STUDY OF THE $^{93}$Nb + $^{7}$Li REACTIONS WITH APPLICATION TO DOUBLE CHARGE EXCHANGE AND POSSIBLE PRODUCTION OF NEW NEUTRON-RICH NUCLEI.

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This investigation began with dual motivations, one based on nuclear reactions and the other on nuclear spectroscopy. It was hoped that with the use of a neutron-rich projectile, such as $^{7}$Li, and selected neutron-rich targets it might become possible to produce an array of new exotic neutron-rich nuclei. In our study the reaction would involve at least a double charge exchange between the target and projectile or perhaps a multiple exchange of nucleons. Knowledge of the mass distributions and excitation functions would enable one to distinguish between the two mechanisms. Indeed, a radiochemical measurement of the mass distribution removed by Z=2 from the target could be used to study two-proton transfer, three nucleon transfer, and possible double charge exchange processes.

Initial work was done at the Brookhaven 3-stage Tandem accelerator where $^{7}$Li ions could be accelerated to a maximum of 60 MeV. The cross sections for the $^{93}$Nb($^{7}$Li,5pxn)$^{93-xn}$Y reactions were measured at energies of 52.8 MeV and 57.6 MeV by Nb foil irradiations followed by radiochemical separations and γ-ray spectroscopy. Possible interferences from small amounts of elemental impurities were carefully investigated and ruled out. At IUCF, the same procedures were followed and the radiochemical yields of the Y and Sr isotopes were measured at 90.7 MeV. Preliminary results of these investigations are shown in Fig. 1 where the yield of yttrium isotopes is plotted. Clearly the two-proton transfer from the target dominates the mass yield producing $^{91}$Y and lower mass Y isotopes through

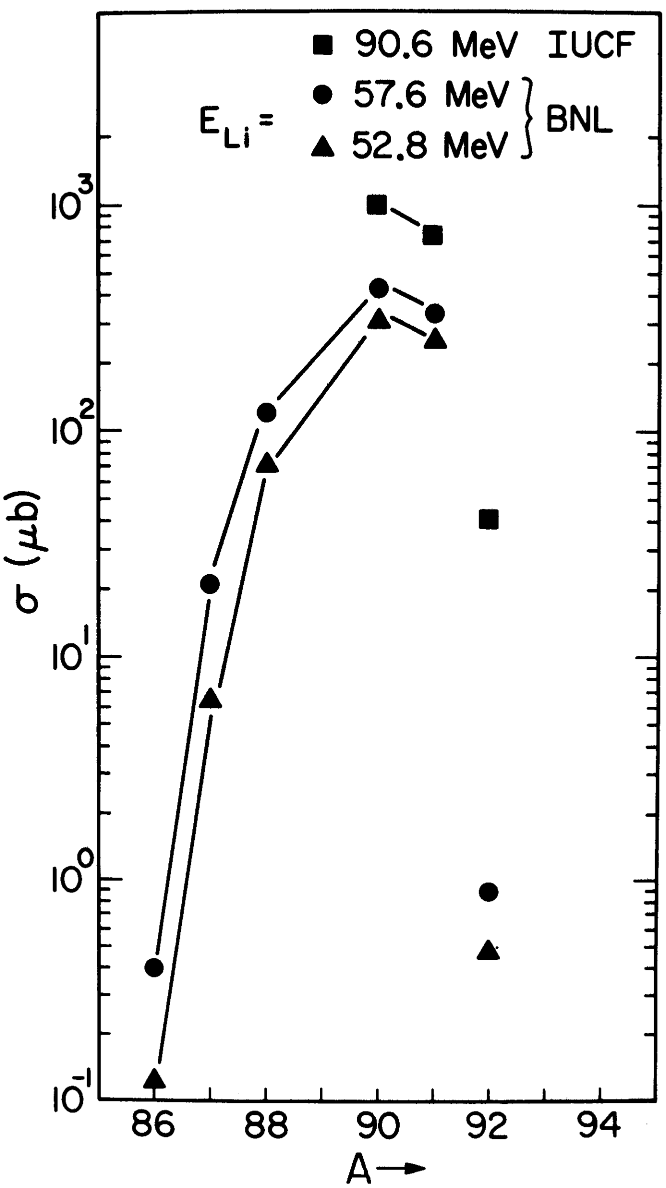


*Figure 1. Total radiochemical cross sections for the production of yttrium isotopes in the $^{93}$Nb+$^{7}$Li reaction at intermediate energies.*

neutron channels. As noted by Gray, Tickle and Bent[1] the two proton pick-up in the Zr region using the ($^6Li,^8B$) reaction is useful in studying the proton configurations of the ground state and first excited $0^+$ states. They assume a simple direct, single-step cluster transfer and have calculated the cross sections using a finite range DWBA code. They find good agreement between calculation and experiment for two-proton transfer to the specific states. Our data represent inclusive total cross sections for two-proton transfer to all bound and neutron unstable states of $^{91}Y$. Although the α-transfer reaction is possible it is not expected to contribute greatly to the Y isotope production.

The most interesting feature of the data in Fig. 1 is the steeply rising excitation function of $^{92}Y$ corresponding to the ($^7Li,^8B$) reaction or two-proton transfer from the target in conjunction with one neutron pick-up to the target. A second possible mechanism could be the double charge exchange (DCE) reaction (pp → nn) with subsequent neutron emissions. Further analysis of the data is required before we can estimate the yield of $^{93}Y$, the DCE product.

Further work is planned at lower energies, in particular at about 60 and 75 MeV, in order to obtain a consistent set of data between the BNL and IUCF results. Later, when higher energy $^7Li$ beams become available ($E_{Li}$ > 100 MeV), we hope to observe a marked increase in the cross sections of the very neutron rich Y isotopes.

1) R.S. Tickle, W.S. Gray and R.D. Bent, "Studies in the Zr Region using the ($^6Li,^8B$) Two proton Pick-up Reaction." IUCF Report 121 (1979). Also see this annual report.

## SEARCH FOR 3p-3h STATES IN THE A=12 AND 16 SYSTEMS WITH THE ($^6Li$,t) AND ($^6Li$, $^3He$) REACTIONS

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There has been a great deal of interest, both experimental and theoretical, in the location of three particle-three hole (3p-3h) states in $^{12}C$-$^{12}B$ and $^{16}O$-$^{16}N$. We started to search for these states with the ($^6Li$,t) and ($^6Li,^3He$) reactions on $^9Be$ and $^{13}C$ at 99 MeV bombarding energy. Due to the momentum mismatch between the entrance and exit channels and due to the geometrical coefficients in the structure amplitude, the transfer of a $(d_{5/2})^3_{J=13/2}$ cluster is favored. Hence, final states with a configuration of $[(\text{target})_J \otimes (d_{5/2})^3_{J=13/2}]$ are expected to be strongly excited.

Figure 1 shows spectra of the $^{13}C(^6Li,t)^{16}O$ and $^{13}C(^6Li,^3He)^{16}N$ reactions. States in $^{16}O$ at 6.13, 11.25, 14.40, 14.80, 20.80 and 24.80 MeV and states in $^{16}N$ at 7.65, 9.81, 11.21, 11.81 and 14.00 MeV are the most strongly populated. Analog pairs of states in $^{16}N$-$^{16}O$ are clearly seen.

A simple weak-coupling calculation using the method of Bansal-French-Zamick[1,2] predicts the centroid of the 3p-3h states with T=0 in $^{16}O$ of the form $^{13}C(1/2^-,\text{g.s.}) \otimes {}^{19}F(13/2^+,4.6)$ at around 15 MeV and those with T=1 at around 20.5 MeV. This is approximately what is observed. The state at 20.80 MeV has a counterpart in $^{16}N$ and therefore should have very likely T=1, whereas the states at 14.40 and 14.80 MeV have