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THE (d,^{6}Li) REACTION STUDIES

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We are beginning a study of the (d,^{6}Li) reaction with vector polarized deuterons at the IUCF. Several interesting features of the vector analyzing powers are predicted by DWBA reaction calculations. Firstly, the VAP is expected to exhibit much more sensitivity to the transferred angular momentum, L_{Tr}, than do the differential cross sections. Thus, it is hoped that the VAP will provide considerably more definitive spectroscopic information than can be obtained from the cross sections alone. Secondly, this sensitivity of the VAP to L_{Tr} should provide the possibility of accurate determinations of L_{Tr}-mixing in (d,^{6}Li) reactions on odd A targets. These features provide the motivation for the ($\vec{d}$,^{6}Li) studies on ^{39}K and ^{40}Ca.

In addition, the DWBA calculations suggest that the VAP is, for some nuclei, quite sensitive to the spin-orbit term of the ^{6}Li distorting potential. While this is not the case for ^{39}K and ^{40}Ca targets, this sensitivity does appear for fp shell targets. We therefore plan to examine ($\vec{d}$,^{6}Li) data on Ni targets, both in the hope of producing some systematic data on alpha clustering states, and of determining the ^{6}Li spin-orbit potential.

STUDY OF TWO-PROTON PICKUP USING THE (^{6}Li,^{8}B) REACTION

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A considerable body of experimental data has been obtained from reactions which transfer two identical nucleons - reactions such as (p,t), (t,p), and (^{3}He,n).

Almost no data are available, however, from reactions which pickup two protons from a target. We have studied one such reaction, the (^{6}Li,^{8}B) two-proton pickup reaction, on nine even targets ranging from ^{56}Fe to ^{130}Te. Some of these results, principally on targets in the tin region, were presented in the 1978 IUCF Progress Report.[1]

Using a ^{6}Li bombarding energy of 90 MeV, we have measured lab cross sections at 8^o for ground-state transitions which have ranged from 27 μb/sr for a ^{66}Zn target to 0.3 μb/sr for ^{130}Te.

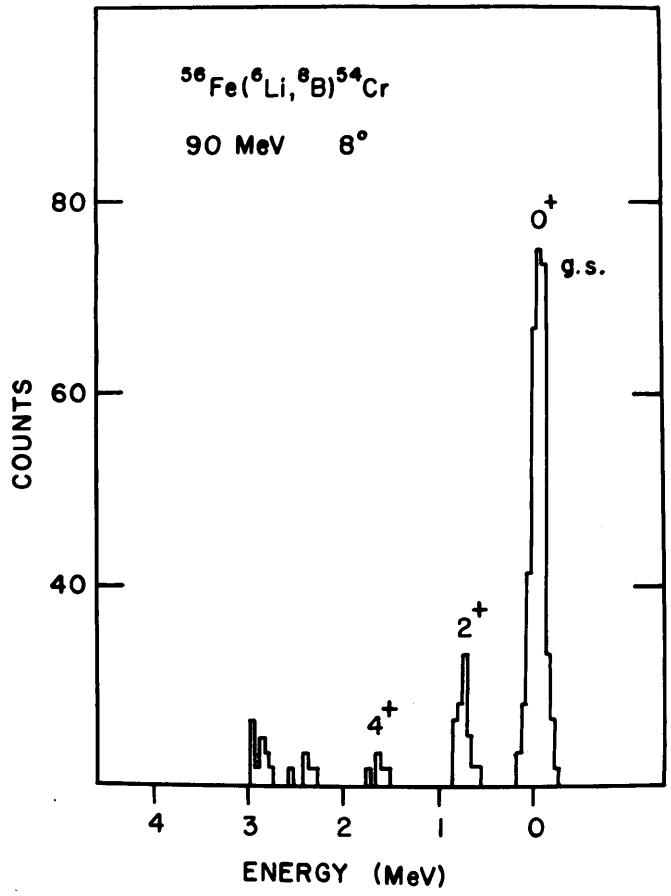

Figure 1. Spectrum at 8° lab from the $^{56}Fe(^{6}Li,^{8}B)^{54}Cr$ reaction at 90 MeV. The lab cross section for the g.s. transition is 18 μb/sr.

The spectrum in Fig. 1, obtained with an ^{56}Fe target and leading to states in ^{54}Cr, is typical of many of the spectra we have measured. The spectrum is dominated by the transition to the ground state; transitions to excited states are, by comparison, relatively weak. In multiple proton pickup reactions, such as this one, the energy resolution is often dominated by the energy loss of the ejectile in the target. The ^{56}Fe target used to obtain this spectrum had a thickness of 400 μg/cm^2 and the energy resolution is approximately 200 keV. The lab cross section for the ground state transition is 18 μb/sr.

We have measured spectra, which are shown in Fig. 2, on Mo targets leading to ^{96}Zr and ^{92}Zr. It is immediately apparent that the two spectra are quite dissimilar. In ^{96}Zr the transition to the first excited 0^+ state at 1.59 MeV is as strong as the transition to the ground state, while in ^{92}Zr the transition to the 0^+ state at 1.38 MeV is much weaker than the ground-state transition. This is contrary to the naive expectation that the proton configurations in these isotopes would be approximately the same, and hence the two-proton pickup spectra would be similar.

To provide a theoretical prediction of the $0^+ \rightarrow 0^+$ transition strengths observed for the two molybdenum targets, we have carried out exact finite-range dis-

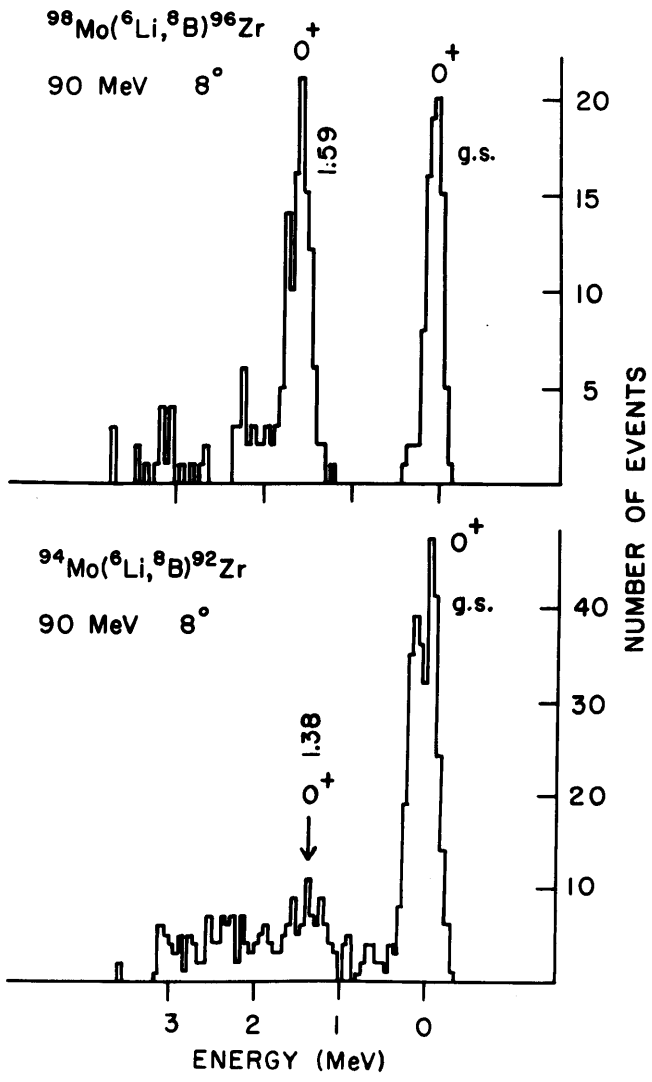

Figure 2. Spectra at 8° lab from the $^{94,98}Mo(^{6}Li,^{8}B)^{92,96}Zr$ reactions at 90 MeV. Note the lack of relative excited 0^+ strength in ^{92}Zr as compared to that in ^{96}Zr.

torted-wave Born approximation (EFR DWBA) calculations using the code DWUCK5.[2] The form factors were calculated in the cluster approximation. We have assumed that the reaction proceeds only via the pickup of a T=1 pair in a singlet spin state. The entrance channel optical parameters were obtained from an analysis of 99 MeV ^{6}Li ions elastically scattered from ^{90}Zr.[3] Data from ^{8}B elastic scattering are not available as ^{8}B is unstable, hence parameters from the elastic scattering of ^{11}B from ^{208}Pb at 72 MeV[4] were substituted.

Using the EFR DWBA code, the ratio of cross sections to the first excited 0^+ state and the ground state were calculated for both ^{96}Zr and ^{92}Zr. These ratios, of course, depend sensitively on the choice of spectroscopic amplitudes for the (Mo,Zr) pair, which were calculated assuming the proton configurations shown in Table I.

With these assumed proton configurations and taking into account the statistical accuracy of the data (5-8%), there is essentially complete agreement between experiment and calculation for the two cross section ratios. The results are displayed in Table II.

Table I. Spectroscopic amplitudes for the (Mo,Zr) pair in the (^{6}Li,^{8}B) reaction were based on the following assumed proton configurations:

$$\Psi(\mathrm{Mo})_{gs} = (p_{1/2})^2\,(g_{9/2})^2$$

$$^{96}\mathrm{Zr}: \quad \Psi(gs) = \sqrt{90\%}\,(p_{1/2})^2 + \sqrt{10\%}\,(g_{9/2})^2$$

$$\Psi(0_2^+) = \sqrt{10\%}\,(p_{1/2})^2 - \sqrt{90\%}\,(g_{9/2})^2$$

$$^{92}\mathrm{Zr}: \quad \Psi(gs) = \sqrt{50\%}\,(p_{1/2})^2 + \sqrt{50\%}\,(g_{9/2})^2$$

$$\Psi(0_2^+) = \sqrt{50\%}\,(p_{1/2})^2 - \sqrt{50\%}\,(g_{9/2})^2$$

Table II. Ratio of the cross sections to the first excited 0^+ state and ground state, for the (^{6}Li,^{8}B) reaction leading to ^{92}Zr and ^{96}Zr.

Residual Nucleus	$\sigma(0_2^+)/\sigma(gs)$ Experimental Ratio	Calculated Ratio
^{96}Zr	1.1	1.2
^{92}Zr	0.21	0.17

Our Zr data explain an apparent discrepancy noted in some recently published (d,^{6}Li) results.[5] A group at Groningen, in a study of (d,^{6}Li) on four even targets of molybdenum leading to final states in zirconium, observed an unusually strong excitation of the first excited 0^+ state in ^{96}Zr. In a semi-microscopic description, the structure amplitude for α-transfer can be factored into a two-neutron and a two-proton part. Thus for α-pickup on a chain of isotopes, one might expect the relative strength to correlate with that of two-neutron pickup to the same final states, the protons acting as "spectators". The α-pickup strengths, however, do not correlate with the two-neutron strengths from the Zr(p,t) reaction. The explanation for the behavior of the Groningen (d,^{6}Li) date is provided by our (^{6}Li,^{8}B) results, which demonstrate that differences in the Zr proton configurations are responsible for the unexpected variations in the excited 0^+ transition strengths.

1) IUCF Annual Report (1978), p. 79

2) P.D. Kunz, Program DWUCK5, unpublished.

3) P. Schwandt et al., IUCF Annual Report (1978), p. 93.

4) J.L.C. Ford et al., Phys. Rev. C 10, 1429 (1974).

5) A. Saha, G.D. Jones, L.W. Put, and R.H. Siemssen, Phys. Lett. 82B, 208 (1979).