Precision Studies of Three-Nucleon System Dynamics: Coulomb Force Effects in the Deuteron-Proton Breakup

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A crucial step towards full understanding of nuclear interactions and structure is a proper modeling of all details of the few-nucleon system dynamics. Three-nucleon (3N) system is the simplest testing ground in which the quality of modern nucleon-nucleon (NN) interaction models can be probed quantitatively by means of rigorous technique of solving the Faddeev equations. It has been found that a proper description of the experimental data cannot be achieved with the use of NN forces alone, what indicates a necessity of including additional dynamical ingredients. Their nuclear part consists of subtle effects stemming from suppressed degrees of freedom, and is introduced as genuine three-nucleon forces (3NF). It has been recently established that also the long-neglected Coulomb force effects are very important, especially in certain regions of the 3N scattering continuum.

As an example of a thorough testing of various theoretical predictions, I discuss details of a project in which exclusive cross-section and analyzing power data for the $^1H(d_{pol},pp)n$ breakup reaction at 130 MeV deuteron energy were obtained in a broad phase-space region. Comparison of nearly 1800 cross-section data points with the predictions using nuclear interactions generated in various ways (realistic NN and 3N potentials based on semi-phenomenological meson exchanges, coupled barion channels approach, methodology of chiral perturbation theory), allowed to establish for the first time a clear evidence of importance of the 3N forces in the breakup process [1,2]. Moreover, the results confirmed predictions of sizable Coulomb force influences in this reaction [3], demonstrated even more clearly in the second stage of the project. Of a particular interest is the analysis of the combined action of both of these additional dynamical ingredients. Studies of the relativistic effects, another dynamical effect only recently introduced in the theoretical treatment of the breakup process, are under way. Investigations of a comparably rich set of polarization observables reveal much smaller influences of additional (more than just NN force) dynamics in this sector [4,5], but still indicate flaws of the existing 3NF models. Further experimental studies to resolve the persisting questions on the details of few-nucleon system dynamics are planned at various laboratories worldwide.

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