Measurement of the Analyzing Power for the $\vec{\mathrm{p}}+^{6}$He Elastic Scattering at 71 MeV/u

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Scattering experiments making use of radioactive ion (RI) beams have expanded the scope of nuclear physics to nuclei far from the stability line. A plenty of new phenomena which are characteristic for unstable nuclei have been discovered such as neutron skin and change of the shell structure. On the other hand, direct reactions induced by polarized protons have revealed various aspects of nuclear structure and reaction mechanisms in the study of stable nuclei. It is naturally expected that polarized protons play a central role also in the study of unstable nuclei and provide a valuable information through polarization observables. Because of this, a polarized solid proton target for RI beam experiments has been constructed at Center for Nuclear Study, University of Tokyo [1,2]. This target has a unique capability of operating under a modest condition of $B = 0.1\ T$ and $T = 100\ K$, which is realized by the use of an electron alignment in photo-excited triplet states of aromatic molecules. This advantageous operating condition makes the target applicable to RI beam experiments.

Making use of the polarized solid proton target, the vector analyzing power was measured for the $\vec{p}+^{6}$He elastic scattering at 71 MeV/u. Aims of the measurement are (a) to determine the spin-orbit potential between a proton and a ^{6}He particle from the analyzing power and then (b) to discuss the effectiveness of microscopic theories from the viewpoint of polarization phenomena in weekly bound systems. It is also expected that polarization observables provide new information on the neutron skin structure of a ^{6}He particle because the spin-orbit interaction is sensitive to the surface structure of nuclei. The experiment was carried out using RIKEN Projectile-fragment Separator (RIPS) at RIKEN Accelerator Research Facility (RARF). A ^{6}He beam was produced through a projectile fragmentation of a ^{12}C beam penetrating a Be target. The energy and the typical intensity of the ^{6}He beam were 71 MeV/u and 250 kcps, respectively. The average and the maximum polarization of the target were 13.8% and 20.4%, respectively. Scattered ^{6}He particles and recoiled protons were detected and identified. The elastic scattering events were selected by requiring the conditions of kinematical consistency. The analyzing power was then deduced from the left/right asymmetry of the scattering.

The measured analyzing power exhibits a significant discrepancy with the predictions of microscopic models based on the g-matrix theory [3]. This indicates the inadequacy of the conventional microscopic models in the description of polarization phenomena involving light unstable nuclei which have weakly bound neutrons. The spin-orbit potential of $\vec{p}+^{6}$He elastic scattering was determined by the phenomenological optical potential analysis of the analyzing power and the differential cross section. All the parameters of the spin-orbit potential were deduced and compared with those of stable nuclei and a global optical potential. We found the indication that the ^{6}He has a relatively shallow and widely extended spin-orbit potential.

[1] T. Uesaka et al., "Polarized Proton Target for RI Beam Experiments", *contribution to this conference.*
[2] T. Wakui et al., Nucl. Instr. and Meth. A **550**, 521 (2005)
[3] D. Gupta et al., Nucl. Phys. A **674**, 77 (2000)