# Three Nucleon Force Study via *dp* Breakup Reaction at Intermediate Energies

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A main interest of nuclear physics is to understand the forces acting between nuclear constituents. Few nucleon systems offer good opportunities to investigate these forces. A recent topic of present day few-nucleon system studies is to explore the properties of three-nucleon forces (3NFs) acting in systems with more than A=2 nucleons. Indication of 3NF for the three-nucleon scattering was first pointed out in the cross section minima for nucleon-deuteron (*N*d) elastic scattering at intermediate energies ($E/A \sim 100$ MeV) by Witala *et al.*[1] in 1998. Since then experimental studies of elastic proton-deuteron (*pd*) and neutron-deuteron (*nd*) scattering at intermediate energies have been performed intensively at RIKEN, RCNP, KVI and IUCF[2] and provided precise data of cross sections and various spin observables. Cross section data for elastic *pd* scattering have shown large disagreement between data and rigorous Faddeev calculations with modern NN forces. Combination of these NN forces and 2π-exchange type 3NFs removes this discrepancy and leads to a good description of the measured cross sections. However spin observables are not always explained by addition of the 3NFs. Indeed, elastic *Nd* scattering shows the ability of 3NF study at the intermediate energies. In complete breakup ($d+p \rightarrow p+p+n$) experiments, the situation might be more interesting since they cover different kinematic conditions. Also the total cross sections of *Nd* breakup reactions have been predicted to be larger than the elastic ones as the incident nucleon energy increases[3], and then it is considered that 3NF effects would be more strongly enhanced in the breakup reactions than elastic ones at the intermediate energies. Therefore we have extended the measurement to *dp* breakup reactions to access further spin parts of three nucleon forces. The measurement we have made are focused on the polarization transfer coefficients $K_{yy}^{y'}$ and deuteron analyzing powers for the specific coplanar configurations in $^1$H(*d*,*pp*)n reaction at 135 MeV/A at the angles of the emerging two protons ($\theta_1$ = 28° -32° , $\theta_2$ = 31° , $\phi_1 - \phi_2$ = 180° ). For these configurations large three nucleon force effects are theoretically predicated[4]. the experiment was performed at the RIKEN Accelerator Research Facility. The vector and tensor polarized deuteron beams at 135 MeV/A bombarded a liquid hydrogen target. The two emerging protons ($p_1$,$p_2$) were detected in coincidence to determine the *dp* breakup events. The $p_1$ was momentum analyzed by the magnetic spectrograph SMART and its polarizations were measured with the focal plane polarimeter EPOL. The $p_2$ was detected by the *dE-E* counters consisting of plastic and NaI(Tl) scintillators installed in a scattering chamber. The kinetic energies were covered from 160MeV-180MeV for the $p_1$ and 40MeV-80MeV for the $p_2$, respectively. In the presentation the measured observables will be presented together with recent Faddeev calculations with/without various 3NFs.

**References**

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