Deuteron breakup $pd \to \{pp\}_s n$ with forward emission of a fast $^1S_0$ diproton *

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The deuteron breakup reaction $pd \to \{pp\}_s n$, where the diproton $\{pp\}_s$ is a fast proton pair emitted in forward direction with small excitation energy $E_{pp} < 3$ MeV, has been studied at proton beam energies of 0.5 – 2.0 GeV using the ANKE spectrometer at COSY-Jülich. The reaction kinematics was similar to that of pd backward elastic scattering and the cross section of the deuteron breakup reaction (Fig. 1) was found to be about two orders of magnitude smaller than the latter. In addition to the previously reported results [1], the high statistics obtained at beam energies of 0.5, 0.8, 1.1, 1.4, and 1.97 GeV allowed us to determine the dependence of the differential cross section on the excitation energy E_{pp} of the proton pair, on the proton emission angle in the rest frame of the proton pair θ_k, and on the neutron emission angle θ_n. For E_{pp} less than 3 MeV the distributions of E_{pp} and θ_k are caused by the final-state interaction between the protons, and are used here to validate the dominance of the $^1S_0$ pp state.

The shape of the energy dependence of the measured differential cross section of the $pd \to \{pp\}_s n$ reaction obtained at $\theta_n = 180^0$ is similar to the one of pd backward elastic scattering. Both processes exhibit a decrease of the cross section in the energy range $0.7-1.4$ GeV by one order of magnitude with a smaller decrease at the higher energies. In the angular range from 168^0 to 180^0 the differential cross sections change smoothly with θ_n and exhibit only a small variation of the slope near $\theta_n = 180^0$ as function of energy. The theoretical analysis shows that the ONE + SS + Δ model with rescatterings in the initial and final states allows one to describe reasonably well the obtained $pd \to \{pp\}_s n$ differential cross section when a rather soft short-distance NN potential is used, like the CD Bonn potential. The results of calculations [2] performed within the same model, but with harder NN potentials, like the Paris or the RSC potentials, are clearly contradicting the data. This observation, first described in Ref. [2] and confirmed here by the new high-statistics data, constitutes the most important finding of the study of the $pd \to \{pp\}_s n$ reaction.

The excitation of a $\Delta(1232)$ in the intermediate state represents a contribution of a three-body force to the $pd \to \{pp\}_s n$ reaction. This contribution turned out to become important at energies 0.5 - 1.0 GeV due to the node in the ONE amplitude, located in this reaction at ~ 0.8 GeV, which is caused by the repulsive NN core in the $^1S_0$ state. One should note, however, that neither Δ mechanism alone, nor the separate ONE mechanism provide an agreement with the experimental data below 1 GeV. Only their coherent sum allows one to describe the data.

In view of high internal momenta $q \sim 0.5-0.6$ GeV/c probed by the ONE mechanism in this energy region, it is important to gain more insight into the ONE contribution by independent measurements. The planned measurements of the tensor analyzing power T_{20} and spin correlation $C_{y,y}$ of the $\vec{p}\vec{d} \to \{pp\}_s n$ reaction could clarify further the underlying dynamics of this process and shed light on the role of the ONE mechanism [3].

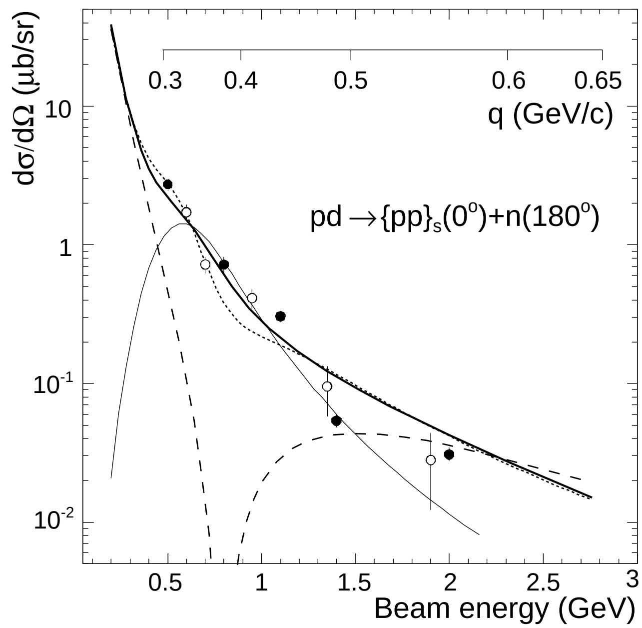

Fig. 1: Differential c.m. cross section averaged over the angular interval $172-180^0$ vs beam energy. The curves are the result of calculations [2] using the CD Bonn NN potential with the ONE (dashed) and Δ mechanisms (full thin), both without distortions and Coulomb effects. The ONE(DWBA) + SS + Δ is the dotted line, and the ONE(DWBA) + Δ (full thick line) contributions are obtained with a Coulomb suppression factor 0.83 [2]. The previously obtained data of Ref. [1] are shown by open circles, and the new data by bullets. The upper scale shows the internal momentum q of the nucleons in the deuteron for ONE at $\theta_n = 180^0$.

References:

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* supported by COSY-FFE and the BMBF project ANKE-PAX