Study of the Spin Dependent ^{3}He-Nucleus Interaction at 450MeV

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Interaction between complex nuclei is most fundamental subjects in nuclear physics and many studies have been performed both experimentally and theoretically. The spin dependence of the nucleus-nucleus interaction is of special interest because it closly related to the nuclear strucure and reaction mechanism as well as to the spin dependence of the interaction between constituent particles.

The spin dependence in proton-nucleus and deuteron-nucleus interaction has been well understood through the experiments using polarized beams owing to developments of polarized ion sources and sophisticated polarization monitors. For deuterons, it has been shown with the method of continuum-discretized coupled-channels(CDCC) that the virtual breakup of the deuteron plays an important role at both vector and tensor parts of the interaction [1]. However the the spin dependent interaction for heavier projectile nuclei is less understood due to a lack of experimental data using polarized beams, except for low-energy data; for t(E_{lab} ≤17MeV), ^{3}He(E_{lab} =33 MeV) and ^{6,7}Li(E_{lab} ≤70 MeV). Thus for the first approach at intermediate energies, it is strongly demanded to measure the polarization observables of ^{3}He-nucleus collisions in order to understand the spin dependent part of interaction and reaction mechanisms.

The advantage of studying the spin dependent interaction between ^{3}He and nuclei is that reaction mechanism is simple. Projectile breakup may not have a large effect on the elastic scattering compared with more loosely bound incident particles like deuteron and ^{6}Li for which proper accounts of the breakup effects are essential to understand their interactions with target nuclei. And microscopic calculations based on the single-folding(SF) and the double-folding(DF) models predict the large effects of the spin-orbit component on the cross secitons and analysing powers for ^{3}He-Nucleus elastic scattering at intermediate energy [2], while such effects are very small at low energy.

Motivated by such a scientific background, we performed the measurement of cross sections and analyzing powers of ^{3}He elastic scattering from ^{58}Ni at $T_{^{3}\mathrm{He}}$=450MeV(RCNP-E157). The experiment has performed at RCNP with the spectrometer Grand Raiden and its Focal Plane Polarimeter system. Angular range covered from 5° to 16° in the center of mass system. Analyzing powers were measured by the double scattering method. Calorie meter which is consist of the plastic scintillator's of 1.5+5+5cm thichness was installed to measure the energy of the secondary scattered ^{3}He by the analyzer target.

At first we measured the absolute value of the polarization for ^{3}He+^{12}C elastic scattering at θ_{lab}=7°, where DF-model calculation predict the maximum value of the polarization, using double scattering method. 2nd level trigger was used to reject the events with small second scattering angles. Preliminary value of the polarization is

$$p = 0.540 \pm 0.035.$$

The systematical error due to the geometrical asymmetry was estimated to be less than 1% by measurement with an faint beam at 0°. Next, FPP system was calibrated with the mesured absolute value of the polarization. The preliminary value of the effective analyzing power $< A_y >$ was obtained as

$$< A_y > = 0.172 \pm 0.026$$

with a plastic scintillator whose thickness was 8mm for the analyzer. The angular integration was performed within the polar angle of $4^\circ \leq \theta \leq 12^\circ$ and the azimuthal angle of $|\phi| \leq 60^\circ$ for the scattering angles off analyzer target. The efficiency was 5×10^{-4}.

Fig. 1 shows the preliminary result of the angular distribution of the cross sections and analyzing powers for the ^{3}He elastic scattering off ^{58}Ni nuclei. The experimental results shows the large values of the polarizations at the angles of local minimam values of the cross sections. Solid line shows the phenomenological optical model calculations with central and spin-orbit potentials. Each optical potential parameters are shown in the Table 1. In the parameter search the real part of the volume integral per nucleon (J'_R) and the spin-orbit radius ($r_{\mathrm{S.O.}}$) was fixed to the value for the protons at 150MeV and the value at the low energy ($T_{^3\mathrm{He}}$=33MeV), respectively. The calculation result suggests the large effect of the spin-orbit potential to the analyzing powers.

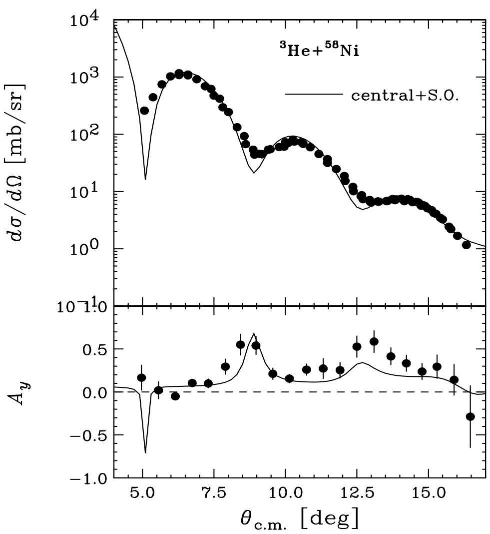

Fig. 1: The differential cross sections of the elastic scattering of ^{3}He by ^{58}Ni at $T_{^3\mathrm{He}}$=450MeV. The lines are the results of the phenomenological optical model.

V_{R}(MeV)	r_{R}(fm)	a_{R}(fm)	J'_{R}(MeV·fm^3)
19.0	1.51	0.597	150
W_{I}(MeV)	r_{I}(fm)	a_{I}(fm)	J'_{I}(MeV·fm^3)
15.7	1.33	0.699	92.8
$V_{\mathrm{S.O.}}$(MeV)	$r_{\mathrm{S.O.}}$(fm)	$a_{\mathrm{S.O.}}$(fm)	χ^2/N_{data}
0.35	1.110	0.8	10.0

Table 1: Parameters obtained by the minimum χ^2 search for the optical model analysis.

References

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