

Experimental studies of few-nucleon systems at medium energies

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Systems composed of 3 nucleons are being studied for many years by means of precise experiments. At the first stage the investigations were mainly focused on elastic deuteron-nucleon scattering, slowly extending also to systematic measurements of the deuteron breakup reaction. Medium energies, below the threshold for pion production, deserve special interest due to many reasons. On the one-hand side, it is the region where comparison with exact theoretical calculations is possible and even Chiral Perturbation Theory can be applied within the currently attainable orders. On the other side, a sensitivity to various aspects of interaction, like subtle effects of the dynamics beyond the pairwise nucleon-nucleon force, influence of the Coulomb interaction in proton-deuteron systems and relativistic effects, make the domain of medium energies interesting. All those effects vary with energy and appear with different strength in certain observables, what calls for systematic (over beam energies) investigations of possibly rich set of observables.

Developments of experimental techniques allowed recently to obtain large data sets fulfilling that demands and representing the precision sufficient for tracing subtle effects predicted by theory. Due to that progress, the database for the breakup of a deuteron in collision with a proton has been significantly enriched with differential cross section, vector (proton)-analyzing power and vector- and tensor (deuteron)-analyzing powers collected in experiments employing detection systems covering a large part of the phase space. Together with the rich set of elastic scattering data, they form the basis for understanding 3-nucleon system dynamics (see recent reviews: [1,2]). It turned out, that an apparently simple system of 3 nucleons can be still a source of surprises and, along with great success of theoretical calculations, certain problems remain, in particular related to the spin part of the interaction models.

Expecting next milestone in theory - the ab-initio calculations for 4-nucleon systems at medium energies - experimental studies of such systems have begun. So far, the comparison of quasi-free scattering in $d(d,p)d$ breakup with elastic dp scattering can be done, but much richer data sets are collected as the testing ground for future calculations.

Systematic survey of the results of experiments performed for pd and dd systems will be given, followed by a discussion of planned investigations, including a few-nucleon program at the Cyclotron Center Bronowice.

[1] N. Kalantar-Nayestanaki, E. Epelbaum, J.G. Meschendorp and A. Nogga, Rep. Prog. Phys. 75 (2012) 016301.

[2] St. Kistryn, E. Stephan, J. Phys. G: Nucl. Part. Phys. 40 (2013) 063101.

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