The $D_{03}(2380)$ dibaryon resonance excitation in the $pd \to pd\pi\pi$ reaction.

Nurbek Tursunbayev[1,2,3⋆] and Yuriy Uzikov[1,2,4]

1 Joint Institute for Nuclear Researches, Dubna, 141980, Russia
2 Dubna State University, Dubna, 141980, Russia
3 Institute of Nuclear Physics, Almaty, 050032, Kazakhstan
4 Department of Physics, M.V. Lomonosov Moscow State University, 11991 Moscow, Russia
⋆ tursunbayev.n@gmail.com

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Abstract

The recent ANKE@COSY data on the differential cross section of reaction $pd \to pd\pi\pi$ demonstrate a peak at invariant mass of the final $d\pi\pi$ system 2.38 GeV, that corresponds to the isocalar $J^P = 3^+$ dibaryon D_{03}, and also enhancement in the distribution over the invariant mass of two final pions. The two-resonance model involving the t-channel σ-meson exchange between the proton and deuteron in the subprocess $pd \to pD_{03}$ and the sequential decays $D_{03} \to D_{12} + \pi$ and $D_{12} \to d + \pi$ was applied to describe the shapes of these distributions with the lowest orbital angular momenta in the corresponding vertices. A possible role of higher orbital momenta in those vertices is studied here.

Contents

Introduction

At present as one of the most realistic candidate to dibaryon resonance is considered the resonance $D_{IJ} = D_{03}$ observed by the WASA@COSY [1] in the total cross section of the reaction of two-pion production $pn \to d\pi^0\pi^0$, here I is the isospin and J is the total angular momentum of this resonance. The mass of this resonance 2.380 GeV is close to the $\Delta\Delta$-threshold, but its width $\Gamma = 70\ MeV$ is twice lower as compared to the width of the free Δ-isobar that is an indication to its unusual structure. Another interesting feathure of this reaction is a resonance behavior of its differential cross section as a function of the invariant mass of the final two-pion system $M_{\pi\pi}$ known as the ABC-effect [2]. Possible mechanisms proposed yet in the early 1970s for interpreting the ABC effect in the two-pion production are the t-channel excitation of the noninteracting $\Delta\Delta$ or $NN^*(1450)$ systems and their subsequent decay into the pion channel (see Ref. [3] and references therein). These mechanisms made it possible to describe to some extent the old inclusive data, however, fail to explain new exclusive data obtained in 4π geometry with very high statistics [1]

After discovery of the dibaryon resonance D_{03} in the reaction $pn \to d\pi^0\pi^0$, naturally the question whether dibaryons could be produced in collisions of other particles arose. Recently a very similar resonance structure was observed in the differential cross section of the two-pion production reaction $pd \to pd\pi\pi$ in experiments performed by the collaboration ANKE@COSY at beam energies $0.8 - 2.0$ GeV with high transferred momentum to the deuteron at small scattering angles of the final proton and deuteron [4]. At proton beam energies at 1.1 GeV and 1.4 GeV the resonance peaks were observed in the distribution over the invariant mass $M_{d\pi\pi}$ of the final $d\pi\pi$ system at $M_{d\pi\pi} \approx 2.38$ GeV [4] that is the mass of the isoscalar two-baryon resonance $D_{IJ} = D_{03}$, while the kinematic conditions differ considerably from that in [1]. Furthermore, the ABC-like effect was observed in [4] in the distriution over the invariant mass of the two pions $M_{\pi\pi}$. An attempt to explain the observed behavior of this reaction within the modified two-resonance model [5] of the reaction $pn \to d\pi^0\pi^0$ was undertaken in Refs. [6] and [7] and the shape of the distribution over the $M_{d\pi\pi}$ was explained qualitatively. However some questions appeared cocerning the origin of the ABC-like structure in the $M_{\pi\pi}$ distribution in the data [4]. Only the lowest orbital momenta in the resonance vertices were considered in [6,7]. Here we are focused on the role of possible higher orbital momenta in those vertices.

The model

Different mechanisms of the ABC effect in the reaction $pn \to d\pi^0\pi^0$ were discussed in [8]. One possible mechanism of this reaction suggested in paper [5] involves sequential excitation and decay of two intermediate dibaryon resonances, D_{03} (2380) and D_{12} (2150). We modify this model by including the t-channel σ-meson exchange between the proton and deuteron which leads to excitation of deuteron to the D_{03} dibaryon, $\sigma + d \to D_{03}$, and after that the dibaryon decays sequentially as $D_{03} \to D_{12} + \pi \to d + \pi + \pi$. This mechanim is depicted in Fig. 1 where the second diagram takes into account identity of two π^0- mesons. Since not all required partial widths are known, we discuss mainly the shapes of the distributions over the invariant masses of the final $d\pi\pi$ and $\pi\pi$ systems. The total amplitude of the reaction $pd \to pd\pi\pi$ corresponding to the sum of two Feynmann diagrams in Fig. 1 has the following form

$$T^{\mu'_p\mu'_d}_{\mu_p\mu_d}(pd \to pd\pi\pi) = T^{\mu'_p}_{\mu_p}(p \to p'\sigma)\frac{1}{{p_\sigma}^2 - {m_\sigma}^2 + im_\sigma\Gamma_\sigma}T^{\mu'_d}_{\mu_d}(\sigma d \to d\pi\pi), \quad (1)$$

where $p_\sigma, m_\sigma, \Gamma_\sigma$ are the 4-momentum, mass, and the total width of the σ-meson; μ_i (μ'_i) is the spin projection of the initial (final) particle i. The amplitude of the virtual process $p \to p\sigma$ is based on the phenomenological σNN interaction and its spin averaged form $\overline{|T^{\mu'_p}_{\mu_p}(p \to p'\sigma)|^2}$ is given in [10].

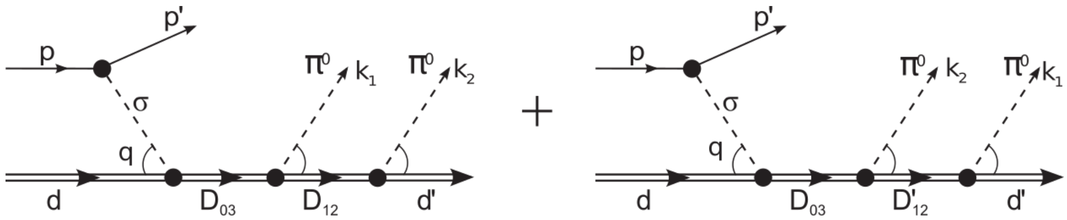

Figure 1: Two resonance mechanism of the reaction $pd \to pd\pi\pi$

$$
\begin{aligned}
T_{\mu_d}^{\mu_d'}(\sigma d \to d\pi\pi) = &\sum_{\mu_2,\mu_3,\mu,m_1,m_2} \frac{F_{D_{03}\to d\sigma}(q) F_{D_{03}\to D_{12}\pi_1}(k_1)}{P_{D_{03}}^2 - M_{D_{03}}^2 + iM_{D_{03}}\Gamma_{D_{03}}} \frac{F_{D_{12}\to d\pi_2}(\lambda_1)}{P_{D_{12}}^2 - M_{D_{12}}^2 + iM_{D_{12}}\Gamma_{D_{12}}} \\
&\times C_{1\mu_d L\mu}^{3\mu_3} \mathcal{Y}_{L\mu}(\hat{\mathbf{q}}) C_{2\mu_2 l_1 m_1}^{3\mu_3} \mathcal{Y}_{l_1 m_1}(\hat{\mathbf{k}}_1) C_{1\mu_d' l_2 m_2}^{2\mu_2} \mathcal{Y}_{l_2 m_2}(\hat{\boldsymbol{\lambda}}_1) + \\
&+ \frac{F_{D_{03}\to d\sigma}(q) F_{D_{03}\to D_{12}\pi_2}(k_2)}{P_{D_{03}}^2 - M_{D_{03}}^2 + iM_{D_{03}}\Gamma_{D_{03}}} \frac{F_{D_{12}\to d\pi_1}(\lambda_2)}{P_{D_{12}}^2 - M_{D_{12}}^2 + iM_{D_{12}}\Gamma_{D_{12}}} \\
&\times C_{1\mu_d L\mu}^{3\mu_3} \mathcal{Y}_{L\mu}(\hat{\mathbf{q}}) C_{2\mu_2 l_1 m_1}^{3\mu_3} \mathcal{Y}_{l_1 m_1}(\hat{\mathbf{k}}_2) C_{1\mu_d' l_2 m_2}^{2\mu_2} \mathcal{Y}_{l_2 m_2}(\hat{\boldsymbol{\lambda}}_2). \qquad (2)
\end{aligned}
$$

The matrix element for the amplitude of the decay $D_{03} \to d\pi^0\pi^0$ via two decays $D_{03} \to D_{12}+\pi^0$ and $D_{12} \to d + \pi^0$ has the following form

$$
\begin{aligned}
T_{(D_{03}\to d\pi\pi)} = &\sum_{\mu_2 m_1 m_2} F_{D_{03}\to D_{12}\pi}(k_1) \cdot C_{2\mu_2 l_1 m_1}^{3\mu_3} k_1^{l_1} \sqrt{4\pi} Y_{l_1 m_1}(\hat{\mathbf{k}}_1) \\
&\times F_{D_{12}\to d\pi}(\lambda_1) C_{1\mu_d l_2 m_2}^{2\mu_2} \lambda_1^{l_2} \sqrt{4\pi} Y_{l_2 m_2}(\hat{\boldsymbol{\lambda}}_1) \frac{1}{P_{D_{12}}^2 - M_{D_{12}}^2 + iM_{D_{12}}\Gamma_{D_{12}}^2} + \\
&+ F_{D_{03}\to D_{12}\pi}(k_2) \cdot C_{2\mu_2 l_1 m_1}^{3\mu_3} k_2^{l_1} \sqrt{4\pi} Y_{l_1 m_1}(\hat{\mathbf{k}}_2) \\
&\times F_{D_{12}\to d\pi}(\lambda_2) C_{1\mu_d l_2 m_2}^{2\mu_2} \lambda_2^{l_2} \sqrt{4\pi} Y_{l_2 m_2}(\hat{\boldsymbol{\lambda}}_2) \frac{1}{P_{D_{12}}'^2 - M_{D_{12}}^2 + iM_{D_{12}}\Gamma_{D_{12}}^2}. \qquad (3)
\end{aligned}
$$

Here $P_{D_{03}}$, $M_{D_{03}}$ and $\Gamma_{D_{03}}$ ($P_{D_{12}}$, $M_{D_{12}}$ and $\Gamma_{D_{12}}$) are the 4-momentum, mass and total width of the dibaryons D_{03} (D_{12}), respectively, $P_{D_{12}}$ is 4-momentum of dibaryon D_{12}, which appeared as a result of the emission of a pion with an impulse k_1 (first pion): $P_{D_{12}} = P_{D_{03}} - k_1$, and $P'_{D_{12}}$ appeared as a result of the emission of a pion with an impulse k_2 (second pion): $P'_{D_{12}} = P_{D_{03}} - k_2$; $\mathbf{q}$ is the 3-momentum of the initial deuteron in the cms of the D_{03}, $\mathbf{k_1}$ ($\mathbf{k_2}$) is the 3-momentum of the pion π_1 (π_2) in the cms of D_{03}, and $\boldsymbol{\lambda}_1$ ($\boldsymbol{\lambda}_2$) is the 3-momentum of the pion π_2 (π_1) in the cms of the D_{12}. We use in Eq. (3) the standard notations for the Clebsch-Gordan coefficients $C_{j_1 m_1 j_2 m_2}^{JM}$ and spherical functions $\mathcal{Y}_{lm}(\hat{\mathbf{k}}) = k^l Y_{lm}(\hat{\mathbf{k}})$; l_1 is the orbital momenta of relative motion of dibaryon D_{12} and the first pion in the vertex $D_{03} \to \pi D_{12}$, l_2 is the orbital momenta of relative motion of final deuteron and the second pion in the vertex $D_{12} \to d\pi$ and L is the orbital momentum of the relative motion of the initial deuteron and the σ-meson in the vertex $d + \sigma \to D_{03}$. From the parity and angular momentum conservation one can find the following allowed values for the orbital momenta: $L = 2,4$; $l_1 = 1,3,5$; $l_2 = 1,3$. Since we do not know decays parameters for higher orbital momenta, we consider below the differential cross section and the partial width of the decay $\Gamma_{D_{03}\to d\pi\pi}$ for each allowed set of orbital momenta separately.

The vertex functions $F_{R\to ab}(q)$ in Eqs. (2)- (3) are related to the corresponding partial

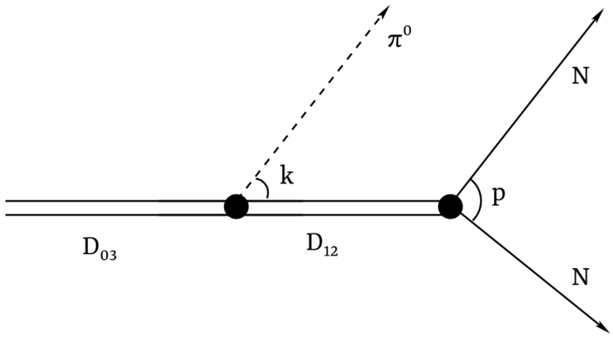

Figure 2: The mechanism of the decay $D_{03} \to \pi^0 NN$

widths of the decay of the resonance R to the system $a+b$, $\Gamma_{R\to ab}$, as [9]:

$$F_{R\to ab}(q_{ab}) = M_{ab}\sqrt{\frac{8\pi\Gamma^{(l)}_{R\to ab}(q_{ab})}{q_{ab}^{2l+1}}}, \tag{4}$$

where M_{ab} is the mass of the $a+b$ system, l is the orbital momentum of the relative motion of the particles a and b, and q_{ab} is their relative 3-momentum determined as $q_{ab} = [(s-(m_a-m_b)^2)(s-(m_a+m_b)^2)/4s]^{1/2}$, where $s \equiv M^2_{ab}$. We use the following parametrization of the energy dependence of the partial widths [9]:

$$\Gamma^{(l)}_{R\to ab}(q_{ab}) = \Gamma^{(l)}_{R\to ab}\left(\frac{q_{ab}}{q_0}\right)^{2l+1}\left(\frac{q_0^2+\lambda^2_{ab}}{q^2_{ab}+\lambda_{ab}}\right)^{l+1}, \tag{5}$$

here $\Gamma^{(l)}_{R\to ab} \equiv \Gamma^{(l)}_{R\to ab}(q_0)$, q_0 is the relative momentum q_{ab} of the particles a and b at the resonance point defined as $M_{ab}(q_0) = M_R$, where M_R is the nominal mass of the resonance.

According to Eqs. (4), (5), the vertex function
$F_{D_{03}\to d\sigma}(q)$ is written as

$$F_{D_{03}\to d\sigma}(q) = M_{d\sigma}(q)\sqrt{\frac{8\pi\Gamma^{(L)}_{D_{03}\to d\sigma}(q)}{q^{2L+1}}}, \tag{6}$$

where the factor $\Gamma^{(L)}_{D_{03}\to d\sigma}(q)$ is defined as

$$\Gamma^{(L)}_{D_{03}\to d\sigma}(q) = \Gamma^{(L)}_{D_{03}\to d\sigma}\left(\frac{q}{q_0}\right)^{2L+1}\left(\frac{q_0^2+\lambda^2_{d\sigma}}{q^2+\lambda_{d\sigma}}\right)^{L+1}; \tag{7}$$

Here q is relative 3-momentum of deuteron and σ-meson in cms of D_{03}, q_0 is 3- momentum at the resonance point $M_{D_{03}} = 2.38$ GeV and $q_0 = 0.362$ Gev/c, $\lambda_{d\sigma} = 0.18$ GeV is the parameter which given in [5].
The vertex function and the partial width of the decay $D_{03} \to D_{12}\pi$ at l_1 $(= 1,3,5)$ are the following

$$F_{D_{03}\to D_{12}\pi}(k_1) = M_{D_{12}\pi}(k_1)\sqrt{\frac{8\pi\Gamma^{(l_1)}_{D_{03}\to D_{12}\pi}(k_1)}{k_1^{2l_1+1}}},$$

$$\Gamma^{(l_1)}_{D_{03}\to D_{12}\pi}(k_1) = \Gamma^{(l_1)}_{D_{03}\to D_{12}\pi}\left(\frac{k_1}{k_{10}}\right)^{2l_1+1}\left(\frac{k_{10}^2+\lambda^2_{D_{12}\pi}}{k_1^2+\lambda_{D_{12}\pi}}\right)^{l_1+1}, \tag{8}$$

where k_1 is the relative 3-momentum of the dibaryon D_{12} and the pion in the cms frame of the D_{03}, k_{10} is the 3-momentum at the resonance point $M_{D_{03}} = 2.38$ GeV, the parameters $k_{10} = 0.177$ GeV/c,

and $\lambda_{\pi D_{12}} = 0.12$ GeV are taken from [5].

The vertex function and the partial width of the decay $D_{12} \to d\pi$ at $l_2 = 1, 3$ are the following

$$F_{D_{12}\to d\pi_2}(\lambda_1) = M_{d\pi}(\lambda_1)\sqrt{\frac{8\pi\Gamma^{(l_2)}_{D_{12}\to d\pi}(k_2)}{k_2^{2l_2+1}}},$$
$$\Gamma^{(l_2)}_{D_{12}\to d\pi}(\lambda_1) = \Gamma^{(l_2)}_{D_{12}\to d\pi}\Big(\frac{\lambda_1}{\lambda_{10}}\Big)^{2l_2+1}\Big(\frac{\lambda_{10}^2 + \lambda_{d\pi}^2}{\lambda_1^2 + \lambda_{d\pi}}\Big)^{l_2+1}, \tag{9}$$

where λ_1 is relative 3-momentum of deuteron and pion in cms of D_{12}, λ_{10} is 3-momentum at the resonance point $M_{D_{12}} = 2.15$ GeV and $\lambda_{10} = 0.224$ GeV/c, $\lambda_{d\pi} = 0.25$ GeV [5].

The differential cross section of the reaction $pd \to pd\pi\pi$ within the considered model can be writen as following

$$d\sigma = ((2\pi)^7 \cdot 64 \cdot q_{pd} \cdot s)^{-1} \cdot \overline{|T_{fi}(pd \to pd\pi\pi)|^2} k \cdot q \cdot p' \cdot d\Omega_{\mathbf{k}} d\Omega_{\mathbf{q}} d\cos\theta'_p dM_{D_{03}} dM_{\pi\pi}, \tag{10}$$

and the partial width of the $D_{03} \to d\pi^0\pi^0$ decay takes the form

$$d\Gamma(D_{03} \to d\pi\pi) = \frac{1}{(2\pi)^5}\frac{1}{4M_{D_{03}}^2} k \cdot q \cdot \overline{|T_{fi}(D_{03} \to d\pi\pi)|^2} d\Omega_{\mathbf{k}} d\Omega_{\mathbf{q}} dM_{\pi\pi}. \tag{11}$$

In Eq. (10) q_{pd} is the relative 3-momentum between the initial proton and the deuteron and p' is the 3-momentum of the final proton in the center of mass of the reaction. In Eqs. (10) and (11) $\mathbf{k}$ is the relative 3-momentum between two pions, and $\mathbf{q}$ is the relative 3-momentum between the final deuteron and the center mass of the $\pi\pi$ system in the center mass of the of the dibaryon D_{03}.

Numerical results and discussion

The values $M_{D_{03}} = 2.380$ GeV and $\Gamma_{D_{03}} = 70$ MeV ($M_{D_{12}} = 2.15$ GeV, $\Gamma_{D_{12}} = 0.11$ GeV) are used in our calculations for the masses and widths of the resonance D_{03} (D_{12}), respectively, and $m_\sigma = 0.5$ GeV, $\Gamma_\sigma = 0.55$ GeV for the σ-meson. The values for the vertex parameters appeared in Eqs. (7), (8) and (9) are given in the section 2. The partial widths $\Gamma^{(l=1)}_{D_{12}\to d\pi} = 10$ MeV and $\Gamma^{(l=1)}_{D_{12}\to pn} = 10$ MeV were found in Ref. [9] from the analysis if the reaction $pp \to d\pi^+$. The partial width $\Gamma^{(L=2)}_{D_{03}\to d\sigma} = 8.5$ MeV was found by us [7] from normalization of the calculated differential cross section within this two-resonance model to the data [4]. To get this value we assumed in Ref. [7] that the experimental value of the width $\Gamma^{exp}_{D_{03}\to d\pi\pi} = 10$ MeV [11] is completely determined by the decays chain $D_{03} \to D_{12}\pi \to d\pi\pi$ and on this way we found that the value $\Gamma_{D_{03}\to D_{12}\pi}$ has to be equal to ≈ 140 MeV. Here we used for the orbital angular momentum l_1 in the decay vertex $D_{03} \to D_{12}\pi$ the value $l_1 = 1$.

The following partial widths are unknown at present: $\Gamma^{(l_1)}_{D_{03}\to D_{12}\pi}$ at $l_1 = 1, 3, 5$ and $\Gamma^{(l_2=3)}_{D_{12}\to d\pi}$. In order to estimate them we use Eqs. (5),(7), (8), (9) with the same parameters q_0 and λ as for the minimal orbital angular momenta $l_1 = l_2 = 1$, $L = 2$, but substitute the higher orbital momenta $l_1 = 3, 5$, $l_2 = 3$ and $L = 4$.

Using the mechanism of the decay $D_{03} \to \pi NN$ depicted in Fig. 2 and experimental constraints on the width $\Gamma_{D_{03}\to\pi^0 NN} < 6.3$ MeV from [12] we found the corresponding constraints

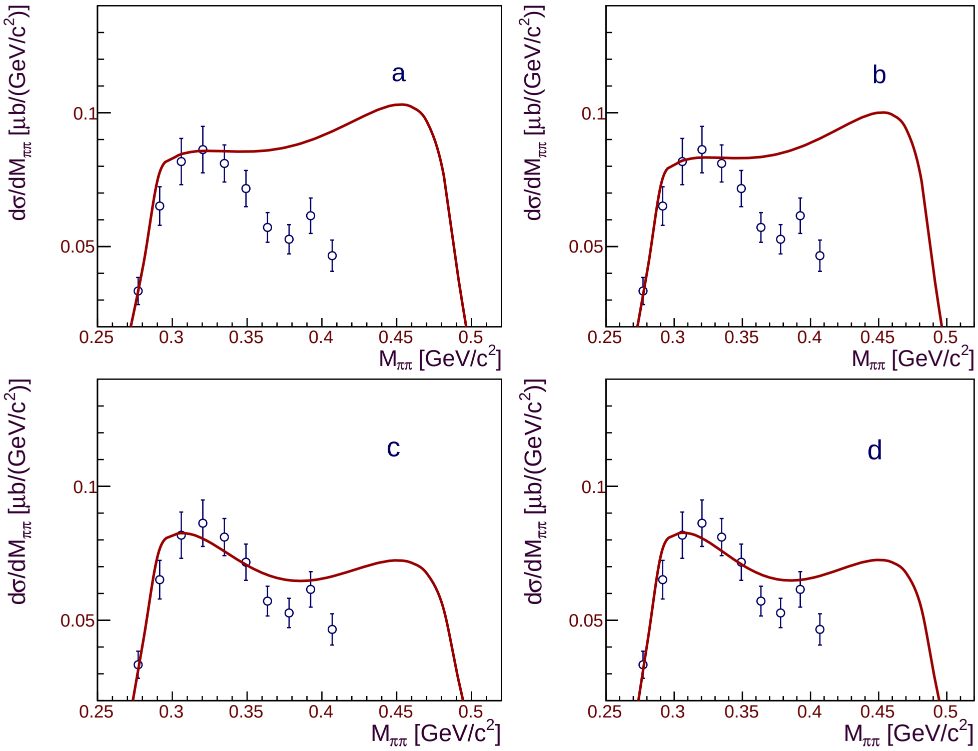

Figure 3: The distribution over the invariant mass of two final pions system $M_{\pi\pi}$ at different orbital angular momenta. a: $L = 2$, $l_1 = 1$, $l_2 = 1$, b: $L = 4$, $l_1 = 1$, $l_2 = 1$, c: $L = 2$, $l_1 = 1$, $l_2 = 3$, d: $L = 4$, $l_1 = 1$, $l_2 = 3$. Here L,l_1 and l_2 are the orbital momenta in the vertices $d + \sigma \to D_{03}$, $D_{03} \to \pi D_{12}$ and $D_{12} \to d\pi$, respectively. The results of the model calculations (full lines) are normalized to the data [4] (open circles). In the calculations the scattering angle $\theta_d^{c.m.}$ of the final deuteron belongs to the full interval $0° < \theta_d^{c.m.} < 180°$.

Table 1: The partial width $\Gamma_{D_{03}\to d\pi\pi}$ at different values of the orbital angular momenta l_1 and l_2 (see text for details)

l_1	l_2	$\Gamma_{D_{03}\to d\pi\pi}$ (MeV)	$\Gamma_{D_{03}\to d\pi\pi}$ (MeV)
1	1	< 6.5	10
1	3	< 2.02	3.1
3	1	< 1.81	2.78
3	3	< 0.6	0.92
5	1	< 4.42	6.8
5	3	< 3.6	5.5

on the partial widths: $\Gamma^{l=1}_{D_{03}\to D_{12}\pi} < 95$ MeV, $\Gamma^{l=3}_{D_{03}\to D_{12}\pi} < 82$ MeV, $\Gamma^{l=5}_{D_{03}\to D_{12}\pi} < 65$ MeV, here is l the orbital angular momentum of the relative motion of the D_{12} and the π^0.

Let us consider now the partial width $\Gamma_{D_{03}\to d\pi\pi}$. We have two possibilities to calculate this partial width. (i) One can take into account the upper limit $\Gamma_{D_{03}\to \pi^0 NN} < 6.3$ MeV [12]. (ii) One may assume that the experimental value $\Gamma^{exp}_{D_{03}\to d\pi\pi} = 10$ MeV [11] is completely determined by the decays chain $D_{03} \to D_{12}\pi \to d\pi\pi$. The results of calculations of the $\Gamma_{D_{03}\to d\pi\pi}$ for the first and the second approximation are given in the third and the fourth columns in the Tab. 1, respectively.

In Ref. [7] we didn't consider the channel $\sigma + d \to D_{03}$ with the orbital angular momentum $L = 4$. Here when calculating the corresponding partial width $\Gamma^{(L=4)}_{D_{03}\to d\sigma}$ in a similar way as for the channel $L = 2$ we find the value $\Gamma^{(L=4)}_{D_{03}\to d\sigma} = 6.4$ MeV.

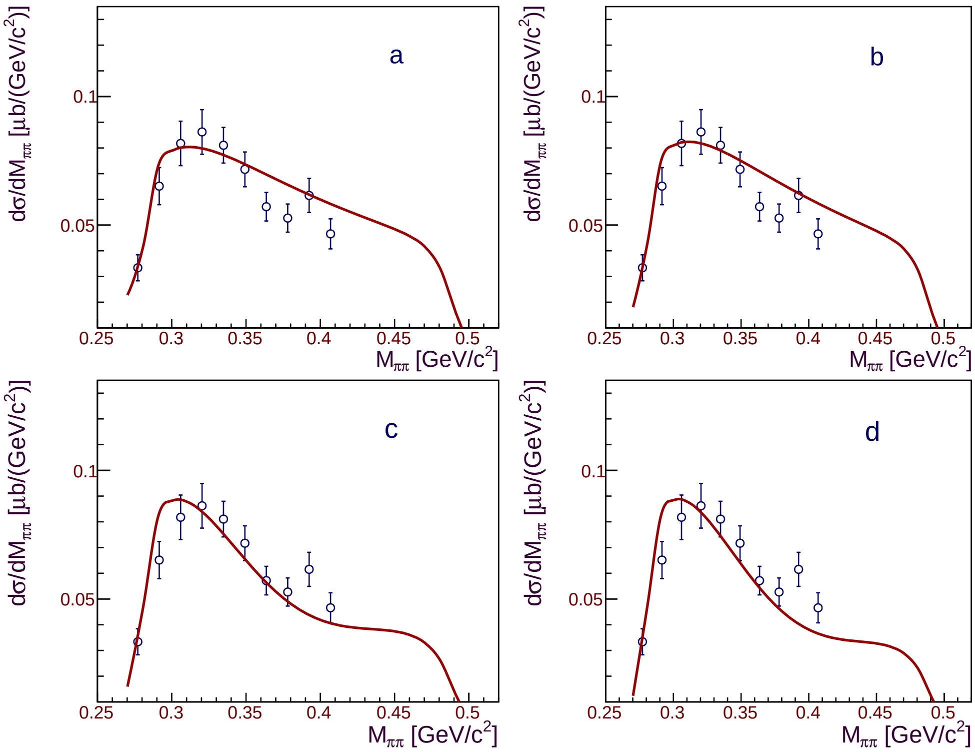

Figure 4: The same as in Fig. 3 but with the model calculations at the scatering angle $\theta^{c.m.}_d$ of final deuteron in the interval $0° < \theta^{c.m.}_d < 11°$ as in the experiment [4].

Considering the cross section of reaction $pd \to pd\pi\pi$ we should note that in our previous work [7] we found that "ABC-type" shape is caused mainly by the collinear kinematics of the experiment [4] and does not occur within the considered model for the case when scattering angle of the final deuteron is in the full interval $0° < \theta^{c.m.}_d < 180°$. In Ref. [7] we performed calculation only for the lowest orbital angular momenta. Here we study the role of other possible orbital angular momenta L, l_1, l_2. We use in Eq. (5) the same partial width $\Gamma^l_{R\to ab}(q_0)$ for the higher orbital angular momenta l as for their lowest values. The calculated differential cross section as a function of the mass of two final pions is shown in Fig. 3. One can see from this figure that at some orbital angular momenta the ABC effect is reproduced qualitatively (Fig. 3 c and d). Other higher orbital angular momenta do not reproduce "ABC-type" shape and we do not show the corresponding results.

From the results of calculations shown in Fig. 4, one can conclude that the contribution of the decay width $\Gamma^{l_2=3}_{D_{12}\to d\pi}$ to the reaction $pd \to d\pi\pi$ is approximately equal to the contribution of tyhe $\Gamma^{l_2=1}_{D_{12}\to d\pi}$, therefore, interference effects, not taken into account here, will be important.

The differential cross section of the reaction $pd \to pd\pi\pi$ calculated at orbital angular momenta $L = 2$, $l_1 = 5$, $l_2 = 3$ for the interval of the scattering angle of the deuteron $0° < \theta^{c.m.}_d < 11°$ is depicted in Fig. 5a as a function of the mass $M_{\pi\pi}$. The results of calculations are normalized to the experimental data. One can see that the model fails to reproduce the ABC effect for these (and higher) orbital angular momenta. We should note, that the absolute value of differential cross section decreases with increasing orbital angular momenta.

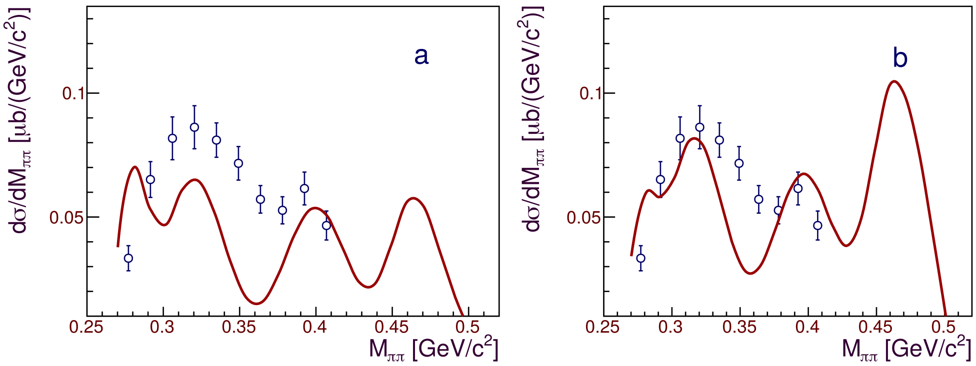

Figure 5: The distribution over the invariant mass of two final pions $M_{\pi\pi}$ at the orbital angular momenta $L = 2$, $l_1 = 5$ and $l_2 = 3$. The scattering angle $\theta_d^{c.m.}$ of the final deuteron belongs to the experimental interval $0° < \theta_d^{c.m.} < 11°$ (a) and to the full interval $0° < \theta_d^{c.m.} < 180°$ (b). The results of the model calculations are normalized to the data [4].

We do not show distribution of the differential cross section on the $M_{d\pi\pi}$ invariant mass because when changing the orbital angular momenta the shape of the differential cross section practically is not changed, while its absolute value is slowly diminished.

Conclusion

The two-resonance model of the reaction $pd \to pd\pi\pi$ considered in Refs. [7] allows one to describe shapes of the measured in [4] distributions over the invariant masses $M_{d\pi\pi}$ and $M_{\pi\pi}$ if the lowest orbital angular momenta are used in the vertices $\sigma + d \to D_{03}$, $D_{03} \to D_{12} + \pi$ and $D_{12} \to d + \pi$. The ABC-like effect observed in the experiment [4], which was performed at small scattering angles of the deuteron $\theta_d^{c.m.} = 0{-}11°$, dissappears in this reaction within the considered model if the full angular interval for the scattered deuteron is allowed, $0 \le \theta_d^{c.m.} \le 180°$. In the present work the higher orbital angular momenta were included into consideration in the vertices $\sigma + d \to D_{03}$, $D_{03} \to D_{12} + \pi$ and $D_{12} \to d + \pi$ and it was found that for some of them the ABC-like effect takes the place for the full interval of the deuteron scattering angle $\theta_d^{c.m.} = 0 - 180°$. The interference effects were not taken into account since the absolute values and relative phases of transition amplitudes with different orbital angular momenta are unknown.

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