CONTRIBUTION OF THE "HANGED" DIAGRAMS INTO THE REACTION np → npπ⁺π⁻

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Abstract

The contribution of "hanged" diagrams into the reaction np → npπ⁺π⁻ was considered. It was shown that taking into account of these diagrams permits to get better description of the effective mass spectrum of π⁺π⁻-combinations.

In paper [1] it was studied the mechanism of the reaction np → npπ⁺π⁻ at intermediate energies (1.73 < P₀ < 5.2GeV/c). It was shown that the main contribution made the diagrams with exchange by reggeized pi-meson (Fig.5 and Fig.7 in [1]). Moreover it is necessary to take into account also the diagrams of one-baryon exchange (Fig.10 in [1]) at energies below 3 GeV. A good description of the characteristics of the reaction np → npπ⁺π⁻ was obtained at the considered energy region. So-called "hanged" diagrams of pi-meson exchange (similar to shown in Fig.1) was not considered because their contribution did not exceed 2% at P₀ = 5.20GeV/c.

Figure 1: So-called "hanged" diagrams for the reaction np → npπ⁺π⁻ including π-meson and pomeron (P) exchanges.

Some exceeding of experimental distribution above the theoretical curve in the effective mass spectrum of π⁺π⁻ - combinations at P₀ = 1.73 GeV/c (Fig.11b in [1]) was considered as a fluctuation at small statistics.

But the data of the reaction np → npπ⁺π⁻ at T_kin = 1.25GeV [2] (10⁷ events) obtained at HADES set-up [3] shown that the bump in the effective mass spectrum of π⁺π⁻ - combinations is statistically significant and therefore has a dynamic nature. Then it was decided to study the contribution of the "hanged" diagrams into the reaction np → npπ⁺π⁻ more detailed.

Let us consider the structure of these "hanged" diagrams.
The matrix element of the "hanged" diagrams being the result of $\pi$-meson exchange is written in the following form:

$$ T_\pi = G \bar{u}(Q_1)\gamma_5 u(Q_0) \frac{F_\pi(S_{N_1\pi\pi}, t_1, t_2)}{t_1 - m_\pi^2} T_{\pi\pi}(S_{\pi\pi}, t_1, t_2) \frac{F_\pi(S_{N_2\pi\pi}, t_1, t_2)}{t_2 - m_\pi^2} G \bar{u}(Q_2)\gamma_5 u(Q_T) $$ (1)

where $\bar{u}(Q_i)\gamma_5 u(Q_j)$ - vertex functions,
$F_\pi$ - formfactors in the form taken from [1],
$T_{\pi\pi}$ - off shell amplitude of elastic $\pi\pi$-scattering ([4],[5]),
$G$ the constant of strong interaction ($G^2/4\pi = 14.6$),
$t_1 = (Q_0 - Q_1)^2$,
$t_2 = (Q_T - Q_2)^2$,
$S_{N\pi\pi}$: $(Q_1 + q_1 + q_2)^2$ and $(Q_2 + q_1 + q_2)^2$,
$S_{\pi\pi}$: $(q_1 + q_2)^2$.

The corresponding matrix element for the pomeron (P) exchange is written in the form:

$$ T_P = g_P(t_1) F_P(S_{N_1\pi\pi}, t_1, t_2) T_{\pi\pi}^{0,0}(S_{\pi\pi}, t_1, t_2) F_P(S_{N_2\pi\pi}, t_1, t_2) g_P(t_2) $$ (2)

where $g(t)$ - vertex functions [6],
$F_P$ - formfactors with parameters taken from [6],
$T_{\pi\pi}^{0,0}$ the S-wave (I=0, L=0) amplitude of elastic $\pi\pi$ -scattering ([4],[5]),

Squared matrix element of the reaction $np \rightarrow np\pi^+\pi^-$ was written in in the form:

$$ T_h = |T_{\pi^0}|^2 + |T_{\pi^\pm}|^2 + |T_P|^2 $$

neglecting the interference of the diagrams for the present.

The results of the calculations for the reactions $np \rightarrow np\pi^+\pi^-$ at $P_0 = 1.73 \text{ GeV/c}$ are shown in Fig.2. One can see that taking into account the "hanged" diagrams permits to get the noticeably better description of the $\pi^+\pi^-$ masses close to 300 $MeV/c^2$.

The same calculations were carried out also for the reaction $np \rightarrow np\pi^+\pi^-$ at $T_{kin} = 1.25 \text{ GeV}$ to compare with the data obtained from HADES set-up. The result is presented in Fig.3.

References

[1] A.P.Jerusalimov et al. Analysis of the Reaction $np \rightarrow np\pi^+\pi^-$ from the Point of View of Oper-Model.
http://arxiv.org/pdf/1203.3330.pdf

[2] A.K.Kurilkin et al. Single and double pion production in np collisions at 1.25 GeV with HADES.
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[3] P.Salabura et al. HADES Collaboration. NP A749, 150, 2005

[4] S.D.Protopopescu et al. PR D7, p.1279, 1973.
Figure 2: The spectrum of effective masses of $\pi^+\pi^-$-combinations from the reaction $np \rightarrow np\pi^+\pi^-$ at $P_0 = 1.73$ GeV/c. Solid line - the result of taking into account "hanged" diagrams, dashed line - without "hanged" diagrams, dash-dotted line - the contribution of "hanged" diagrams.
Figure 3: The spectrum of effective masses of $\pi^+\pi^-$-combinations from the reaction $np \rightarrow np\pi^+\pi^-$ at $T_{kin} = 1.25$ GeV. The notations are the same as in Fig.2.