MEASUREMENTS OF THE (n,p) REACTION AT IUCF

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In this report we present preliminary results for the angular distribution of the $^6Li(n,p)^6He$ cross section measured between Θ_{cm} = 0° and 22° at E_n = 118 MeV.

It has been well known for some time that, in conjunction with (γ,X), (e,e'), (p,p'), ($\pi^\pm$,γ) and ($\pi^\pm,\pi^0$) reactions, (p,n) and (n,p) measurements at intermediate energies can be used to isolate isovector from isoscalar transitions in the study of giant resonances and sping-flip states.[1] Whereas the sharp isospin selectivity of the (n,p) reaction makes it a unique tool in studies of N > Z nuclei, for self-conjugate targets the (n,p) transitions are expected to mirror the (p,n) transitions faithfully. Thus, being an N = Z nucleus with a known large ground-state (p,n) cross section,[2] ^6Li emerged as a natural choice for the initial (n,p) measurements with the new IUCF facility. This experimental setup is described in a companion paper in this annual report.

The $^6Li(n,p)$ measurements reported here cover six angles: Θ_{lab} = 0°, 5°, 7.5°, 10°, 12.5° and 17.5°, taken in two settings of the proton deflection magnet (B ≅ 0.7 T and B = 0). In addition, at each setting the $^1H(n,p)n$ elastic scattering cross section was measured to provide an absolute normalization of the neutron flux as well as a direct calibration of the acceptance for each individual telescope. The proton energy resolution in the experiment (typically ~2.3 MeV FWHM) was dominated by the thicknesses of the production target and the (n,p) target (290 mg/cm^2 for ^7Li and 462 mg/cm^2 for ^6Li), since the intrinsic energy resolution of each individual HPGe detector (~60 keV) is much smaller than the target energy loss contributions.

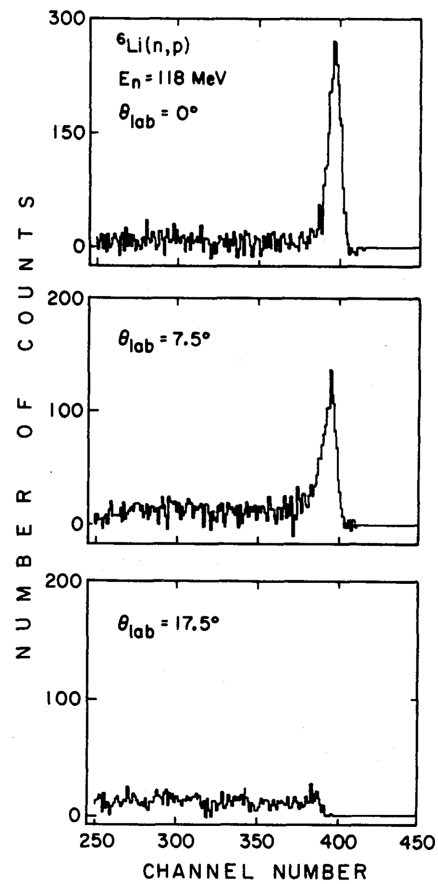

Figure 1. Background-subtracted spectra of the $^6Li(n,p)^6He$ reaction measured at Θ_{lab} = 0°, 7.5° and 17.5°, with E_n = 118 MeV. Vertical scales are approximately normalized to integrated proton beam charge.

Figure 1 shows $^6Li(n,p)$ spectra measured at 0°, 7.5° and 17.5° (Θ_{cm} ≅ 0°, 9° and 21°, respectively).

At forward angles the ground-state transition is a pure Gamow-Teller excitation and, as expected, its cross section is strongly forward-peaked. The continuum has a different, much less pronounced dependence on Θ, and remains relatively featureless throughout the angular range covered.

The ground-state peaks in Fig. 2 are broadened by contributions from the 1.80 MeV 2† state in ^{6}He which lies at the limit of our experimental energy resolution. At 0° this contribution is negligible due to the different nature of the two transitions; however, around Θ_{cm} = 20° the 2+ state may be excited with comparable strength to that of the ground state, as has been observed in ^{6}Li(p,n) measurements at 120 MeV.[3] Thus, in each spectrum, the two overlapping

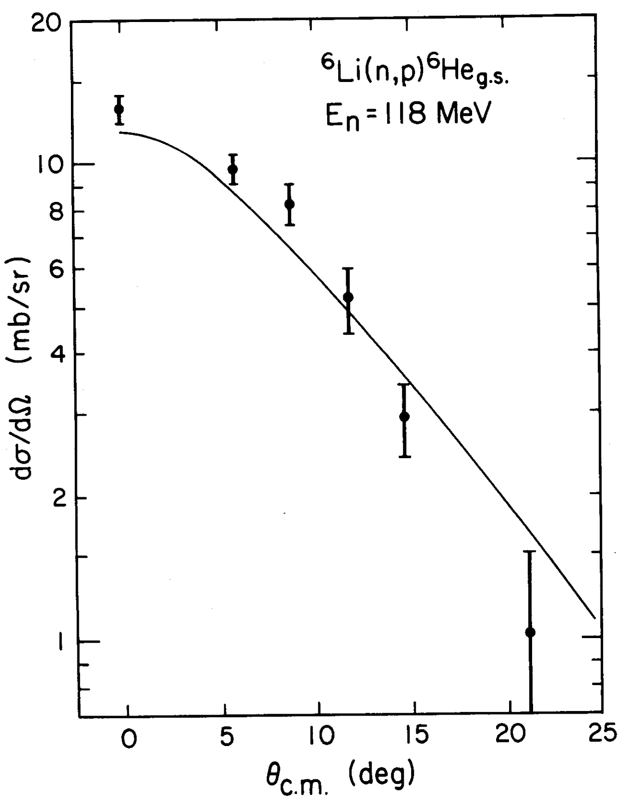

Figure 2. Measured angular distribution of the ^{6}Li(n,p)^{6}He$_{g.s.}$ reaction compared with results of a distorted wave calculation (solid line); for details see text.

peaks must be unfolded through a two-line fitting procedure involving appropriate lineshapes deduced from CH_2 measurements. The results presented below must be regarded as preliminary since the lineshape-unfolding procedure was applied only in an approximate manner.

The angular distribution of the preliminary ^{6}Li(n,p) ground-state cross section is plotted in Fig. 2 along with results of a distorted-wave calculation (solid curve). The calculation was performed using the DW81 code[4] with N-N effective interaction t-matrix from Franey and Love,[5] optical-potential parameters from Meyer et al.[6] and the L-S coupling transition strengths from Lee and Kurath.[7] The large error bars on the data, particularly at larger angles, reflect the uncertainty of the ground-state peak unfolding procedure in addition to the usual sources of experimental error.

At 0° the measured cross section $\sigma(0°)$ = 13.0±0.7 mb/sr exceeds the calculated by ~10%. A similar discrepancy between experimental cross section and distorted-wave calculation was observed by Moake et al. for ^{6}Li(p,n) at 144 MeV.[2] Our measured 0° cross section is, however, in very good agreement with that of ^{6}Li(p,n) at both 120 and 144 MeV. Table I summarizes these results. At larger angles, however, the experimental angular distribution appears to have a

Table I. Comparison of zero-degree cross sections for ^{6}Li(n,p) and (p,n) reactions between 100 and 150 MeV.

Reaction	Projectile energy (MeV)	dσ/dΩ(0°) (mb/sr)	Reference
^{6}Li(n,p)	118	13.0±0.7	Present work.
^{6}Li(p,n)	144	13.1	Ref. 2
^{6}Li(p,n)	120	12.0±1.5	Ref. 3

steeper slope than the calculation and falls below the calculated curve around 13°.

Finally, using the well known relation between 0° cross section, reduced Gamow-Teller matrix element and the strength of the spin-isospin interaction term, we obtain

$$v_{\sigma\tau} = 172 \pm 5 \text{ MeV fm}^3$$

somewhat higher than the 155 MeV fm^3 theoretical value of Love at 100 MeV.[8]

Besides ^6Li, measurements of (n,p) cross sections have also been performed on ^7Li and ^{13}C targets. Experience with these targets indicates that further improvement of the neutron beam purity and of the background rejection would be needed for measurements of medium and heavy targets with smaller cross sections.

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