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Comment on "Sequential Single-Pion Production Explaining the Dibaryon "$d^*(2380)$" Peak"

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In arxiv: 2102.05575 a two-step process $pn \to (pp)\pi^- \to (\Delta N)\pi^- \to (d\pi^+)\pi^-$ was calculated by using experimental total cross sections for the single-pion production processes $pn \to pp\pi^-(I=0)$ and $pp \to d\pi^+$. As a result the authors obtain a resonance-like structure for the total $pn \to d\pi^+\pi^-$ cross section of about the right size and width of the observed $d^*(2380)$ peak at an energy about 40 MeV below the $d^*(2380)$ mass. We object both the results of the sequential process calculation and its presentation as an alternative to the dibaryon interpretation.

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In what is called an unavoidable result of the sequential process the authors of Ref. [1] present their ansatz as an alternative to the dibaryon interpretation of the resonance structure $d^*(2380)$ with $I(J^P) = 0(3^+)$ observed in the $d\pi^+\pi^-$ channel [2]. Note that this resonance has been observed in all possible hadronic decay channels [3–8] with the exception of the isoscalar $NN\pi$ channel. Its nonappearance in the latter channel is in favor of a $d^*(2380)$ decay via an intermediate $\Delta\Delta$ configuration as discussed in detail in Ref. [9]. A signal of $d^*(2380)$ has also been reported in photoexcitation of the deuteron [10–15]. For recent reviews see Refs. [16, 17].

We object both the results of the sequential process calculation and its presentation as an alternative to the dibaryon interpretation as follows:

(i) For the isoscalar $pn(I=0) \to pp\pi^-$ reaction the WASA@COSY results [9] are used in Ref. [1] by enlarging the relatively small statistical uncertainties enourmeously by adding in quadrature a large systematic error due isospin violation. We think that since the latter is not fluctuating randomly from energy point to energy point, it does not behave like statistical uncertainties and can not just be added to them. Only by this procedure the authors of Ref. [1] can arrive at a width as narrow as 70 MeV in a Breit-Wigner fit to the observed structure in the isoscalar $pn \to pp\pi^-$ cross section. In our fits to this structure we obtain a width of about 150 MeV, see Ref.s [9, 18]. Note that the width of this first-step in the proposed sequential process is crucial for the calculated narrow width of the structure in the final $d\pi^+\pi^-$ channel.

(ii) The fact that the peak calculated for the $d\pi^+\pi^-$ channel misses the measured peak by about 40 MeV is associated in Ref. [1] with a pretended experimental resolution of 20 MeV in $\sqrt{s}$. However, here the authors of Ref. [1] mix the experimental resolution up with the bin width used for the presentation of differential distributions in Ref. [2]. Furthermore, a finite experimental energy resolution affects the width of a resonance structure, but not its position. The binning used for the presentation

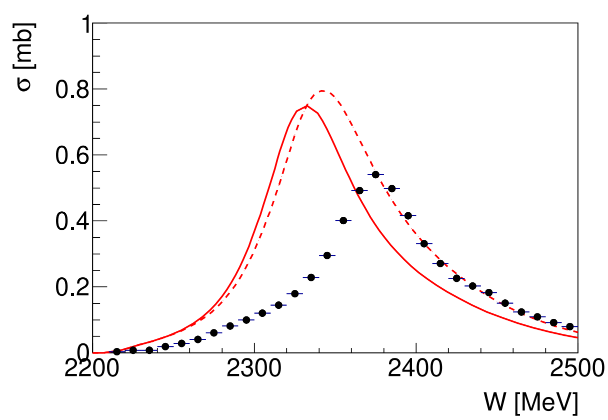

FIG. 1: (Color online) The isoscalar part of the total $pn \to d\pi^+\pi^-$ cross section in the region of the dibaryon resonance $d^*(2380)$. Black filled dots represent the experimental results from WASA-at-COSY [2, 3], the horizontal bars give the binning width used. Red solid and dotted curves show the calculations of Ref. [1].

of total cross section was 10 MeV in Refs. [2, 3] — see Fig. 1 — and the high precision COSY beam had a resolution in the sub-MeV range. The position of the peak calculated in Ref. [1] rather is determined by the data point at 2.33 GeV in the isoscalar single-pion production crossn section [9], which constitutes just a statistically insignificant excursion. In Ref. [9] it was demonstrated that there is no peak structure in the data around 2380 MeV. Hence the concept of Ref. [1] has no possiblity to correct this failure in missing the correct resonance mass, which was independently established in different two-pion production experiments [2–6] and in np scattering [7, 8]

(iii) As shown by many partial-wave analyses [16, 19] of the $pp \to d\pi^+$ reaction the incident $^1D_2$ partial wave is the by far dominating partial wave. Since in the isoscalar $N\pi$-invariant mass spectrum of the $np \to pp\pi^-$ reaction the strength accumulates at highest masses (Fig. 6

of Ref.[9]), it follows already from kinematics that the strength in the associated pp-invariant mass spectrum accumulates at lowest masses — in accordance with a dominance of S- and P-waves between the final pp pair (see also the partial-wave analysis of Ref. [20]). This is at variance with the requirements for incident ${}^1D_2$ pp-waves in the second step reaction. With just low-energetic incident S- and P-waves available the second step reaction provides only tiny cross sections and so does the full sequential process with cross sections at least an order of magnitude smaller than pretended in Ref. [1].

(iv) Consistent $d^*(2380)$ signals have also been observed in the non-fusion channels $np\pi^0\pi^0$ [4], $np\pi^+\pi^-$ [5] and in $pp\pi^0\pi^-$ [6], which are impossible to be explained by the sequential process ansatz due to the absence of the triangle singularity.

(v) The concept of Ref. [1] does not allow for any detailed check with data, since it does not provide any differential distributions.

(vi) The sequential process cannot reproduce the observed pole in the ${}^3D_3 - {}^3G_3$ np-partial waves at 2380 MeV [7]. Since the sequential process produces a variety of spin-parity combinations, it produces also poles in several partial waves at 2.33 GeV simultaneously, which are not in accord with partial-wave analyses [7, 19].

(vii) In contrast to the claim in Ref. [1] various evidences for $d^*(2380)$ signals have been observed in $\gamma d \to d\pi^0\pi^0$ [13–15] and $\gamma d \to pn$ reactions [10–12], see, *e.g.*, the discussion in Ref. [17].

(viii) In order to demonstrate the invalidity of the sequential single-pion production ansatz by yet another example, let us consider instead of the isoscalar part now the isovector part of the $np \to pp\pi^-$ reaction. In this case we deal with the two-pion production process $np(I = 1) \to d\pi^+\pi^-$. Since the isovector part of the $pp\pi^-$ channel is larger than its isoscalar part by roughly a factor of four [9] at the energy of the $d^*(2380)$ peak, we would expect the cross secton for the isovector part of the $d\pi^+\pi^-$ channel to be larger than its isoscalar part by just this factor at the position of $d^*(2380)$. In reality its is smaller by a factor of ten [2, 17] and the sequential single-pion production ansatz fails again vastly.

We finally note that it is already the knowledge of the pole in the ${}^3D_3$ np-partial wave and its associated Argand circle [7], which makes the resonance structure in the various $NN\pi\pi$ channels unavoidable [17].

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