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1.5 Analyzing Power Measurements for Neutron Elastic Scattering from ^{14}N

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The angular distributions of analyzing power $A_y(\theta)$ for neutron elastic scattering from ^{14}N have been measured from 5 to 17 MeV. The initial reason for studying this element was a need for nitrogen data to correct earlier analyzing power data obtained for ^6Li. In the latter measurement the ^6Li sample was slightly contaminated with nitrogen and the neutron elastic scattering peaks from Li and N were not resolved from each other at the forward angles in the time-of-flight spectra. In order to get several complete distributions of $A_y(\theta)$ for theoretical analyses of neutron scattering from N, backward angles were studied for the nitrogen scatterer.

Davé and Gould[1] (DG) tried to apply the optical model to describe neutron elastic scattering from 1-p shell nuclei. Their parameter sets indicate that the spherical optical model is a physically reasonable way of describing the main features of neutron elastic scattering from most 1-p shell nuclei, although the fits are not as good as those seen for heavier nuclei. However, DG did not use any polarization data and fixed the spin-orbit parameters to standard values for lack of analyzing power data. The present $A_y(\theta)$ data should be useful for obtaining the optimum potential parameters, especially for the spin-orbit terms.

The experiments have been carried out at the neutron time-of-flight facility of the TUNL tandem Van de Graaff laboratory. The primary polarized neutron beam is produced in the $^2H(\vec{d},\vec{n})$reaction. The scattering sample is liquid Hydrazine, N_2H_4, which is enclosed in a stainless steel can. The scattered neutrons are detected in two heavily-shielded liquid scintillators, which are symmetrically located at equal scattering angles on opposite sides of the beam axis.

Fairly complete angular distributions have been measured at 10, 12, 14 and 17 MeV. The angular range is from 20° to 159° in the laboratory system. For the 5 to 9 MeV region only data at forward angles have been obtained. At these lower energies there is strong, overlapping resonance behavior in the $n+^{14}N$ system, as seen in the total cross section curves. Our measurements were not detailed enough to permit us to obtain resonance information about the system. Furthermore, we did not attempt to fit these lower energy data with an optical model.

The measured values have been corrected for finite geometry and multiple scattering effects using Monte Carlo simulation. Spherical optical model fits have been made to the cross section data of Templon et al.[2] and our new analyzing power data using a modified version of the computer program GENOA. The results of the fits are shown in Fig. 1. The points are the experimental data, the present calculations are shown as the solid lines and the dashed lines are from the parameters of DG. The present fits describe the data better than the predictions which use the DG model. The present parametrization is compared in Table 1 to the DG parametrization. The real well depths V for both sets decrease with energy, as is conventional with heavier nuclei, although the fall off with energy is only about 30% as large as normal. Our imaginary well depths increase with energy at a rate which is much closer to the global model of DG, rather than their model specific to ^{14}N. Unlike the procedure followed by DG, we felt free to search upon the spin-orbit parameters, since they are constrained by the new polarization data. During the process we found that the addition of an imaginary spin-orbit term improved the fits to $A_y(\theta)$, especially at 12 and 14 MeV. The sign and magnitude of W_{so} is similar to that demanded by our data for ^9Be, ^{40}Ca (see ref. 3 and 4) and for some heavier nuclei[5] for energies around 10 to 14 MeV. Both the strength and radius of the real part of the spin-orbit potential are about 10% smaller than those for heavier nuclei, and the unusually small diffuseness now seems to be a feature typical of light nuclei.

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Table 1. Spherical optical model parameters for neutron elastic scattering from ^{14}N. The potential with Woods-Saxon form has real volume term, surface derivative imaginary term, and Thomas form spin-orbit terms.

	V	r_V	a_V	W_D
Present	53.98-0.100E	1.158	0.664	2.88+0.261E
DG[1]	50.54-0.006E	1.209	0.573	12.07+0.703E
Global for 1-p shell nuclei	45.14-0.020E	1.508-0.0133A	0.5	11.32+0.237E

	γ_D	a_d	V_{so}	r_{so}	a_{so}	W_{so}	r_{wso}	a_{wso}
Present	1.418	0.311	4.9	1.02	0.434	1.146	1.149	0.5
DG[1]	1.415	0.105	5.5	1.15	0.5			
Global for 1-p shell nuclei	1.353	0.200	5.5	1.15	0.5			

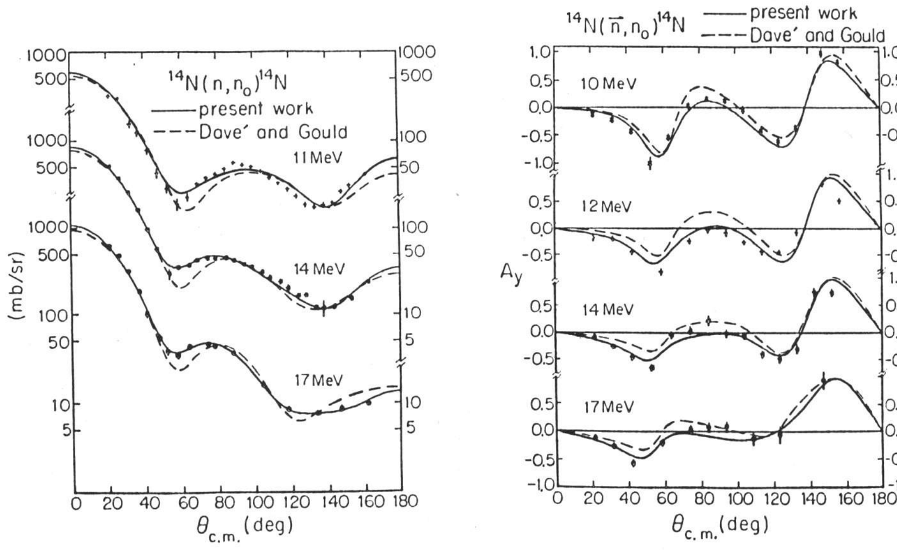

Fig. 1. Neutron elastic scattering angular distributions of cross sections and analyzing powers compared to SOM fits based on the parameters of Table 1.

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