Experiment of p+^{3}He elastic scattering at 100 MeV

A. Watanabe[1], S. Nakai[1], K. Sekiguchi[1], M. Inoue[1], K. Miki[1], D. Sakai[1], S. Shibuya[1], Y. Utsuki[1], K. Hatanaka[2], H. Kanda[2], H. J. Ong[2], D. T. Tran[2], S. Goto[3], Y. Hirai[3], D. Inomoto[3], H. Kasahara[3], S. Mitsumoto[3], H. Oshiro[3], T. Wakasa[3], Y. Maeda[4], K. Nonaka[4], H. Sakai[5], T. Wakui[6], and T. Ino[7]

[1]*Department of Physics, Tohoku University, 980-8578, Japan*

[2]*Research Center for Nuclear Physics(RCNP), Osaka University, Ibaraki, 567-0047, Japan*

[3]*Department of Physics, Kyushu University, Fukuoka, 819-0395, Japan*

[4]*Faculty of Engineering, University of Miyazaki, Miyazaki, 889-2192, Japan*

[5]*RIKEN Nishina Center, Wako, 351-0198, Japan*

[6]*National Institute of Radiological Sciences, Chiba, 263-8555, Japan*

[7]*High Energy Accelerator Research Organization (KEK), Ibaraki, 305-0801, Japan*

Study of three–nucleon forces (3NFs) is essentially important in clarifying nuclear phenomena, e.g. discrete states of nuclei and equation of state of nuclear matter. Few–nucleon scattering offers good opportunities to investigate dynamical aspects of these forces, such as momentum, spin, and iso-spin dependencies. The nucleon–deuteron scattering has provided a solid basis to nail down detailed properties of 3NFs [1]), however, the total isospin channel of the 3NFs is limited to $T = 1/2$. Recently importance of the iso-spin dependence study of 3NFs have been pronounced for understanding of nuclear system with larger-isospin asymmetry, e.g. neutron-rich nuclei, neutron matter, and neutron stars [2]. The p+^{3}He scattering is an attractive probe since this system is the simplest one where the 3NFs in the channels of total isospin $T = 3/2$ can be studied. In order to explore the properties of three–nucleon forces via proton-^{3}He scattering we have performed the measurements of ^{3}He analyzing powers at 100 MeV by using the polarized proton beam and the polarized ^{3}He target.

In the polarized ^{3}He target system alkali-hybrid spin-exchange optical pumping method is adopted for polarizing ^{3}He nucleus [3]. The Rb atoms are optically pumped and polarized and they in turn transfer their polarization to the K atoms. Spin exchange collisions among Rb, K, and ^{3}He atoms transfer the polarization to ^{3}He through hyper-fine interactions [4]. The target cell consists of double chamber which includes the target chamber and the optical pumping one. Both are connected by a thin transfer tube. This is designed to separate the target chamber from the optical pumping one which needs external oven to produce RbK vapor. The target cell contains the ^{3}He gas with pressure of 3 atm at room temperature together with a small amount of N_2 gas and RbK vapor. The pumping chamber is heated to about 493 K to provide high RbK vapor density and maintain the polarization of ^{3}He nucleus. Circularly polarized photons with power of 50 W are used to optically pump Rb atoms. Polarized ^{3}He nuclei are allowed to diffuse into the target chamber. The target cell is made of GE180 glass which is known to have a very long relaxation time for the polarization of ^{3}He. The polarizations are monitored by the adiabatic fast passage (AFP) NMR method. The NMR signals give relative values of the polarization. The absolute values of the target polarization are calibrated by using frequency shift of the electron spin resonance of Rb atoms. Typical values of the target polarization are 50%.

Experiments with 100 MeV polarized proton beams in conjunction with the polarized ^{3}He target were performed at the ENN course. Figure 1 shows the schematic view of the experimental setup. Polarized proton beam bombarded the polarized ^{3}He target and it was stopped in the faraday cup. Beam intensities were about 30 nA during the experiment. Beam polarization was measured by using the beam-line polarimeter. Polarimetry was made by using the *pp* elastic scattering. The polarization of the proton beam was 40–50% during the experiment. Scattered protons were detected by the *dE-E* scintillation counters. They consisted of a plastic scintillator with thickness of 0.5–2 mm and a NaI(Tl) scintillator with thickness of 55 mm. The measured observables were the proton analyzing power A_y^p, the ^{3}He analyzing power $A_y^{^3\mathrm{He}}$, and the spin correlation coefficient C_{yy}. The measured angles were 45–135 degrees in the laboratory system which are equivalent to 47–149 degrees in the center of mass system. In the measurement we successfully obtained asymmetry of the events from proton-^{3}He elastic scattering. The data analysis is in progress now.

References

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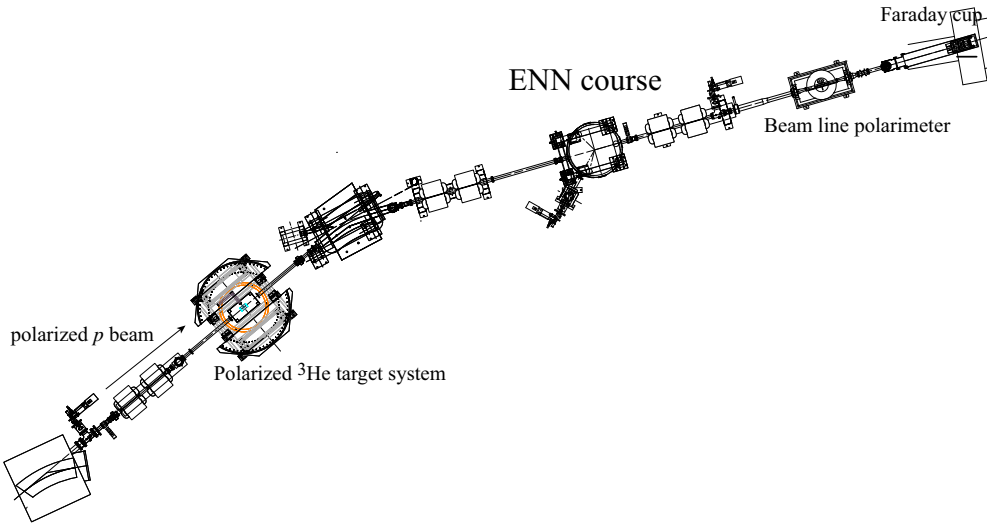

Figure 1: Schematic view of the experimental setup.