Spin Effects in the Deuteron Charge-Exchange Break-up reaction

V. Glagolev[a], A. Kacharava[b,c], V. Komarov[a], G. Macharashvili[a,c], M. Nioradze[c], F. Rathmann, H. Seyfarth

We consider the possibility of using the ANKE spectrometer to investigate the spin structure of the elementary $np \to pn$ charge-exchange (CE) process by measuring the deuteron CE break-up reaction: $dp \to (pp)n$. Following the mathematical formalism developed in [1], the relation between the effective cross sections of this reaction and the elementary $np \to pn$ charge-exchange process in the framework of the impulse approximation can be written as a sum of spin-independent (index 1) and spin-dependent (index 2) parts of the elementary $np \to pn$ process: $(d\sigma/dt)_{dp\to(pp)n} = [1 - S(t)](d\sigma/dt)_1 + [1 - 1/3S(t)](d\sigma/dt)_2$, where t is the momentum transferred to the neutron and $S(t)$ is the deuteron form-factor. At zero momentum transfer from the target proton to the neutron $(d\sigma/dt)_{dp\to(pp)n} = 2/3(d\sigma/dt)_2$. Thus, this reaction in forward direction is completely determined by the spin-dependent part of the elementary $np \to pn$ process. A first attempt to measure the spin-dependent part for the amplitude of the $np \to pn$ reaction was made in a Hydrogen Bubble Chamber experiment [2] at a deuteron beam momentum of 3.34 GeV/c. The results showed an important role of spin effects in the $np \to pn$ process at small scattering angles. At present an experiment, STRELA [3], is in progress at the Nuclotron deuteron beam in Dubna. The STRELA set-up can detect a proton pair with small relative momentum close to 0°. However, this is not sufficient to observe the dynamics of the differential cross section change near 0°. To clarify the different behaviour of the deuteron CE and direct break-up (DIR) reactions at low momentum transfer, the result from ref.[2] is presented in Fig. 1. The differential cross section is shown for events, when both protons are emitted in a narrow 3° forward cone (shaded histogram). Here t is the momentum transfer from the target-proton to the recoil nucleon. A clear peak can be seen around $t \approx 0$, whereas the differential cross section for the direct break-up, when a proton-neutron pair is emitted in the same forward cone, vanishes at low t. As a first step we intend to use the unpolarized deuteron beam. Both fast protons, emitted into a narrow forward cone with typical momenta around half of the deuteron beam momentum, will be detected by means of the forward detector (FD) of the ANKE spectrometer. For estimation of the FD efficiency in registration and for studying the background, a simulation based on data from [2] as GEANT event generator was carried out. The angular-momentum acceptance of the FD is shown in Fig. 2. It presents the ejectile momentum p versus the projection of the polar angle on the median plane θ_{xz} of ANKE. The curves show the kinematical locus for protons and deuterons from several processes. The label $dp \to ppn$ denotes the deuteron CE break-up with emission of a forward proton pair with zero relative momentum. The acceptance region is centered at $\theta_{xz} = 0°$ in a polar angle range of -4° to +4°. Simulation results show that the main count rate in the FD is expected from one-proton events. However, even if all inclusive protons are registered, the count rate is not larger than 220 per two-proton event, when the selection aperture is 3°. Background of two proton events is left only from the channel $dp \to ppn\pi^0$, but an unambigous identification of the reaction is possible using a missing-mass criterion. One can conclude that the ANKE spectrometer is well suited to study the deuteron CE break-up reaction at small momentum transfer and allows one to measure the spin-dependent part of the amplitude of the $np \to pn$ process. Further development of this investigation is connected with polarization experiments, which allows one to estimate the two spin-dependent terms in the amplitude of the $np \to pn$ process under 0° and their relative phase.

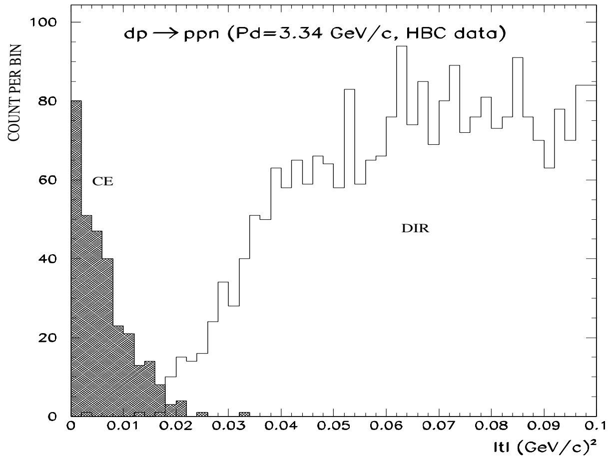

Fig. 1: Events from the bubble chamber experiment [2], interpreted as due to charge exchange (CE) and direct (DIR) deuteron break-up.

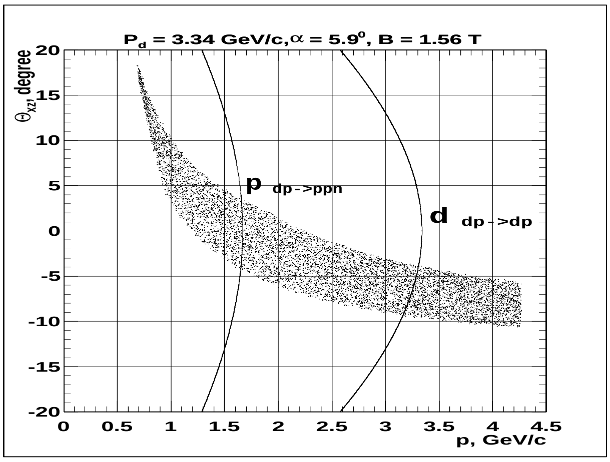

Fig. 2: FD angular-momentum acceptance for a 3.34 GeV/c deuteron beam as used in ref.[2] (α and B denote ANKE-operation parameters).

References:

1. N.W. Dean Phys. Rev. D5 (1972) 1661; D5 (1972) 2832.
2. B. Aladashvili et al. Nucl. Phys. B86 (1975) 707.
3. V. Glagolev et al., Research Program JINR-LHE-0941-1 (1999) 29.

[a] JINR, Dubna, Russia
[b] Universität Erlangen, Germany
[c] HEPI TSU, Tbilisi, Georgia