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STUDY OF THE (^{6}Li,^{8}B) REACTION IN THE Zr REGION

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Using the 90-MeV ^{6}Li beam at IUCF, we have studied the reactions ^{92,94,96,98,100}Mo(^{6}Li,^{8}B)^{90,92,94,96,98}Zr and also the reactions ^{90,92,94}Zr(^{6}Li,^{8}B)^{88,90,92}Sr. These investigations had a twofold objective, first to study two-proton configurations in the Zr region and, second to examine the usefulness of the (^{6}Li,^{8}B) reaction as a spectroscopic tool.

The ^{8}B ions were momentum analyzed by the IUCF QDDM magnetic spectrograph and detected by a gridded ionization chamber[1]. Spectra were recorded at $\theta_{lab} = 8°$ for all targets. Because ^{7}B and ^{9}B are proton unstable, ^{8}B is particularly easy to identify in a detector of this type and was well separated from other ion species in the E-ΔE spectra.

The experimental results obtained from bombardments of the Mo targets are shown in Fig. 1. Focusing attention on the $0^+ \rightarrow 0^+$ transitions to the ground states (g.s.) and the first excited 0^+ states ($0^+{}_2$) in Zr, one immediately notices a pronounced dissimilarity between the ^{96,98}Zr spectra and the spectra of the three lighter-mass isotopes. For instance, in ^{98}Zr the $0^+{}_2$ transition is twice as intense as that to the g.s., while in ^{90}Zr the reverse is true with the $0^+{}_2$ transition having only a quarter of the g.s. strength.

The explanation for this variation in $0^+{}_2$ strength relative to that of the g.s. can be traced to changes in the Zr proton configurations with neutron number. To provide a theoretical prediction of the $0^+ \rightarrow 0^+$ transition strengths observed for the five Mo targets, we have carried out exact finite-range distorted-wave Born approximation (EFR DWBA) calculations using the code DWUCK5[2]. The calculation assumes the reaction consists of a direct, one-step cluster transfer of a T=1, S=0 proton pair. The code was used to calculate the ratio of the cross sections for the $0^+{}_2$ states to those of the ground states for each of the five Zr isotopes. The proton configuration of the Zr ground states was assumed to be of the form $\alpha(p_{1/2})^2 + \beta(g_{9/2})^2$. The $0^+{}_2$ states were taken to be the orthogonal states $\beta(p_{1/2})^2 - \alpha(g_{9/2})^2$. The neutrons were assumed to be inert. Except for ^{98}Zr, where they were adjusted to yield exact agreement with experiment, the amplitudes α and β used in the EFR DWBA calculations were the same as those determined from single-proton pickup[3] and stripping[4] data and are based on averages of the experimentally obtained values given in Table 13 of Ref. 4.

A comparison of the calculated and experimental ratios is given in Table 1, where it can be seen that the agreement is quite good. This suggests that the Zr wave function amplitudes and the simple reaction model we have used are basically correct.

The results obtained from the three Zr targets are

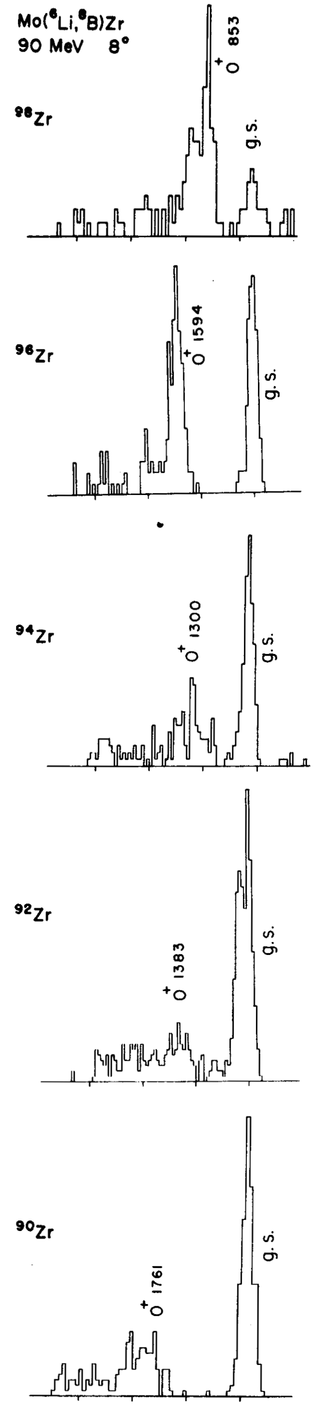

Figure 1. Spectra at 8° lab from the Mo(^{6}Li,^{8}B)Zr reaction at 90 MeV. Note the relatively intense transitions to the first excited 0^+ states in ^{96,98}Zr.

displayed in Fig. 2 and tabulated in Table 2. These spectra are distinctly different from the (Mo/Zr) spectra in that the prominent transitions to excited 0^+ states have been replaced by $0^+ \rightarrow 2^+$ transitions. The transition strength to the excited 2^+ in ^{88}Sr is comparable to that of the g.s., in contrast to the much weaker 2^+ transitions in ^{90,92}Sr. This may be attributable in part to the N=50 closed-shell neutron configuration in ^{88}Sr which could reduce the mixing of the 2^+ proton strength with 2^+ neutron states.

A manuscript describing these results in detail is nearing completion. A comparison of $0^+ \rightarrow 0^+$ transitions in ^{92}Zr and ^{96}Zr has been published[5] earlier.

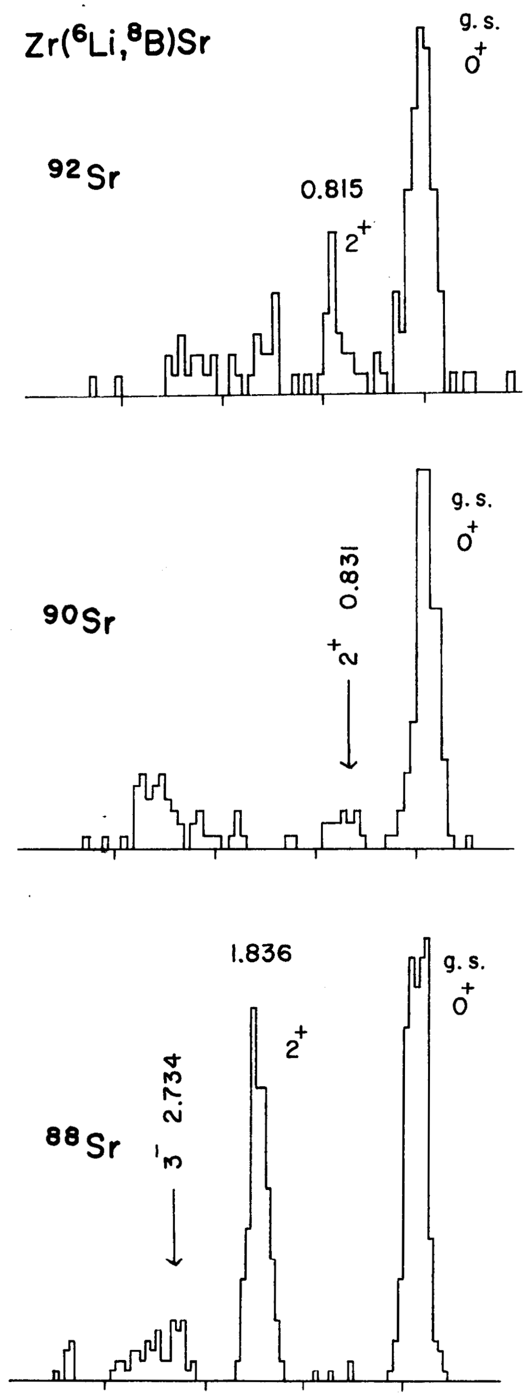

Figure 2. Spectra at 8° lab from the Zr(^{6}Li,^{8}B) Sr reactions at 90 MeV. Note the lack of excited 0^+ strength in Sr as compared to that in Zr.

Table 1. Transitions to 0^+ states in Zr

Target nucleus	final nucleus	Excitation[a] (MeV)	$\sigma_{cm}(8.6°)$ (mb/sr)	α,β[b]	$\sigma(0^+_2)/\sigma_{g.s.}$[c]	$\sigma(0^+_2)/\sigma_{g.s.}$[d]
^{100}Mo	^{98}Zr	0.0 0.853	1.61 3.35	0.98, 0.20	2.1	2.1
^{98}Mo	^{96}Zr	0.0 1.594	5.63 5.43	0.95, 0.32	0.96	1.22
^{96}Mo	^{94}Zr	0.0 1.300	9.59 2.33	0.81, 0.59	0.24	0.35
^{94}Mo	^{92}Zr	0.0 1.383	19.9 4.08	0.71, 0.71	0.21	0.17
^{92}Mo	^{90}Zr	0.0 1.761	24.7 6.31	0.77, 0.64	0.26	0.32

a) Excitation energies quoted in this work were taken from published sources.

b) Amplitudes in the Zr g.s. wave function used in the DWBA calculations.

c) Experimentally determined ratio of transition strengths.

d) Calculated ratio of transition strengths.

Table 2. Transitions to states in Sr

Target nucleus	Final nucleus	Excitation[a] (MeV)	J^π	$\sigma_{cm}(8.6°)$ (mb/sr)
^{94}Zr	^{92}Sr	0.0 0.815	0^+ 2^+	7.32 2.28
^{92}Zr	^{90}Sr	0.0 0.832	0^+ 2^+	15.1 1.78
^{90}Zr	^{88}Sr	0.0 1.836	0^+ 2^+	22.1 14.1

a) Excitation energies quoted in this work were taken from published sources.

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