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Experimental tests of nuclear interaction models in few-nucleon systems

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Systems of three nucleons can serve as a validation tool for the modern approaches to describe nuclear interaction. At the first stage the investigations were mainly focused on elastic nucleon-deuteron scattering, slowly extending to systematic measurements of the deuteron breakup reaction [1,2,3]. Intermediate energies, below the threshold for pion production, deserve special attention: it is the region where comparison with exact theoretical calculations is possible, while the sensitivity to various aspects of interaction, like subtle effects of the dynamics beyond the pairwise nucleon-nucleon force, Coulomb interaction between protons, or relativistic effects, is significant. In addition to differential cross section, the observables related to nuclear polarization are studied, like vector and tensor analyzing powers, spin-correlation coefficients or polarization transfer coefficients. All these effects vary with energy and appear with different strength in certain observables and phase space regions, what calls for systematic investigations of a possibly rich set of observables determined in a wide range of energies. Recently, the data base for the reaction of deuteron breakup in collision with proton has been significantly enriched in the domain of medium energies. High precision experimental data for cross section, vector (proton) analyzing power and vector and tensor (deuteron) analyzing powers were collected with detection systems covering large part of the phase space of the 1H(d,pp)n and 2H(p,pp)n reactions. Usage of the multidetector systems with significant solid angle coverage provides not only very rich data sets but also good opportunities for controlling consistency of the results. The experimental results are compared with the theoretical predictions, in which the full dynamics of the three-nucleon (3N) system is obtained in different ways: Realistic nucleon-nucleon (NN) potentials are combined with model 3N forces or with an effective 3N interaction resulting from the explicit treatment of the Δ-isobar excitation. Alternatively, the chiral perturbation theory approach is used: At the next-to-next-to-leading order with all relevant NN and 3N contributions taken into account, while at the next order (N3LO) without taking into account the corresponding 3NF contributions. The next step in complication of the system are studies of reactions involving 4 nucleons - more sensitive, as expected, to subtle dynamics beyond the pairwise interaction. A survey of recent and planned experiments in the 3- and 4-nucleon systems will be given.

References

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