Analysing power measurement for the charge–exchange breakup reaction $\vec{d}\,p \to \{pp\}n$ at $T_d = 2.27$ GeV*

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Nowadays an understanding of the NN interaction still remains the most important question of nuclear and hadronic physics. The main method of this study is the phase–shift analyses, which requires the precise experimental data as input. Such analyses are possible to carry out over wide energy region for isospin $I = 1$ channel, thanks to wealth of experimental data produced by the EDDA experiment up to 2.5 GeV per nucleon. The situation is far less advanced for the isoscalar channel where the much poorer neutron–proton data only permit the $I = 0$ phase shifts to be evaluated up to at most 1.3 GeV but with significant ambiguity above about 800 MeV. The ANKE collaboration has been embarked on a systematic programme to measure the differential cross section and analysing powers of the $dp \to \{pp\}n$ reaction up to the maximum energy at COSY of 1.15 GeV per nucleon, with the aim of deducing information on the np amplitudes [1]. In single scattering approximation this reaction can be considered as $np \to pn$ scattering, with spectator proton, which amplitude depends on five scalar amplitudes in the cm system as:

$$f_{np} = \alpha(q) + i\gamma(q)(\vec{\sigma}_1 + \vec{\sigma}_2)\cdot\vec{n} + \beta(q)(\vec{\sigma}_1\cdot\vec{n})(\vec{\sigma}_2\cdot\vec{n}) + \delta(q)(\vec{\sigma}_1\cdot\vec{m})(\vec{\sigma}_2\cdot\vec{m}) + \varepsilon(q)(\vec{\sigma}_1\cdot\vec{l})(\vec{\sigma}_2\cdot\vec{l}),$$

where α is the spin–independent amplitude between the initial neutron and final proton, γ is a spin–orbit contribution, and β, δ, and ε are the spin–spin terms. The one–pion–exchange pole is contained purely in the δ amplitude and this gives rise to its very rapid variation with momentum transfer, which influences very strongly the deuteron charge–exchange observables. The relative momentum of proton pair defines the final state of this system. If it remains low then the final system is in ${}^1S_0$ state. Under such conditions the tensor analysing powers of the reaction are connected with the np amplitudes in the following way:

$$A_{xx} = \frac{|\beta(q)|^2 + |\gamma(q)|^2 + |\varepsilon(q)|^2 - 2|\delta(q)|^2}{|\beta(q)|^2 + |\gamma(q)|^2 + |\delta(q)|^2 + |\varepsilon(q)|^2},$$
$$A_{yy} = \frac{|\delta(q)|^2 + |\varepsilon(q)|^2 - 2|\beta(q)|^2 - 2|\gamma(q)|^2}{|\beta(q)|^2 + |\gamma(q)|^2 + |\delta(q)|^2 + |\varepsilon(q)|^2}.$$

where all amplitudes and consequently analysing powers also are the functions of q - transferred momentum on neutron. If cross section of the process is known, then $|\beta(q)|^2 + |\gamma(q)|^2$, $|\delta(q)|^2$, and $|\varepsilon(q)|^2$ extraction is possible for small values of the momentum transfer $\vec{q}$ between the initial proton and final neutron. The methodology described above has been checked at 1.17 GeV beam energy (585 MeV per nucleon). The results for the tensor analysing powers (A_{ii}) and differential cross sections were compared with the predictions of the impulse approximation program using as input the np amplitudes taken from the SAID analysis. The agreement with the calculation is very encouraging [1]. The success of these analyses has motivated us to do the same measurements at higher energies.

The experiment with polarised deuteron beam at 2.27 GeV energy ($T_n \approx 1.15$ GeV) was carried out at ANKE in November 2006. The COSY beam with two flattops (1.2 GeV and 2.27 GeV) in one 'super' cycle has been used in order to higher energy. Data are currently being analysed and the first preliminary results for the two tensor analysing powers are shown in Figures 1 and 2, as a function of the momentum transfer. The solid red lines are the impulse approximation predictions, for which the input np amplitudes were taken from SAID program.

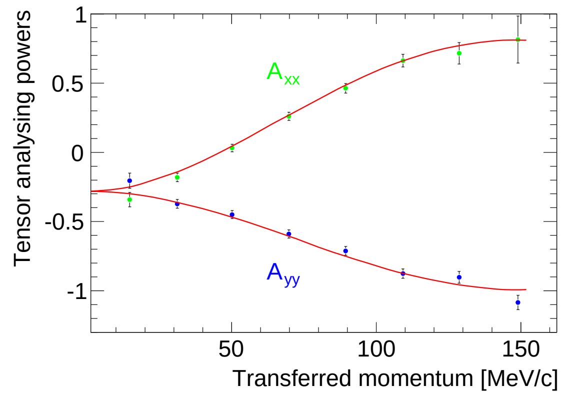

Fig. 1: Tensor analysing powers of the $dp \to \{pp\}n$ reaction at $T_d = 1.2$ GeV for $E_{pp} < 3$ MeV together with theoretical predictions.

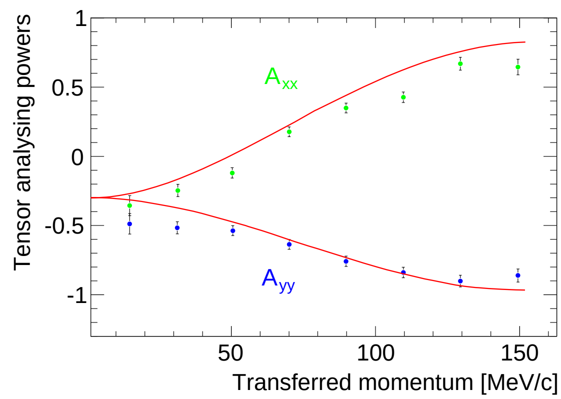

Fig. 2: Tensor analysing powers of the $dp \to \{pp\}n$ reaction at $T_d = 2.27$ GeV for $E_{pp} < 3$ MeV together with theoretical predictions.

The agreement between theory and experiment is pretty good at $T_p = 1.2$ GeV, proving the reliability and consistancy of the analyses, but it is far from the ideal description at higher energy, esspesially for low momentum transfer region. The reason of these differences could be the fact, that there is no precise np data at this energy region. Therefore, the neutron–proton amplitudes are not well known and the deviations from the curves predicted on the basis of the current SAID solutions strongly suggest that these data can contribute to the establishment of reliable np amplitudes.

References:

[1] D. Chiladze et al., Eur. Phys. J. A 40 (2009).

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