Energy dependence of the deuteron break-up at high-momentum transfer

V. Komarov[a], S. Dymov[b], A. Kacharava[c,d], A. Kulikov[a], V. Kurbatov[a], G. Macharashvili[a,d], A. Petrus[†], F. Rathmann, R. Schleichert, H. Seyfarth, H. Ströher, Yu. Uzikov[a,e], S. Yaschenko[c,a], and B. Zalikhanov[a]
for the ANKE collaboration

The energy dependence of the proton induced deuteron break-up with forward emission of a fast proton pair

$$p + d \to (pp) + n \tag{1}$$

has been measured at ANKE at six beam energies from 0.6 to 1.9 GeV [1]. The chosen kinematics, close to the kinematics of backward elastic pd scattering, leads to high momentum transfer. The Lorentz-invariant momentum transfer from the projectile to the backward neutron is 2.0–6.7 $(\mathrm{GeV/c})^2$ and 0.10-0.21 $(\mathrm{GeV/c})^2$ to one of the forward-emitted protons. Therefore, information about the short-range structure of the NN interaction and the dynamics of high-momentum transfer within few-nucleon systems can be obtained in such a study [2]. Selection of proton pairs of small excitation energy E_{pp} in the reaction (1) results in an important advantage compared to $pd \to dp$ scattering: the spin-singlet $^1S_0$ state of the forward nucleon pair provides an essential suppression of those mechanisms which involve the low-momentum components of the deuteron wave function. Therefore, the one-nucleon exchange (ONE) mechanism, requiring the high-momentum components, is expected to get more distinct [3].

The experiment and the data analysis are described in Ref. [1]. Additional details are found in Refs. [4, 5, 6]. The differential cross sections of the investigated reaction (1) for $E_{pp} < 3\,\mathrm{MeV}$ are shown in Fig. 1. Due to the limited statistics obtained in the run of February 2001, when the cluster target provided a density lower than the standard value, the data had to be summed over the cm polar angle ϑ_{pp} of the pair emission from 0° to 8°. Thus, only average cross section values are given. The measured $pd \to dp$ cross section, also shown in the figure, has a similar energy dedendence, but it lies higher by about two orders of magnitude. The experimental data are compared with model calculations based on earlier works taking into account one-nucleon exchange (ONE), single-scattering (SS) and $\Delta(1232)$-excitation in the intermediate state (Ref. [10] for the scattering and Ref. [11] for the break-up process). For the break-up, the figure gives cross sections averaged over the experimental acceptance. Further discussions of the results are found in Refs. [2, 3]. The excitation energy distribution of the summed 0.6, 0.7 and 0.8 GeV data can be compared with that of the final-state interaction theory. It is consistent with the expectation for S-state pp-pairs of $E_{pp} < 3\,\mathrm{MeV}$ [1]. The same set of data exhibits a distribution over the angle between the relative and total momenta of the pairs close to isotropy, although the statistical uncertainty does not exclude several percent of a nonisotropic contamination to the differential cross section.

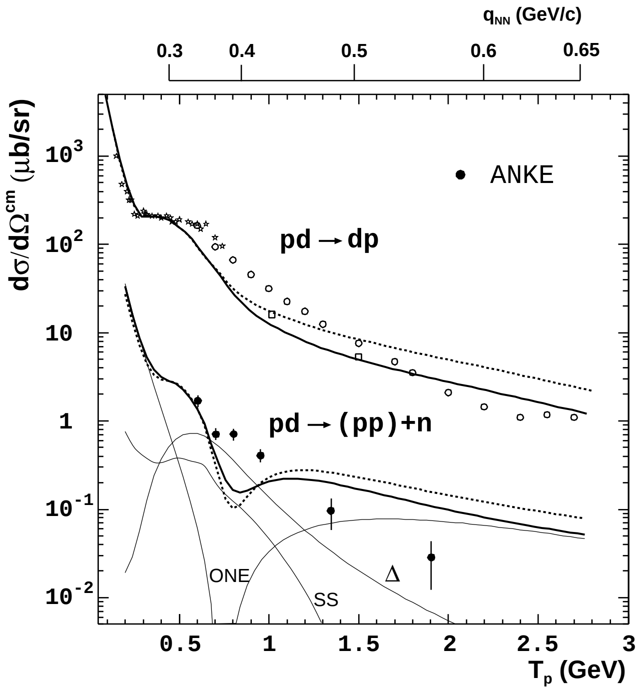

Fig. 1: The $pd \to (pp)+n$ cross section for $E_{pp} < 3\,\mathrm{MeV}$, measured at ANKE/COSY, versus the proton-beam energy compared with the data for backward elastic $pd \to dp$ scattering ($d\sigma/d\Omega_p^{cm}$, stars: Ref. [7], circles: Ref. [8], squares: Ref. [9]), and the results of $ONE + SS + \Delta$ model calculations performed to predict the break-up energy dependence and to describe the earlier scattering data with use of the Reid Soft Core (dotted line) or the Paris (solid line) NN potential. The upper scale gives the internal momentum of the nucleons inside the deuteron for ONE in collinear kinematics at E_{pp}=3 MeV.

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[a] JINR, Dubna, Russia
[b] PhD student from JINR, Dubna
[c] Universität Erlangen, Germany
[d] HEPI TSU, Tbilisi, Georgia
[e] Kazakh State University, Almaty, Kazakhstan
[†] killed in a tragic accident on 19 May 2002