PRODUCTION OF THE $2\pi^+\pi^-$ SYSTEM ON LIGHT NUCLEI BY 4-GeV/c MESONS

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It is shown that no process with participation of the virtual isobar $\Delta^-(1238)$ exists. The mechanism of the reaction is determined in the main by the production of a virtual π^- meson which is subsequently absorbed in the nucleus.

One of the possible mechanisms of nuclear reactions in high-energy beams is the process with production of virtual particles that subsequently interact inside the nucleus. The importance of the study of these processes is universally known, since they contain information on the nuclear reaction and on the interaction of virtual particles with nuclei or with part of the nucleus, including nucleons. The latter is of particular interest if resonances assume the role of virtual particles. The experimental study of these processes has hardly even begun [1].

We have attempted to isolate a nuclear reaction in which a virtual isobar Δ^- interacting with the residual nucleus is produced. To this end we investigated the process

$$\pi^- + A \to 2\pi^+ + \pi^- + n\gamma + A^* \tag{1}$$

(A and A* are the initial and final states of the nucleus, respectively; $n \geq 0$), in the freon bubble chamber of our Institute (nuclei C, F, and Cl) bombarded by 4 GeV/c π^- mesons. It was assumed that the reaction (1) is optimal for the solution of the problem, since the cross section of the "reference" reaction

$$\pi^- + p \to 2\pi^+ + 2\pi^- + n \tag{2}$$

reaches a maximum at primary momenta 4 - 6 GeV/c, in which case the yield of the $\Delta^-(1238)$ isobar is 30% of the total cross section (~300 μb). We selected events topologically corresponding to the reaction (1) without visible products of the disintigration of the nucleus, or events accompanied by emission of protons with $E_{kin} \lesssim 30$ MeV. After the measurements we were left with 1023 reactions (1), corresponding to an average secondary-particle momentum error smaller than 14%. Positive particles with momenta up to 0.6 - 0.7 GeV/c were identified by the standard methods. An analysis has shown that the fraction of the stars with relativistic protons in the investigated sampling did not exceed 0.3.

We plotted the spectrum of the missing masses MM of the system of observed mesons ($2\pi^+\pi^-$) for the selected events, under the assumption that the primary process takes place on the immobile proton of the nucleus (Fig. 1). The spectrum of the sampling without the accompanying γ quanta (Fig. 1) reveals a relatively narrow peak ($\Delta \sim 100 - 150$ MeV) in the region $1.0 \leq \text{MM} \leq 1.1$ GeV. The missing mass spectrum for the events with γ quanta (Fig. 1) does not reveal such strongly pronounced singularities. An analysis of the position of the peak of Fig. 1b as a function of the 4-momentum transfer t shows that the peak is determined in the main by events with $t < 0.5\ (\text{GeV/c})^2$. The statistics do not suffice to trace the motion of the peak as a function of the three-dimensional momentum transfer P. By starting from the position and width of the peak in question and by investigating the possibility of its production as a result of purely methodological effects, we can conclude that the observed singularity is due mainly to soft π^- mesons with momenta less than 40 MeV/c, which have a range insufficient to permit their registration in the chamber. Simulation with the aid of the "FORS" program confirms the possibility of such an intimation. The "shoulder" in the region MM ~ 1 GeV in the spectrum of the events with the accompanying γ quanta, which can be referred to with a certain degree of caution,

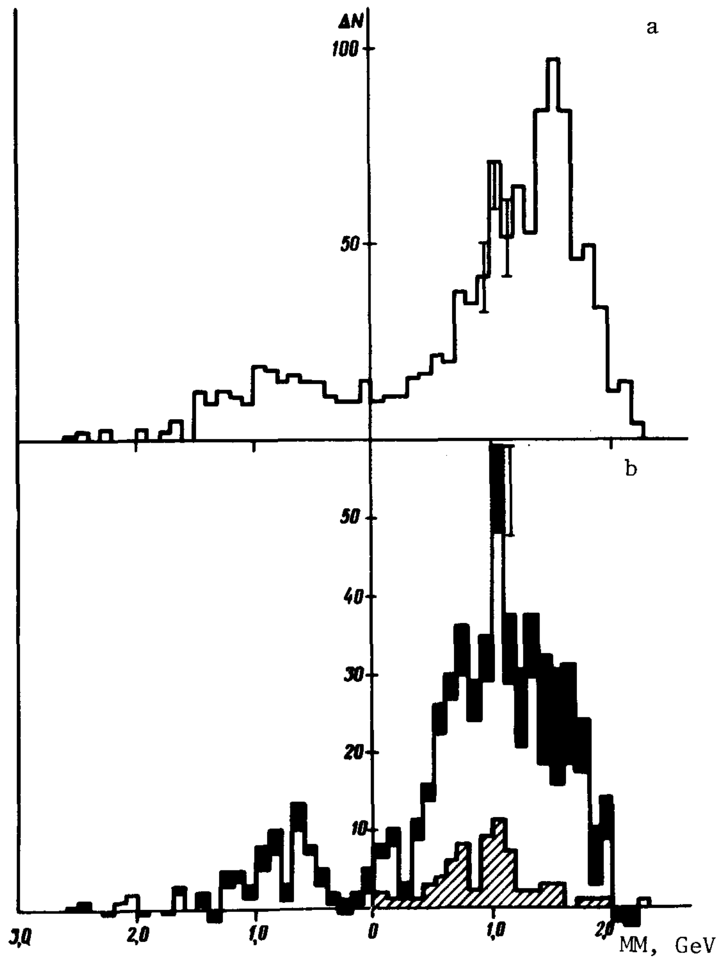

Fig. 1. Distribution of missing masses in the $2\pi^+\pi^-$ system: a) reactions with accompanying γ quanta, b) without γ quanta. The correction for the efficiency of γ-quantum registration in the chamber is blackened. The distributions take into account the weight of the events, which is determined by the selection conditions for the measurements. The histogram for the reaction with $t \leq 0.5$ (GeV/c) , without allowance for the weight, is shown shaded.

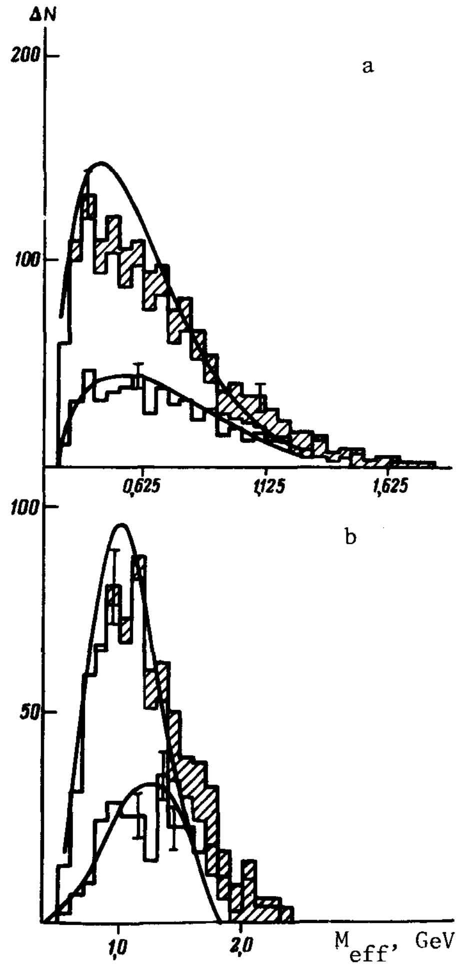

Fig. 2. Effective-mass distributions for all events with MM > 0: a) the combination $(\pi^+\pi^-)$, b) the combination $(2\pi^+\pi^-)$. Lower histograms — samplings without accompanying γ quanta. The shaded events are those outside the region of the experimental resolution of the MM for the reaction on an individual nucleon (0 < MM < 0.6 GeV). Smooth curves — calculation by the "FORS" program.

is produced (under the same conditions) by low-energy π^- mesons that undergo charge exchange near the parent nucleus. Thus, the bulk of the spectrum of Fig. 1 for MM $\gtrsim$ 1 GeV has no singularities of physical nature, and is connected with the production of virtual π^- mesons that are absorbed (experience charge exchange) in the nucleus. To verify the assumption that the virtual bar (which is produced in our case with momenta higher than 0.6 - 0.7 GeV/c) leads to a very strong excitation of the nucleus, control measurements were made of events accompanied by protons of arbitrary energy. The distribution of this group likewise fails to reveal any singularities that might be ascribed to Δ^-.

To reveal the meson resonances, which might play a rather important role, say in double charge-exchange reactions [2], we analysed the effective-mass spectra of all the possible meson combinations. No singularities whatever were observed in the indicated spectra. Figure 2 shows the mass spectra of the combinations ($2\pi^+\pi^-$) and ($\pi^+\pi^-$). For comparison, the figure shows also the summary curves calculated with the "FORS" program for the reactions (2) and

$$\pi^- p \to 2\pi^+ 2\pi^- \pi^0 n \qquad (3)$$

The channels were summed with allowance for the experimental ratio of the meson interaction in the nucleus and the efficiency of γ-quantum registration in the chamber. We see that the experimental distributions duplicate qualitatively the calculated curves. Figure 2 illustrates at the same time the following conclusion: Since we know that the role of meson resonances in reactions (s) and (3) is negligible and that the corresponding mass spectra have a statistical character [3], the agreement between the experimental data and the calculated distributions shows that in our case the main contribution to the investigated reaction (1) is indeed made by the processes (2) and (3). This conclusion follows from a detailed analysis of the characteristics of reaction (1).

Conclusions: No process was observed with production of a virtual isobar in reaction (1). This means that the nucleus is transparent to an isobar with minimal momentum $\sim$0.6 GeV/c. It is also possible that owing to the strong pion absorption in the nucleus the experiments isolate events of the reaction (1) occurring on the periphery of the nucleus.

In the main, the reaction (1) is determined by a process in which a virtual pion is produced and is subsequently absorbed in the nucleus.

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SUPER-ALFVEN RAREFACTION WAVE IN A PLASMA

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A super-Alfven rarefaction wave was seen to propagate in a magnetized plasma with $\beta \ll 1$ in a direction transverse to the magnetic field. At $\omega_{He}/\omega_{pl} \simeq 3\times10^{-2}$, the velocity of the wave reaches $(10 - 30)v_A$. The anomalously low conductivity σ points to a turbulent character of the processes in the wave front, where the penetration of the field has a diffuse character.

As is well known, the rate of penetration of a magnetic-field rarefaction pulse into a magnetized plasma is determined at $\beta = H^2/8\pi nT \ll 1$ by the Alfven velocity v_A. We present here experimental results showing that under certain conditions the rarefaction-wave velocity can reach $(10 - 30)v_A$, where v_A is determined from the initial plasma parameters.

The experiment was performed with the "UN-Phoenix" installation described in [1, 2]. A plasma with concentration $n_0 = 10^{11} - 10^{14}$ cm^{-3} and with initial temperature $T_0 = 1 - 5$ eV was produced in a cylindrical glass volume (ℓ = 100 cm, diam 16 cm) placed in a quasistationary magnetic field ($H_0 = 10^2 - 10^3$ Oe, τ = 1.5 msec). The working gases were H_2, He, and Ar. The rarefaction wave moving towards the system axis in a direction transverse to the initial