# COHERENT PRODUCTION OF THREE PIONS BY $\pi^-$ MESONS WITH MOMENTUM 5 GeV/c ON CARBON NUCLEI

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Experimental investigations of coherent production of $\pi^-$ mesons on nuclei heavier than deuterium have been performed so far for $\pi^-$ mesons with momenta 3.85 [1], 4.0 [2], 6.0 [3], 15 - 18 [4], 45 [5], 60 [5], and 200 [5] GeV/c by emulsion and chamber procedures and with the CERN spectrometer. In all the indicated investigations, with the exception of the last, the target was a mixture of different nuclei. It is therefore of definite interest to obtain data for a pure target such as carbon.

To investigate the foregoing problem, we scanned 124,000 photographs obtained with the meter propane chamber [6] of Nuclear Problems Laboratory, exposed in a $\pi^-$-meson beam with momentum 5 GeV/c of the proton synchrotron of the High-energy Laboratory of the Joint Institute of Nuclear Research. The scanning revealed about 5.5 thousand three-prong events satisfying the assumed selection criteria for the interactions of the incoming pion with the "neutral" target - the carbon nucleus, namely, the number of visible secondary tracks was equal to three with a total charge "-1" there is no "blob" at the vertex of the interaction to indicate disintegration of the nucleus, and the interaction is not accompanied by $V^0$ particles. The indicated selection criteria correspond to reactions of the type:

$$\pi^- + C \to \pi^+\pi^-\pi^- + C, \qquad 1a$$

$$\pi^- + N \to \pi^+\pi^-\pi^- + N + m\pi^0, \qquad 1b$$

$$\pi^- + N \to P\pi^-\pi^- + m\pi^0, \qquad 2$$

where C - carbon nucleus, N - quasifree neutron of the carbon nucleus, P - proton, m = 0, 1, 2, ... The sought process corresponds to reaction 1a, and if the interaction is coherent, then the target should remain in the ground state after the interaction and the momentum transfer to it should be small ($\sim$120 MeV/c). Reactions 1b and 2 are background reactions accompanying the sought process in the case when either the $\gamma$ quanta from the $\pi^0$ mesons are not converted in the volume of the chamber, or the positive particle has a momentum larger than 1.0 GeV/c and the proton cannot be distinguishable with respect to its ionizing ability from the $\pi^+$ meson.

After measurement [8] and reduction of all the events in accordance with the program for the identification of the reaction channels (fit-channels), there were left for subsequent analysis 1700 events satisfying simultaneously reactions 1a and 1b with m = 0. The admixture of 1b with $m \neq 0$ and of 2 in 1a did not exceed 20% of the total number of events, according to estimates obtained from calculations by the Monte Carlo method (generation of events with the aid of a random-star program with subsequent calculation in accordance with the program of the fit-channels and applying the ionization criterion to the positive track).

To separate the events corresponding to coherent production of three pions, we investigated the distribution of the number of events as a function of the square of the 4-momentum $t' = |t - t_{min}|$, transferred by the incoming

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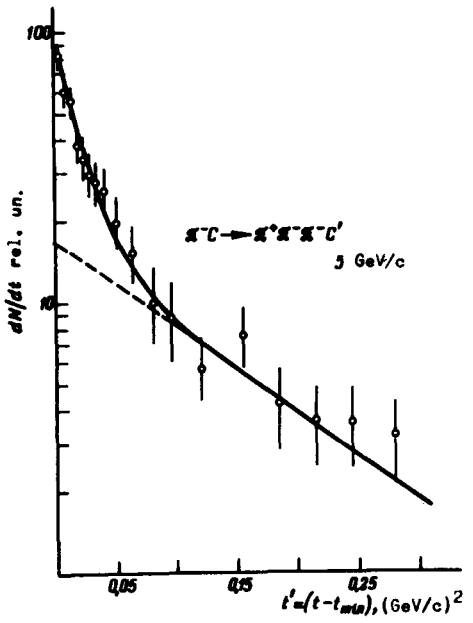


Fig. 1

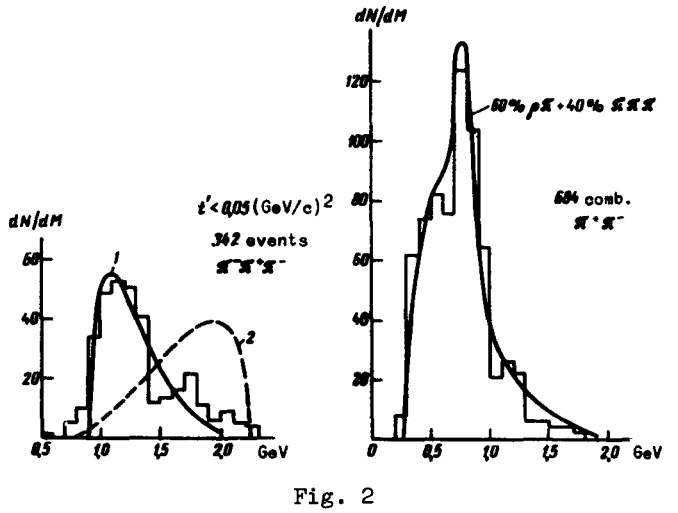


Fig. 2

Fig. 1. t'-distribution. Solid curve - sum of two exponentials $A \exp(-B_1 t') + B \exp(-B_2 t')$; $B_1 = 51.7 \pm 11.8$ $(GeV/c)^{-2}$, $B_2 = 7.25 \pm 2.20$ $(GeV/c)^{-2}$.

Fig. 2. Effective-mass distribution of the combinations $\pi^+\pi^-$ and $\pi^-\pi^+\pi^-$ from the category $\pi^-C \to \pi^+\pi^-\pi^-C$ for $t' < 0.05$ $(GeV/c)^2$. 1 - Berger's reggeized model for one-pion exchange [7], 2 - calculations by the Monte Carlo method (statistical model).

pion to the system of three pions for small t' (Fig. 1). It is seen from the figure that at $t' < 0.1$ $(GeV/c)^2$ there is observed a rapid growth of the number of events with decreasing momentum transfer t', which can be attributed only to coherent interactions of the incoming pion with the carbon nucleus as a whole. Approximation of the experimental data by a sum of two exponentials, $A \exp(-B_1 t') + B \exp(-B_2 t')$ yields $\chi^2_{exp} = 6.7$ as against the expected 14. The parameters $B_1$ and $B_2$ corresponding to the two sections of the distribution on Fig. 1 turned out to be $51.7 \pm 11.8$ and $7.25 \pm 2.20$ $(GeV/c)^{-2}$, respectively. This corresponds to interacting-target dimensions $R_1 = (2.45^{+0.27}_{-0.30})$ and $R_2 = (0.92^{+0.13}_{-0.15})$ F, respectively, which coincide within the limits of experimental errors with the radii of the carbon nucleus and of the nucleon.

The area between the fitted curve and the continuation of the gently-sloping part of the curve of Fig. 1 for $t' < 0.1$ $(GeV/c)^2$ contains 132 events, corresponding to the following value for the cross section of coherent production of three pions by pions with 5 GeV/c momentum on carbon nuclei:

$$\sigma_{coh} = 264 \pm 37 \ \mu b.$$

The error includes here the statistical error of the normalized coefficient for the given irradiation of the chamber and the uncertainty in the position of the fitted curve on Fig. 1.

Figure 2 shows the effective mass distributions of the $\pi^+\pi^-$ and $\pi^+\pi^-\pi^-$ combinations for a transferred 4-momentum squared $t'_{\pi^- \to (3\pi^-)} < 0.05$ $(GeV/c)^2$. The effective-mass distribution of the pion triad has a broad peak in the

region 0.9 - 1.4 GeV with a maximum at 1.1 - 1.2 GeV, this being characteristic of coherent-production processes. The effective-mass distribution of the $\pi^+\pi^-$ combinations reveals a distinct peak in the ρ-meson mass region.

In conclusion, the authors consider it their pleasant duty to thank the scanning and measurement groups of the Nuclear Problems Laboratory and of the Computational Techniques and Automation Laboratory of the Joint Institute for Nuclear Research, for processing the photographs from the meter propane chamber.

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## CONTRIBUTION TO THE THEORY OF THE OPTOELECTRIC EFFECT IN A MAGNETIC FIELD

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In [1] there was investigated the electric field (which we shall call "optoelectric") produced in a conducting medium in which electromagnetic waves propagate. This field is due to the momentum transferred by the flux of electromagnetic waves to the free carriers.

A recent paper [2] reports experimental observation of the optoelectric emf in bismuth in an external magnetic field. In the present paper we investigate in greater detail the influence of the magnetic field on this effect. We confine ourselves here to the case of waves of low frequency ω, satisfying the condition $\omega\tau < 1$, where τ is the relaxation time. In the approximation linear in the wave field ($\vec{E}_1$, $\vec{H}_1$) the equation for the correction $f_1$ to the equilibrium distribution function of the carriers is*

$$\frac{\partial f_1}{\partial t} + \mathbf{v}\nabla f_1 + \frac{e}{mc}[\mathbf{vH}]\frac{\partial f_0}{\partial \mathbf{v}} + \frac{e\mathbf{E}_1}{m}\frac{\partial f_0}{\partial \mathbf{v}} = -\frac{f_1}{\tau}.$$

Consequently $f_1$ is equal to

*$[\vec{v}\vec{H}] \equiv \vec{v} \times \vec{H}$.