Proc. Sixth Int. Symp. Polar. Phenom. in Nucl. Phys., Osaka, 1985
J. Phys. Soc. Jpn. 55 (1986) Suppl. p. 556-557

1.1 Measurements of $A_y(\theta)$ for Neutron and Proton Elastic Scattering from ^{6}Li between 5 and 17 MeV Compared to Resonating Group Calculations

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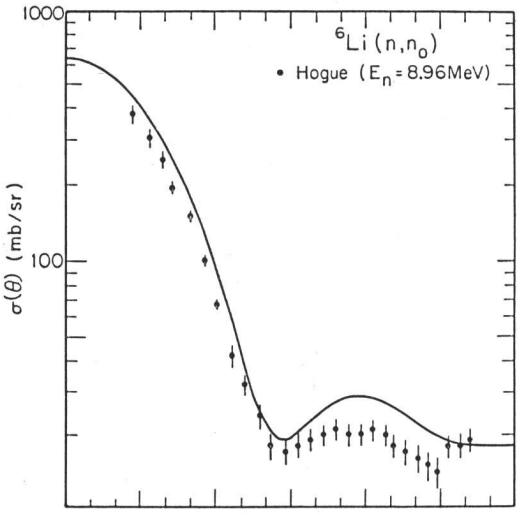
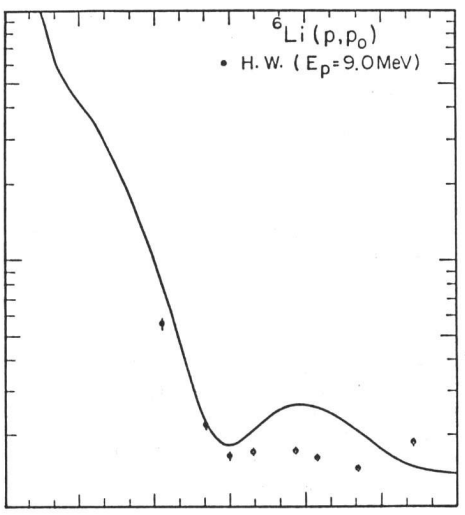
Previously, there were no neutron and very little proton elastic scattering analyzing power data available at low energies for comparison with resonating group calculations being performed for ^{6}Li. Since this observable is particularly sensitive to details of the reaction mechanism, we have performed measurements at TUNL of $A_y(\theta)$ for ^{6}Li($\vec{n}$,n) throughout the angular range of 20° to 159°, at 9 energies from 5 to 17 MeV. A pulsed deuteron beam from the TUNL Lamb-shift polarized ion source was accelerated by the tandem Van de Graaff and directed into a deuterium gas cell to produce a pulsed polarized neutron beam via the D($\vec{d}$,$\vec{n}$)^{3}He reaction[1]. This neutron beam was scattered from a ^{6}Li sample contained in an aluminum can. Time-of-flight (TOF) was measured from the target to two organic scintillator detectors, placed symmetrically about the beam axis to eliminate instrumental asymmetries. Separate TOF spectra were obtained for an identical empty can and subtracted from the ^{6}Li spectra. Nitrogen and oxygen contaminants of approximately 8% each were present in the lithium sample. Independent measurements of elastic scattering analyzing powers were made for N and O[2], and it was determined that corrections to the ^{6}Li data were very small. The data have been corrected for finite geometry and multiple scattering effects using the code JANE.

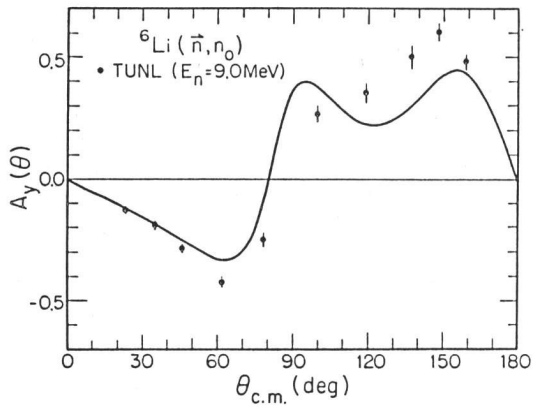
In addition, we have obtained $A_y(\theta)$ data for ^{6}Li($\vec{p}$,p) in 10° steps from 20° to 165° at 12 energies from 5 to 17 MeV. For this measurement the proton beam was scattered from a 180 μg/cm^2 thick ^{6}Li layer supported by a 44 μg/cm^2 thick Al foil backing and into 4 pairs of symmetrically placed surface-barrier detectors 2000 μm thick. These data are not in final form yet, however.

Recent microscopic multi-channel resonating group calculations[3,4] indicated the possible existence of a low-lying $7/2^+$ resonance. It was demonstrated[3,4] that the analyzing power, but not the cross section, of ^{6}Li(n,n) depended sensitively on this resonance for 4 to 7 MeV neutrons. To corroborate the prediction of new levels in ^{7}Li and to better understand the reaction mechanism in a wider energy range, we performed an extended calculation[5] in which not only ^{4}He+^{3}H, ^{6}Li+n and ^{5}He+d structures were taken into account[3,4] but also the T=1 excited states of ^{6}Li and ^{6}He+p structures. Almost all results found in Ref. 3 were improved in the new calculation, e.g., the elastic scattering cross sections for ^{4}He+^{3}H and ^{6}Li+n (see Fig. 1) and the analyzing power for ^{4}He+^{3}H. However, the previous $7/2^+$ resonance became so broad that one might not call it a resonance any more. Hence, it no longer influences the neutron analyzing power. In addition, by trying to reproduce all thresholds better, the new ^{6}Li wave function gives a root-mean-square radius 10% too large, leading to a coupling of the ^{6}Li+n to the ^{5}He+d negative parity channels that is too strong. Through interference these negative parity matrix elements produce the bump in the analyzing power near 90° (see Fig. 1), thus destroying the previous agreement[3,4]. However, in preliminary calculations just completed, we found that by using a ^{6}Li wave function with the correct r.m.s. radius, the bump (shown in Fig. 1) disappears. The analyses herein demonstrate once more the necessity of polarization data to reveal a reaction mechanism in detail.

We acknowledge the support of the U.S. Department of Energy, Director of Energy Research, Office of High Energy and Nuclear Physics, under contract No. DE-AC05-76ER01067 and the support of the U.S. National Science Foundation under P.L.-480 for one of us (I.S.) to participate in the measurements.







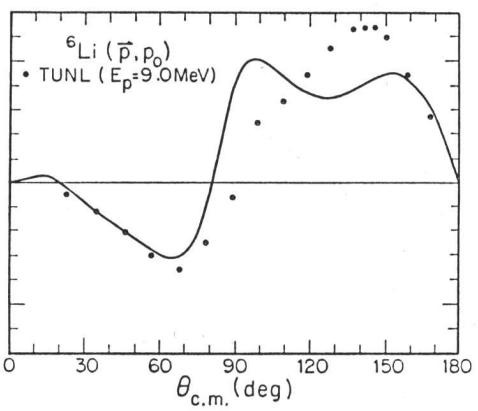


Fig. 1a. Data and resonating group calculations at E_n= 9.08 MeV for ^{6}Li(n,n$_o$). The σ(θ) data are from Ref. 6.

Fig. 1b. Data and resonating group calculations at E_p= 8.72 MeV for ^{6}Li(p,p$_o$). The σ(θ) data are from Ref. 7.

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