi^{+,0} + (n, p).$$

The $\cos^2\varphi^*$ form of the distribution indicates that the production of the ρ meson proceeds with zero projection of the spin onto the initial direction $J_z = 0$ (polarized meson), which is a consequence of the peripheral nature of the collision when the production of the mesons takes place in a narrow cone of forward angles in the barycentric frame of the pion-nucleon system ($\theta^* \lesssim 15°$ for $p_0 = 2.8$ BeV/c and $\theta^* \lesssim 7°$ for $p_0 = 7.2$ BeV/c). Indeed, for forward production the zero projection of the orbital angular momentum $l_z = 0$ is conserved, since for $l_z \neq 0$ the scattering is described by associated Legendre polynomials $P_l^{l_z}(\cos\theta^*)$ which do not contribute for $\cos\theta^* = \pm 1$. One can also verify that no change takes place in the spin state of the nucleon since the spin dependence of the amplitude is given by the invariants γ_5 and $\gamma_5\hat{p}_0$, which are equivalent in the pion-nucleon barycentric frame to the invariants $\sigma\cdot\mathbf{p}_1$ and $\sigma\cdot\mathbf{p}_2$, where $\mathbf{p}_1$ and $\mathbf{p}_2$ are the initial and final momenta of the nucleon and σ are the Pauli matrices. For $\mathbf{p}_1 \| \mathbf{p}_2 \| \mathbf{p}_0$ the amplitude depends only on the diagonal matrix σ_z, which leaves unchanged the nucleon spin projection in the final state. From here the conservation law for the projection of the total angular momentum onto the initial direction gives $J_z = 0$.

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*We remark that the study of the isovector electromagnetic form factors of the nucleon[4] tends to support the hypothesis that this resonance is a ρ-meson effect (kinematical resonance).

[1] Ya. Ya. Shalamov and A. F. Grashin, JETP (in press).

[2] Ya. Ya. Shalamov and A. F. Grashin, JETP **42**, 1115 (1962), this issue p. 770.

[3] Aĭnutdinov, Zombkovskiĭ, Nikitin, Selektor, and Grashin, JETP (in press).

[4] A. F. Grashin and V. N. Mel'nikov, JETP **42**, 1404 (1962), Soviet Phys. JETP **15**, in press.

Translated by A. M. Bincer
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