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Measurement of spin correlation coefficients in p–^{3}He scattering at 65 MeV

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Abstract

We performed the experiment of p–^{3}He scattering at 65 MeV by using polarized proton beams and the newly constructed polarized ^{3}He target. The proton analyzing power A_y, the ^{3}He analyzing power A_y^{T}, and the spin correlation coefficient C_{yy} were measured. In the conference, the experimental data were compared with the rigorous numerical calculations based on various nuclear potentials. Large discrepancies between the experimental data and the calculations were found in the A_y^{T} and the C_{yy} at the backward angles.

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1 Introduction

One of the important topics of nuclear physics is to understand the nuclear forces. We especially focus on the three–nuclear force (3NF). 3NFs appear in systems with more than two nucleons. Importance of 3NFs has been indicated in various nuclear phenomena, such as few nucleon scattering [1], binding energies of nuclei [2] and equation of state of nuclear matter [3]. In order to study the dynamical aspects of 3NFs, such as momentum, spin and isospin dependencies, a few nucleon scattering system is one attractive probe.

For exploring the properties of 3NFs, we extensively performed the nucleon–deuteron scattering at intermediate enegies (65–300 MeV/nucleon) [4, 5]. Results of comparison between the experimental data and the rigorous numerical calculations show clear signatures of 3NFs in the cross section. However, the total isospin of N–d scattering system is limited to $T = 1/2$. To investigate the $T = 3/2$ channel of 3NFs, we have extended the study to proton–^{3}He (p–^{3}He) elastic scattering at intermediate energies. Here we report the measurement of the analyzing powers (A_y and A_y^{T}) and the spin correlation coefficient C_{yy} in p–^{3}He scattering at 65 MeV.

2 Experiments

The experiment was performed at the Research Center for Nuclear Physics (RCNP) cyclotron facility, Osaka University in Japan. Polarized proton beams were provided by a polarized ion source and they were transported to the experiment hall. Measurement of p–^{3}He elastic scattering was conducted at the ENN course. Schematic view of the experimental setup for p–^{3}He elastic scattering is shown in Figure 1. Polarized proton beams bombarded the newly

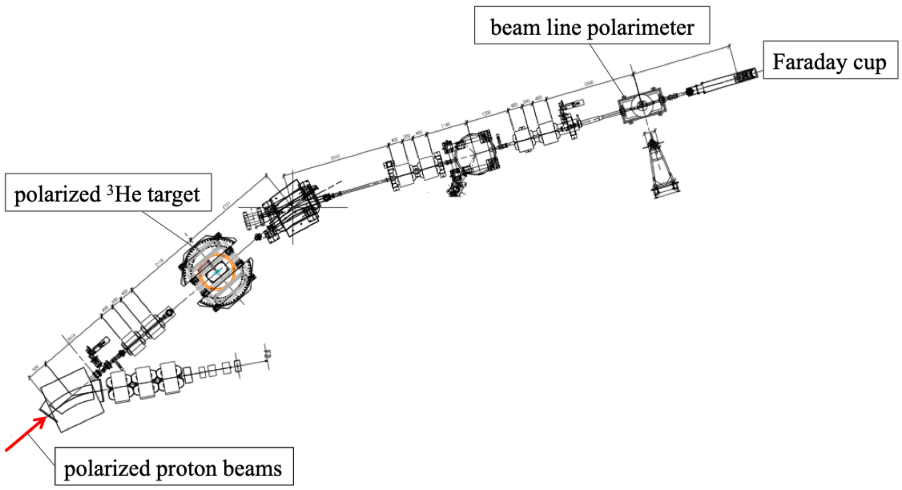

Figure 1: Schematic view of the experimental setup for p–^{3}He scattering at the ENN course, RCNP.

constructed polarized ^{3}He target [6]. Then, the proton beams were refocused onto a CD_2 thin-film target in a beam line polarimeter. Subsequently, they were stopped in the Faraday cup which was installed in the wall of the ENN course. Typical beam intensities were 10 nA. Elastically scattered protons from the polarized ^{3}He target were detected by ΔE–E detectors which consisted of plastic and NaI(Tl) scintillators. The detectors were placed symmetrically in left and right directions. Measured angles were $\theta_{\mathrm{Lab}} = 35°, 70°, 115°$($\theta_{\mathrm{C.M.}} = 47°, 89°, 133°$). During the experiment, the direction of the spin axis for the polarized ^{3}He target was flipped and the relative values of the polarization was monitored by the adiabatic fast passage-NMR (AFP-NMR) method. The absolute value of the target polarization was calibrated by the electron paramagnetic resonance (EPR) method [7]. Typical value of the target polarization was 40 %. The beam polarization was monitored by a beam line polarimeter. The polarimetry was made by the known analyzing powers in p–d elastic scattering [8]. The CD_2 thin-film with the thickness of 14.8 mg/cm^2 was used as a deuterium target. Scattered protons and recoiled deuterons were detected by plastic scintillators in kinematical coincidence conditions. The typical beam polarizations were $p_y^{\uparrow} \sim 50\%$ and $p_y^{\downarrow} \sim 20\%$.

3 Results

Figure 2 shows preliminary results of the proton analyzing power A_y, the ^{3}He analyzing power A_y^{T} and the spin correlation coefficient C_{yy} as a function of the scattering angle in the center of mass system. Open circles show the experimental data. The statistical uncertainties are shown only. Red squares in the figure are the data taken in the different experiment [9]. The A_y data have a good agreement to those measured in Ref. [9]. In the conference, the obtained data were compared with the calculations based on various nuclear potentials, namely AV18 [10], INOY [11], SMS51 [12], SMS53 [12], CD Bonn [13] and CD Bonn+Δ [13], [14]. The calculations are not shown here. The A_y data had a moderate agreement to the calculations. Meanwhile, large discrepancies were found in the A_y^{T} data and the C_{yy} data at the backward two angles.

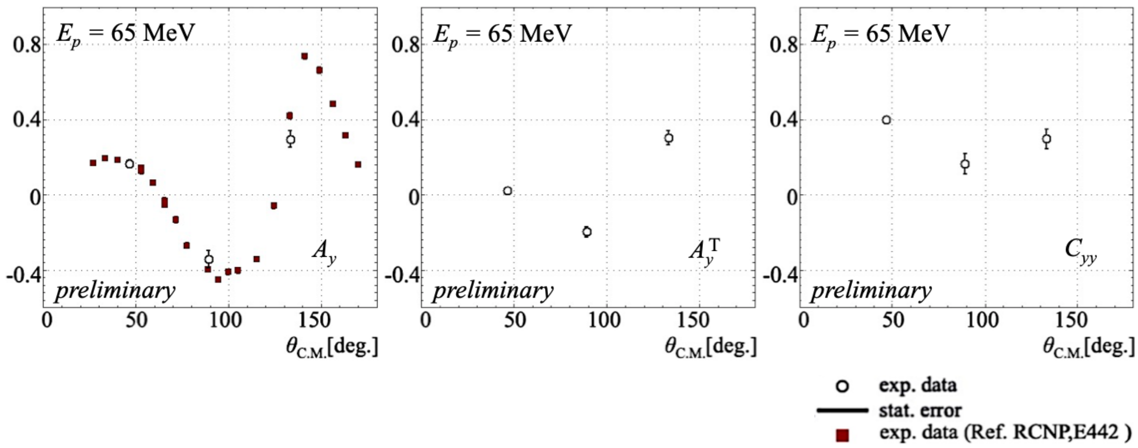

Figure 2: Results of the proton analyzing power A_y, the ^{3}He analyzing power A_y^{T} and the spin correlation coefficient C_{yy} for p–^{3}He elastic scattering at 65 MeV.

4 Summary and Outlook

We have measured p–^{3}He scattering at 65 MeV by using polarized proton beams and the polarized ^{3}He target. Measured angles were $\theta_{\mathrm{Lab}} = 35°, 70°, 115°$($\theta_{\mathrm{C.M.}} = 47°, 89°, 133°$). By comparing the experimental data with the rigorous numerical calculations based on various nucleon potentials, clear discrepancies were found at the backward angles in the ^{3}He analyzing power A_y^{T} and the spin correlation coefficient C_{yy}. The discrepancies between the data and the rigorous numerical calculations could be accounted for by 3NFs.

In order to perform quantitative discussions on 3NF effects in p–^{3}He elastic scattering, we are planning the measurement of a complete set of spin correlation coefficients in a wide angular range.

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