STUDY OF THE $^{12}$C($^7$Li,$t$)$^{16}$O $\alpha$-TRANSFER REACTION AT HIGH ENERGIES

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A study of $^{12}$C($^7$Li,$t$)$^{16}$O at $E(^7$Li) = 101 MeV was completed at IUCF using two Si $\Delta E$ detectors backed by thick intrinsic Ge $E$ detectors. Also, $\alpha$-particles were observed in coincidence at back angles to identify decay from high spin states in $^{16}$O. This utilized a 600 mm$^2$ Si $E$ detector with time-of-flight used for identification.

In addition to the well-known levels at $E_x < 20$ MeV, we may have observed new levels at $E_x > 20$ MeV to 30 MeV and possibly some at $E_x > 30$ MeV (see Figure 1). The analysis of the coincidence $\alpha$-particle decay data from specific levels has just begun.

A related high-resolution study of $^{12}$C($^7$Li,$t$) for the region in $^{16}$O, $E_x < 10$ MeV was started at NSCL (MSU) using $E(^7$Li) = 80 MeV with the $k = 320$ spectrometer. An initial run resolved both the 7.12/6.92 MeV 1$^-$/2$^+$ doublet and the 9.6 MeV 1$^-$level in $^{16}$O which are of interest in astrophysics (helium burning). A second run is scheduled for Spring 1986. This work will be continued and may be extended to higher energies at IUCF using the new $k = 600$ spectrometer.

The high energy $^{12}$C($^7$Li,$t$)$^{16}$O data should provide new information on high-spin $\alpha$-cluster levels in $^{16}$O, $E_x > 10$ MeV. It will also permit comparisons with our earlier$^1$ data and analysis of $^{12}$C($^6$Li,$d$)$^{16}$O done at IUCF with $E(^6$Li) = 90 MeV. These data can be used to

![Figure 1. A triton energy spectrum and corresponding levels in $^{16}$O observed in $^{12}$C($^7$Li,$t$) at $E(^7$Li) = 101 MeV.](image-url)
test various α-cluster models\(^2\) of \(^{16}\)O and provide additional measurements of α-widths needed for astrophysical calculations.


**SEARCH FOR HIGH SPIN STATES IN \(^{27}\)Al AND \(^{27}\)Si**

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Previous studies\(^1\) of the \(A(p,\pi^-)A+1\) reaction have demonstrated the high selectivity of the reaction for states in the residual nucleus which are presumed to have a stretched or nearly stretched two-particle one-hole configuration with respect to the target nucleus. This feature of the \((p,\pi^-)\) reaction has been observed for both light and heavy nuclei\(^1\) and for two cases in the sd-shell: \(^{18}\)O(\(p,\pi^-\))\(^{19}\)Ne and \(^{26}\)Mg(\(p,\pi^-\))\(^{27}\)Si.\(^2\) Studies throughout the lower half of the sd-shell are in progress.\(^3\) To increase the reliability of the \((p,\pi^-)\) reaction as a spectroscopic tool in the sd-shell, it is necessary to obtain, for at least a few cases, independent evidence regarding the spin structure of the states preferentially populated in the \((p,\pi^-)\) reaction.

It has been observed that the \(^{26}\)Mg(\(p,\pi^-\))\(^{27}\)Si reaction populates selectively and strongly two excited states in \(^{27}\)Si at excitation energies of 7 MeV and 9.5 MeV. These states have been tentatively assigned \(13/2^+\) spin and parity. This is the highest spin possible if all the active nucleons are restricted to the sd-shell. Recent shell model calculations\(^4\) predict a \(13/2^+\) state in \(^{27}\)Si at an excitation energy between 7 and 8 MeV and several high spin states around 10 MeV excitation energy.

To date there is little experimental evidence for high spin states in \(^{27}\)Si besides that provided by the \((p,\pi^-)\) reaction. The \(^{27}\)Al(\(^3\)He,\(t\))\(^{27}\)Si reaction is expected to populate the presumed stretched two-particle one-hole states seen in the \(^{26}\)Mg(\(p,\pi^-\))\(^{27}\)Si reaction, and the \(^{24}\)Mg(\(a,p\))\(^{27}\)Al reaction can populate the mirror states in \(^{27}\)Al. We have studied these two reactions in order to obtain supporting evidence for the high spin assignments inferred from the \((p,\pi^-)\) reaction.

We measured the angular distributions of the \(^{24}\)Mg(\(a,p\))\(^{27}\)Al and \(^{27}\)Al(\(^3\)He,\(t\))\(^{27}\)Si reactions using the Princeton AVF (K=60) cyclotron and Quadrupole-Three Dipoles (Q3D) magnetic spectrograph. The angular distributions of the reaction \(^{26}\)Mg(\(^3\)He,\(t\))\(^{26}\)Al leading to the known \(5^+(g.s.), 0^+ (0.228 \text{ MeV}),\) and \(3^+ (0.417 \text{ MeV})\) states were also measured in order to calibrate the "L-signature" for possible high spin state transitions in the \(^{27}\)Al(\(^3\)He,\(t\))\(^{27}\)Si reaction.

The spectra obtained from the \(^{24}\)Mg(\(a,p\))\(^{27}\)Al and \(^{27}\)Al(\(^3\)He,\(t\))\(^{27}\)Si reactions at bombarding energies of