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Few-Nucleon Scattering Experiment to Explore Three-Nucleon Forces

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One of the main interests of nuclear physics is to understand
the forces acting between nuclear constituents.
Importance of the three-nucleon force (3NF) in the nuclear
Hamiltonian has been studied in few-nucleon systems
as well as in many-nucleon systems [1–3].

Nucleon–deuteron (Nd) scattering,
the three-nucleon ($3N$) scattering system,
offers a good opportunity
to study dynamical aspects of 3NFs, which are momentum,
spin and isospin dependent, since it provides
not only cross sections but also a variety of spin observables
at different incident nucleon energies.
Direct comparison between the experimental data
and the rigorous numerical calculations in term of Faddeev theory
based on the realistic bare nuclear potentials
provides information on 3NFs.
Indeed, the last two decades have witnessed the extensive experimental
and theoretical investigations of the Nd scattering performed
in a wide range of incoming nucleon energies up to 300 MeV/nucleon.

The four-nucleon ($4N$) systems could also play an
important role in the study of 3NFs.
3NF effects are expected to be sizable in the $4N$ system.
In addition,
while the Nd scattering is essentially a pure isospin $T = 1/2$
state, tests of the $T = 3/2$ channel in any 3NFs can
be performed in a $4N$ system such as proton-^{3}He scattering.
In recent years, there has been a large progress in
solving $4N$ scattering problem with realistic Hamiltonian
even above four-nucleon breakup threshold energies [4],
which opens up new possibilities of approaching to
properties of 3NFs.

With the aim of exploring the 3NFs
experimental programs of deuteron–proton scattering
as well as proton–^{3}¥$rmHe$ scattering
using the polarized beam and target systems
are in progress at RIKEN, RCNP, and CYRIC in Japan.
In the conference, we introduce recently conducted experiments
and present the results of comparison between the
experimental data and the theoretical predictions
based on the realistic bare nuclear potentials.
Parts of the results are published in Refs.[5,6].

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