Investigation of the Three-Nucleon System Dynamics in the Deuteron-Proton Breakup Reaction

Izabela Ciepał[(a)], Barbara Kłos[(b)]

[(a)]Jagiellonian University, PL-30059 Kraków, Poland
[(b)]University of Silesia, PL-40007 Katowice, Poland

Nowadays, rigorous theoretical predictions for three-nucleon (3N) system observables can be obtained from numerically exact solutions of the Faddeev equations. The physical input to the calculations, i.e. the dominant nucleon-nucleon (NN) potential and the additional dynamics referred to as three-nucleon force (3NF), can be introduced via various approaches. One way of modeling the nuclear dynamics is a combination of phenomenological NN potentials with 3NF forces, with possible extensions to an explicit treatment of the Δ degrees of freedom (the coupled channels approach). An alternative treatment is anchored in Chiral Perturbation Theory, in which the nuclear potential is obtained in a way of a systematic expansion in terms of momentum variable.

For verification and further developments of 3NF models possibly large basis of precise data is necessary. New-generation experiments at KVI Groningen, dedicated to investigations of the $^1H(d,pp)n$ breakup reaction in a large phase space region, demonstrated importance of the Coulomb interaction in describing the breakup process dynamics, especially in the range of very small polar angles. This conclusion is consistent with the recent predictions obtained within the coupled channels approach.

Experiments devoted to study such subtle ingredients of nuclear dynamics were carried out in KVI Groningen [1,2,4,5] and FZ-Jülich [3] with the use of the $^1H(d,pp)n$ breakup reaction at 100 and 130 MeV deuteron beam energy.

The obtained high precision data of the diffrential cross sections, vector and tensor analyzing powers were confronted with the set of modern predictions what allowed to established for the first time a clear evidence of importance of the 3N forces and Coulomb component in the breakup cross sections. In case of the analyzing powers [4,5], the theories describe very well vector analyzing power data and no three-nucleon force effects were found. Tensor analyzing powers can be also quite well reproduce by calculations in most of the studied regions, hovewer locally certain discrepancies were observed [4].

Moreover, the results from the dedicated experiments at 130 MeV deuteron beam energy confirmed sizible effects of Coulomb force in the breakup differential cross sections. These data were collected for the phase-space region encompassing very small proton emission angles, where the electromagnetic component is dominant in the cross sections. For investigated vector analyzing powers in this region no dynamical effects were found [8].
Additionally, the data were confronted with the AV18+UIX [6] potential in which very recently the Coulomb interaction was succesfully implemented [7,8].

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E-mail: izabela.ciepal@uj.edu.pl