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Extraction of nn-scattering length in nd-breakup reaction at neutron energy of 10-80 MeV

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One of the main few-body reactions, in which data on *nn*-interaction are obtained, is the *nd*-breakup reaction $n + {}^2\mathrm{H} \longrightarrow n + n + p$. However, the data on main *nn* interaction parameter - *nn* scattering length, extracted from this reaction at different energies, have a large scatter of values that exceeds the experimental errors. In [1], it was assumed that this dispersion is related to the unaccounted contribution of 3N forces depending on the energy of primary neutrons. Moreover, at low energies, the contribution of 3N forces is relatively large, while at high energies it is negligible, and we can assume that the extracted scattering length value is independent on the 3N interaction. To verify this assumption, it is necessary to obtain data for various energies.
The advantage of RADEX channel of the Moscow Meson Factory (INR RAS) is a possibility of studying *nd*-breakup reaction in a wide range of neutron energies. Although the energy spectrum of neutrons formed in the beamstop of INR linear proton accelerator is wide and includes all energies up to the limit ones equal to the energy of the proton beam, the energy of the primary neutron may be reconstructed from the kinematics of the reaction and, thus, the data may be obtained in a wide range of primary energies.
In [2], data on *nn*-scattering length were obtained in *nd*-breakup reaction at energy of 60 MeV. In this work, the reaction was studied both at low energy ~ 10 MeV and at high one ~ 80 MeV. Two neutrons were detected in the kinematic region of FSI at neutron opening angle of $\Delta\Theta = 5^\circ$. The proton was detected in the active C_6D_6 scintillator target. The energies of secondary neutrons were determined by the time of flight, and the relative energy of the *nn*-pair was calculated for each event using the energies of two neutrons and their opening angle.
In this experimental setup, the neutron-neutron interaction in the final state manifests as a maximum in the dependence of reaction yield on the relative energy of two neutrons, the shape of which is sensitive to the scattering length a_{nn}. To determine a_{nn}, the experimental dependence of *nd*-breakup reaction yield was compared with the simulation results.

1. E.S.Konobeevski et al. // Physics of Atomic Nuclei. 2018. V. 81. P. 595.
2. E.S.Konobeevski et al. // arXiv:1911.05450 [nucl-ex].

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