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AN ANALYSIS OF PION SPECTRA OF THE CHARGE-EXCHANGE REACTION Mg (t, ^{3}He)

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We have studied the charge-exchange reaction Mg (t, ^{3}He) by using the π–ρ–g'-model and formalism of effective number. Attempts have been made to find information about the value of the (NN – $N\Delta$)-interaction renormalization in going from vacuum to nuclei. We obtained a good qualitative description of the position of the Δ-peak of the theoretical pion full-energy spectrum by changing the attributes of the nucleon-nucleon interaction in going from vacuum values of effective masses of nucleons, mesons and Δ-isobar to nuclei.

The investigation has been performed at the Bogoliubov Laboratory of Theoretical Physics, JINR.

Анализ спектров пионов реакции перезарядки Mg (t, ^{3}He)

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Реакция перезарядки Mg (t, ^{3}He) изучалась в рамках π–ρ–g'-модели и формализма эффективных чисел. Была сделана попытка получить информацию о величине перенормировки (NN – $N\Delta$)-взаимодействия при переходе от вакуума к ядерной материи. Введением фактора изменения эффективных масс нуклонов, мезонов и Δ-изобары при переходе от вакуума к ядру получено хорошее качественное описание положения пика теоретического спектра полной энергии мезонов.

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Interest in the study of the charge-exchange reactions with the Δ-isobar excitation is connected with attempts to find information about the value of the (NN – $N\Delta$)-interaction renormalization in going from vacuum to nuclei. The experimental data analysed and presented in the review [1] show the differences in masses and widths of the Δ-isobars in vacuum and nuclei. The calculations in the framework of the well-known Nambu — Jona–Lasinio model [2] and the model of constituent quarks [3] have qualitatively the same results.

The models predict reduction of meson and nucleon masses in the nuclear matter. We assume that surpluses of quark-quark interactions in the Δ-isobar satisfy the same equations

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$$\lambda = \frac{M^*}{M} = \frac{M_\rho^*}{M_\rho} = \frac{M_\omega^*}{M_\omega} = \frac{M_\Delta^*}{M_\Delta},$$

where M^* and M are masses of nucleons, mesons and Δ-isobars in the nuclear matter and vacuum, respectively.

In this note, we try to qualitatively describe pion spectra of the charge-exchange reaction Mg (t, ^{3}He) on the assumption of the influence of the nuclear matter. The π- and ρ-meson diagrams were taken into account. The experimental data have been obtained in the GIBS experiment [4] at the beam momentum 9.15 GeV/c and angle 0°.

We use the manner [5,6] that is based on the π–ρ–g'-model and the formalism of effective numbers. The inclusive cross section of the charge-exchange reaction on nuclei is

$$\frac{d\sigma[^{24}\mathrm{Mg}\ (t, {}^3\mathrm{He})_\Delta, X]}{d\Omega\, dE} = 3 * N_{\mathrm{eff}}^* F(t) * \frac{d\sigma(n + n \to p + \Delta^-)}{d\Omega\, dE}\Big|_{\mathrm{free}},$$

where $\frac{d\sigma(n + n \to p + \Delta^-)}{d\Omega\, dE}\Big|_{\mathrm{free}}$ is the cross section of the elementary process on the free nucleon, and $F(t)$ is the form factor.

Calculations have been done for the $(1\pi^-, 0p)$-topology when only π^--mesons were among the products of the reaction. The unperiphery's degree of the process (the influence

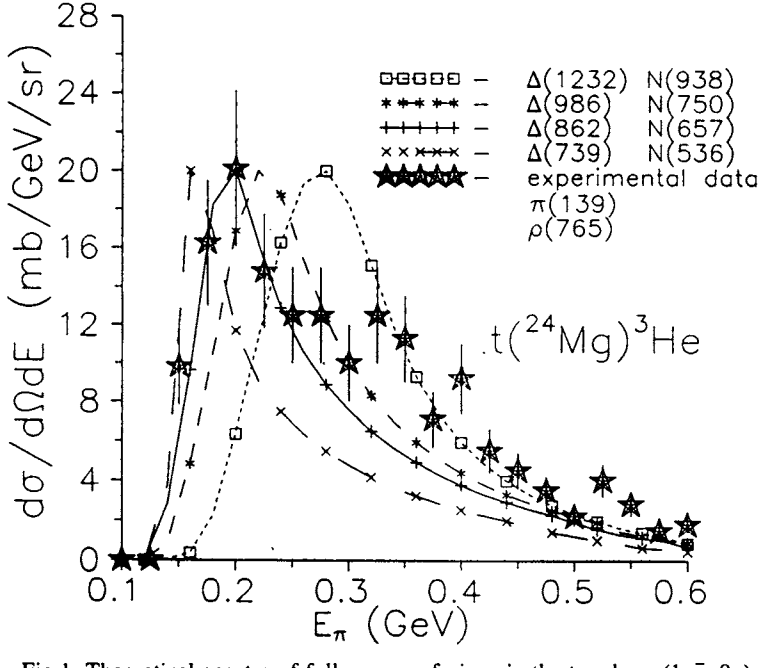

Fig.1. Theoretical spectra of full energy of pions in the topology $(1\pi^-, 0p)$ at different values of the effective masses of the nucleon and Δ-isobar normalized to the maximum of the experimental spectrum

of the nuclear matter) was taken into account by the λ(ρ)-parameter. This parameter describes reducing the effective mass of the nucleons, ρ-mesons and Δ-isobars inside nuclei:

$$\lambda(\rho) = \frac{M^*}{M} = \frac{M_\rho^*}{M_\rho} = \frac{M_\Delta^*}{M_\Delta} .$$

We have calculated the energy spectra of pions with the set of values of λ(ρ): 1, 0.9, 0.8, 0.7, 0.6.

The main results of calculations are shown in Figs.1 and 2.

Figure 1 shows the data of theoretical and experimental energy spectra of pions for the $(1\pi^-, 0p)$-topology. We did not change the ρ-meson mass in these calculations. It has a vacuum value. All theoretical spectra were normalized to the maximum of the experimental spectrum. The analysis of spectra shows that the experimental spectrum has the peak at 200 MeV. The theoretical spectrum using the vacuum effective mass of the nucleon, ρ-meson and Δ-isobar has the peak at 300 MeV. We used the parameter λ reducing the effective masses of the nucleon, ρ-meson and Δ-isobar thus shifting the theoretical peak towards zero. The theoretical and experimental spectra have the same position of the peaks when the parameter is equal to $\lambda = 0.7$. This fact means that the effective masses of the nucleons and Δ-isobar in the nuclear matter can be estimated as: $M^* = 0.7M$ and $M_\Delta^* = 0.7M_\Delta$. The results of our calculations agree with the data in [2,3].

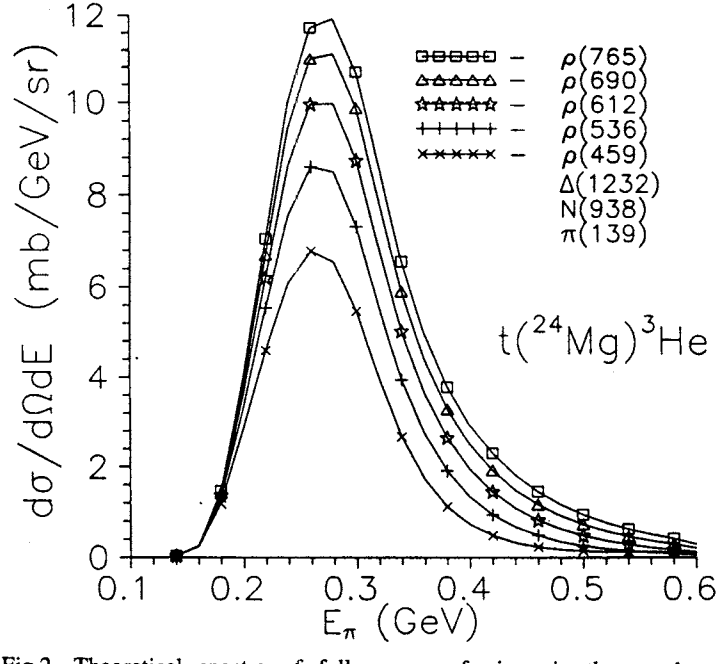

Fig.2. Theoretical spectra of full energy of pions in the topology $(1\pi^-, 0p)$ at different values of the effective masses of the ρ-meson

We also studied the influence of the effective mass of the ρ-meson on the energy spectra of mesons in the ($1\pi^-$, $0p$)-topology (Fig.2). The calculations show that the reducing of the effective mass of the ρ-meson from vacuum value to nuclear matter value by using factor $\lambda(\rho)$ results in contraction and some shift of the peaks towards lower energies. In all the calculations the vacuum value of the π-meson M_π = 139 MeV has been used.

So, we obtained a good quality description of the position of the Δ-peaks of the theoretical pion full-energy spectrum by reducing the attributes of the nucleon-nucleon interaction in going from the vacuum effective mass values of nucleons, mesons and Δ-isobar to the nuclear values. This was predicated in the chiral theories.

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