Deuteron breakup $pd \to \{pp\}_s n$ and the contact d-term in the $pN \to \{pp\}_s \pi$ subprocesses

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A number of spin observables for the single-pion production reactions $pp \to \{pp\}_s \pi^0$ and $pn \to \{pp\}_s \pi^-$, where $\{pp\}_s$ is the pp pair in the $^1S_0$ state, was measured at ANKE@COSY at 353 MeV [1, 2, 3] including the unpolarized differential cross section $d\sigma/d\Omega$, the vector analyzing power A_y, and the spin correlation coefficient $C_{x,x} = -C_{z,z}$, in the notation of [4]. (Note that $C_{y,y} = 1$.) A partial wave analysis (PWA) of these data was done and as a result three different solutions for the set of five partial-wave amplitudes in the isospin channels $T = 0$ and $T = 1$ were found. The aim of that study was to extract one low-energy constant (LEC), d, associated with a $(N\bar{N})^2\pi$ contact term that arises in the treatment of few-nucleon reactions within chiral effective field theory. This LEC determines the strength of the one-pion exchange three-nucleon force and contributes also to electroweak processes. It means that the amplitudes of the following reactions are connected with each other via this contact term: single-pion production $NN \to NN\pi$, the reaction $\pi^- d \to nn\gamma$, $\nu(\tilde{\nu})d$ breakup, pion absorption on the deuteron $\mu^- d \to nn\nu_\mu$, pp fusion $pp \to d\, e^+ \nu_e$, the so called hep process $^3He\, p \to\, ^4He\, e^+ \nu_e$, the triton β decay, and many others with a larger number of nucleons involved [5, 6, 7]. Once the LEC d is determined from one process, it can be used to calculate observables of any of the other reactions. However, it is important to compare the strength of the contact term, extracted from data at higher energies, i.e. at $T_p = 353$ MeV, with that found at low energies [8] in order to check the applicability of ChEFT in different energy regions.

Unfortunately, the obtained data on the reactions $pp \to \{pp\}_s \pi^0$ and $pn \to \{pp\}_s \pi^-$, are incomplete because the last nontrivial spin-correlation coefficient $C_{x,z}$ was not measured. As a consequence of the incompleteness of the data set it turned out that the obtained PWA solution is ambiguous and several solutions were found as mentioned above.

In order to put further constraints on those solutions, we will study from theory side spin observables of the reaction $pd \to \{pp\}_s n$ measured recently at ANKE-COSY at the same energy in the kinematics of backward elastic pd scattering. The point is that the transition amplitude of the reaction $pd \to \{pp\}_s n$ involves the triangle diagrams with one-pion exchange and the subprocesses $pp \to \{pp\}_s \pi^0$ and $pn \to \{pp\}_s \pi^-$ (see Fig.1), i.e. the amplitudes discussed above, together with other important mechanisms (see Refs. [9],[13]). The study of the deuteron breakup reaction with fast diproton formation was initiated by the theoretical model of Ref. [9], and then continued in Refs. [10, 11]. First data on the reaction were published in Ref. [12]. Previously we studied the deuteron break-up reaction $pd \to \{pp\}_s n$ measured at higher energies 0.5-1.5 GeV [14] within two different complementary approaches based on other set of triangle diagrams of the one-pion-exchange mechanism with the subprocesses $\pi d \to NN$ in Ref. [15] and also on the basis of the SS+Δ+ONE model [9], which includes the Δ-isobar (Δ) explicitly together with the single scattering (SS) mechanism and the one-nucleon exchange (ONE) with rescattering taken into account [13]. Within this approach the energy dependence of the differential cross section $d\sigma/d\Omega$ of the reaction $pd \to \{pp\}_s n$ at the c.m.s. scattering angle of the final neutron $\theta^n_{cm} = 180^\circ$ and its angular depedence were explained.

At lower energies < 0.5 GeV the $pd \to \{pp\}_s n$ reaction was not yet studied. The proposed here calculation of the spin observables of the deuteron break-up at 353 MeV using triangle diagrams in Fig. 1 with the subprocesses $pp \to \{pp\}_s \pi^0$ and $pn \to \{pp\}_s \pi^-$ will allow us to investigate the sensitivity of these observables to the differences in the obtained PWA solutions for the $pN \to \{pp\}_s \pi$ process. Such a sensitivity could be used to discriminate between those solutions by comparison with the date on the reaction $pd \to \{pp\}_s n$. For this aim a new data on the the reaction $pd \to \{pp\}_s n$ is planned to be get out at 353 MeV [16].

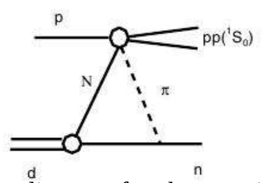

Fig. 1: The tiangle diagram for the reaction $pd \to \{pp\}_s n$ with the subprocess $pN \to \{pp\}_s \pi$.

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