Three-Nucleon Interaction Dynamics Studied via the Deuteron-Proton Breakup

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Systems composed of three nucleons (3N) are the simplest non-trivial environment to explore details of the nucleon-nucleon (NN) potential models. In particular, the nucleon-deuteron (N-d) breakup reaction is especially well suited to study subtle effects of suppressed degrees of freedom, described by means of three-nucleon forces (3NF), as well as effects induced by the long-range Coulomb interaction and influences of relativity. With its continuum of the 3N final states, the N-d breakup process provides very rich testing ground for modern theoretical predictions, obtained via rigorous solutions of the Faddeev equations. Physical input to those calculations is taken e.g. as based on meson exchanges semi-phenomenological, realistic NN potentials combined with model 3NF, as the two- and three-nucleon interactions obtained with the explicit treatment of the Δ-isobar excitation within the coupled-channel framework or as forces obtained via Chiral Perturbation Theory methods.

Precise measurements of the breakup process are experimentally very demanding. Since the predicted effects of additional dynamics are usually small, the data set used to verify the calculations has to be very precise and possibly large. In order to fulfill these demands, a dedicated experiment has been performed at KVI Groningen, with the use of 130 MeV polarized deuteron beam and high acceptance position-sensitive detection system. It delivered a large set of exclusive, high precision cross section and analyzing power data for the ^{1}H($\vec{\text{d}}$,pp)n breakup reaction. Quality of the experimental procedures has been verified by analysis of the d-p elastic scattering [1]. Comparison of nearly 1800 breakup cross-section data points with the theoretical predictions allowed for the first time to establish a clear evidence of importance of the 3N forces in the breakup process [2]. Moreover, the results confirmed presence of sizable Coulomb force effects in this reaction [3]. About 800 data points has been analyzed for each spin observable: vector A_x, A_y and tensor A_{xx}, A_{xy}, A_{yy} analyzing powers. Theoretical predictions generally describe analyzing power data quite well and the quality of description provided by various approaches is rather similar. There are, however, configurations, where the agreement between the data and theory is not so satisfactory. These discrepancies are not always cured by inclusion of 3NF, what indicates incompleteness of the present-day treatment of the three nucleon system dynamics.

[1] E. Stephan *et al.*, Phys. Rev. C **76**, 057001 (2007).
[2] St. Kistryn *et al.*, Phys. Rev. C **72**, 044006 (2005).
[3] St. Kistryn *et al.*, Phys. Lett. B **641**, 23 (2006).

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