Spectroscopic study of $^{27}$Al states above the neutron threshold via the $^{26}$Mg($^3$He,d) reaction

Stephen Gillespie
Department of Physics
University of York
Outline

- Motivation
- Experimental Details
- Current Analysis
- Future Work
Motivation

- High $^{26}\text{Mg}/^{24}\text{Mg}$ ratio present in some Ca-Al-rich meteorites suggest $^{26}\text{Al}$ was present during the formation of the solar system.
- Destruction rate is controlled by the $^{26}\text{Al}(n,p)^{26}\text{Mg}$ and $^{26}\text{Al}(n,\alpha)^{23}\text{Na}$ reactions whose rates are uncertain.
- Resonances for these reactions correspond to excited states in $^{27}\text{Al}$ above the neutron threshold.
Previous Work

- $^{27}$Al(p,p')$^{27}$Al inelastic scattering experiment was performed at Orsay using the Enge Split-Pole magnetic spectrometer.
- Observed 30 new states above the neutron threshold.
- Unable to extract any other spectroscopic information.

Experimental Details

- States were populated using the $^{26}\text{Mg}(^{3}\text{He},d)^{27}\text{Al}$ transfer reaction.
- Experiment was performed at the MLL facility in Munich using the Q3D magnetic spectrometer.
- Used an enriched 20\(\mu\)g/cm\(^2\) $^{26}\text{MgO}$ target.
- Stripped cathode determines position to higher resolution than strip width.


Data was taken at 5 angles to measure differential cross section \( dW/d\Omega \).

Angle of scattered incident particle depends upon \( l \) transferred to target.

Experimental data compared to DWBA calculations to assign spin parity states.

Optical potentials used in DWBA calculated from elastic scattering data.

**DWBA Fit** $^{22}\text{Ne}(^{3}\text{He},d)^{23}\text{Na}$

Top - 10 Degree Focal Plane Spectrum, insert PID plot showing deuterons
Bottom – 10 Degree Focal Plane Spectrum deuteron gated
Top - 10 Degree Focal Plane Spectrum deuteron gated
Bottom – 20 Degree Focal Plane Spectrum deuteron gated
Top - 10 Degree Focal Plane Spectrum, insert PID plot showing protons
Bottom – 10 Degree Focal Plane Spectrum proton gated, insert $^{12}\text{C}(^{3}\text{He},p)^{14}\text{N}$ States
D. Visser nukesim-classes http://nukesim-classes.sourceforge.net/index.html
10 Degree Focal Plane Spectrum deuteron gated

\[ ^{16}\text{O}(^{3}\text{He},d) \]
\[ ^{12}\text{C}(^{3}\text{He},d) \]
\[ ^{24}\text{Mg}(^{3}\text{He},d) \]
Top - 10 Degree Fitted Focal Plane Spectrum
Bottom – Fit Residuals
Proton Spectrum from Previous study, vertical blue lines represent states seen in this work

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Proton Spectrum from Previous study, vertical blue lines represent states seen in this work

Angular Distributions

- Observed 22 States at 3 or more angles
- Cross sections have yet to be calculated

Left – Angular Distribution $E_x = 13.579\text{MeV}$
Right – Angular Distribution $E_x = 13.030\text{MeV}$
DWBA Calculations

- Theoretical angular distributions calculated using FRESCO DWBA code.
- Global optical potentials by Pang \(^{3}\text{He}\) and Daehnick \(^{2}\text{H}\) used in calculations.


Normalised FRESCO DWBA Cross section calculations \(E_x = 13.015\text{MeV}\)
Future Work

- Investigate the effectiveness of background subtraction on peak fitting
- Calculate and compare experimental cross sections to DWBA calculations
- Extract Spin-Parity states for observed levels
Collaborators

University of York - C. J. Barton, A. M. Laird, J. Riley, M. Williams
IPN-Orsay - N. de Séréville, C. Portail, I. Stefan
UPC-Barcelona - A. Parikh
TUM - T. Faestermann
CSNSM - J. Kiener
TUNL - R. Longland
$^{32}\text{S}^{(3}\text{He,d})$ peak fitted with a landau function
Peak Fitting

$^{32}\text{S}(^{3}\text{He,d})$ peak fitted with a landau function

$$\exp \left\{ \frac{-1}{2} \left( \lambda + e^{-\lambda} \right) \right\}$$

$$\lambda = \frac{x - m}{s}$$
10 Degree Fit
10 Degree Fit
10 Degree Fit