Study of $^{22}Ne(^{6}Li,t)^{25}Mg$ three particle transfer reaction using TIARA and MDM spectrometer

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Abstract

The $^{22}Ne(^{6}Li,t)^{25}Mg$ experiment was performed in inverse kinematics using a 7*A* MeV ^{22}Ne beam and ^{6}LiF target at the Texas A&M University Cyclotron Institute. To better understand (^{6}Li,*t*) three particle transfer reaction, measurements of ^{25}Mg, *t*, and gamma-rays are made in coincidence using a magnetic spectrometer, Si, and Ge detectors. By doing this, the populated states of ^{25}Mg are clearly identified thus enabling an understanding of the reaction selectivity. The angular differential cross sections are then measured to extract the spectroscopic factors. The results of this $^{22}Ne(^{6}Li,t)^{25}Mg$ analysis are compared with data from other reaction methods and theoretical calculations to improve the knowledge about the $^{22}Ne(^{6}Li,t)^{25}Mg$ reaction.

Motivation

The (^{6}Li,*t*) transfer reaction serves as a powerful tool to study ^{3}He clustering states. Furthermore, for N=Z target nuclei (^{6}Li,*t*) and (^{6}Li,^{3}He) are expected to populate mirror states [1] in the resulting recoil nuclei, due to the strong ^{3}He + ^{3}H clustering property of ^{6}Li [2]. There is also potential to study nuclear structures by three particle transfer [3], e.g., using a radioactive ion beam, which can be a useful method for nuclear astrophysics.

Set-Up

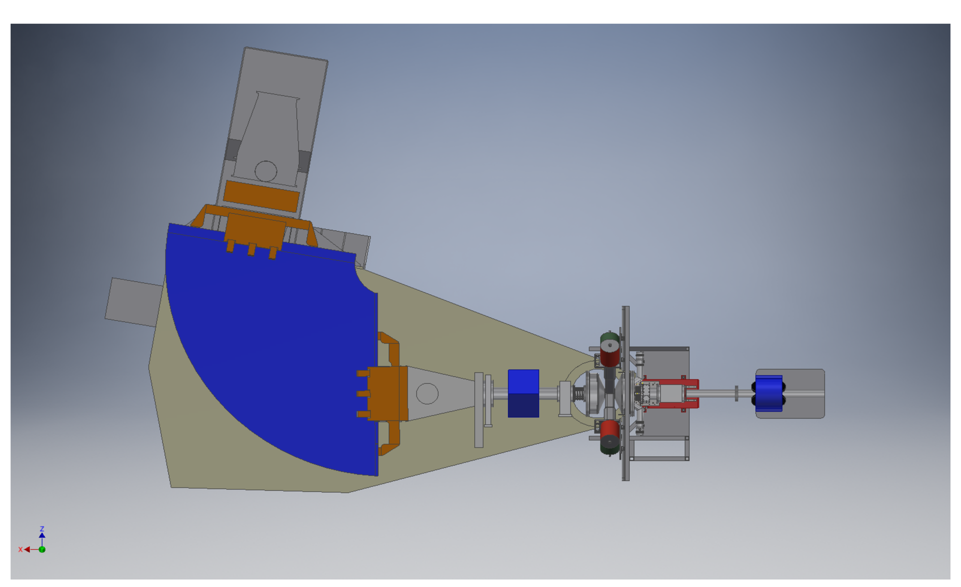

Figure 1: Aerial view of the TIARA detector [4] and MDM spectrometer [5].

Fig. 1 gives an aerial view of TIARA [4], Multipole-Dipole-Multipole (MDM) spectrometer [5], Oxford detector and Ge detectors. All these instruments analyze the reaction depicted in Fig. 2.

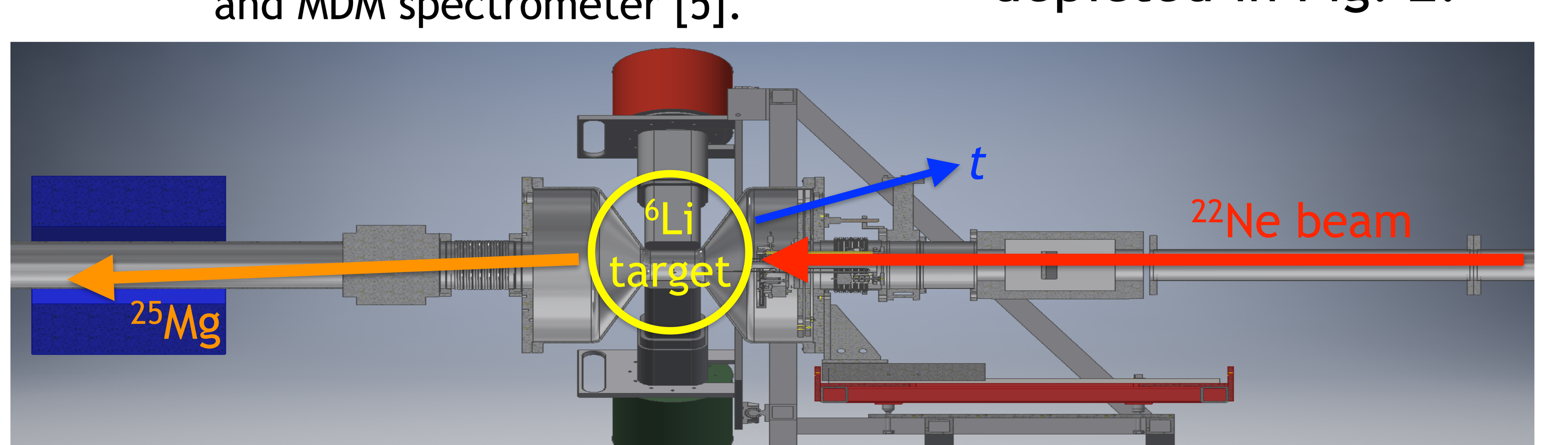

Figure 2: TIARA detector [4] with a visual of the $^{22}Ne(^{6}Li,t)^{25}Mg$ reaction.

Analysis

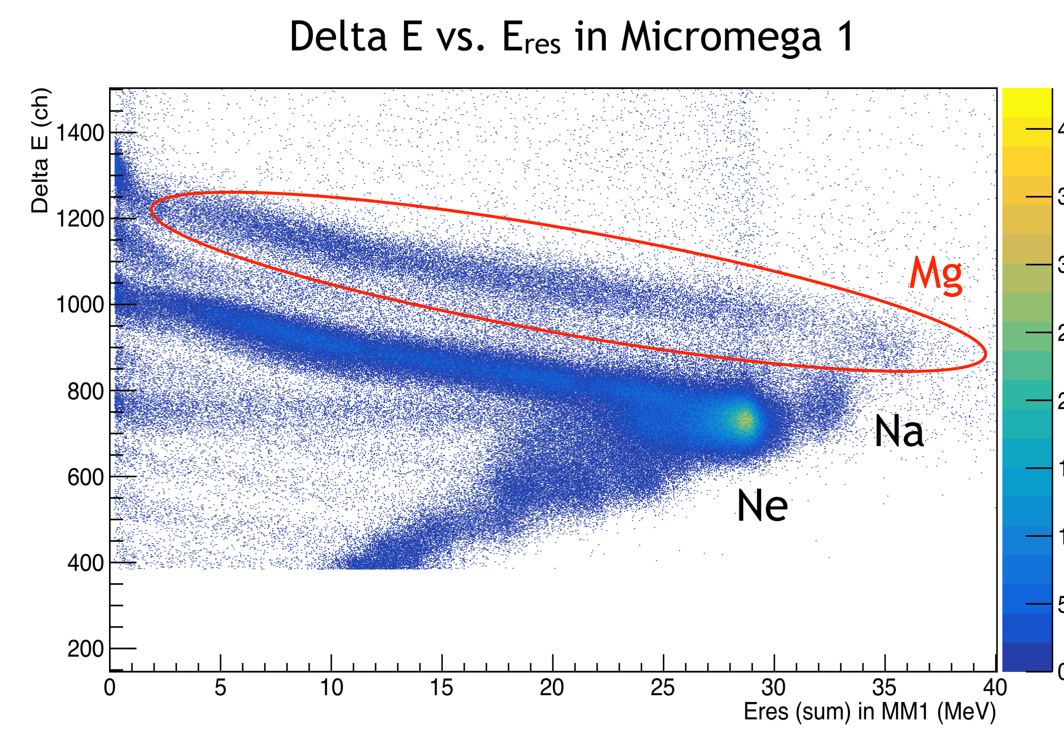

Figure 3: Delta E vs. E_{res} in Micromega 1 of some runs. This is used to gate on Mg.

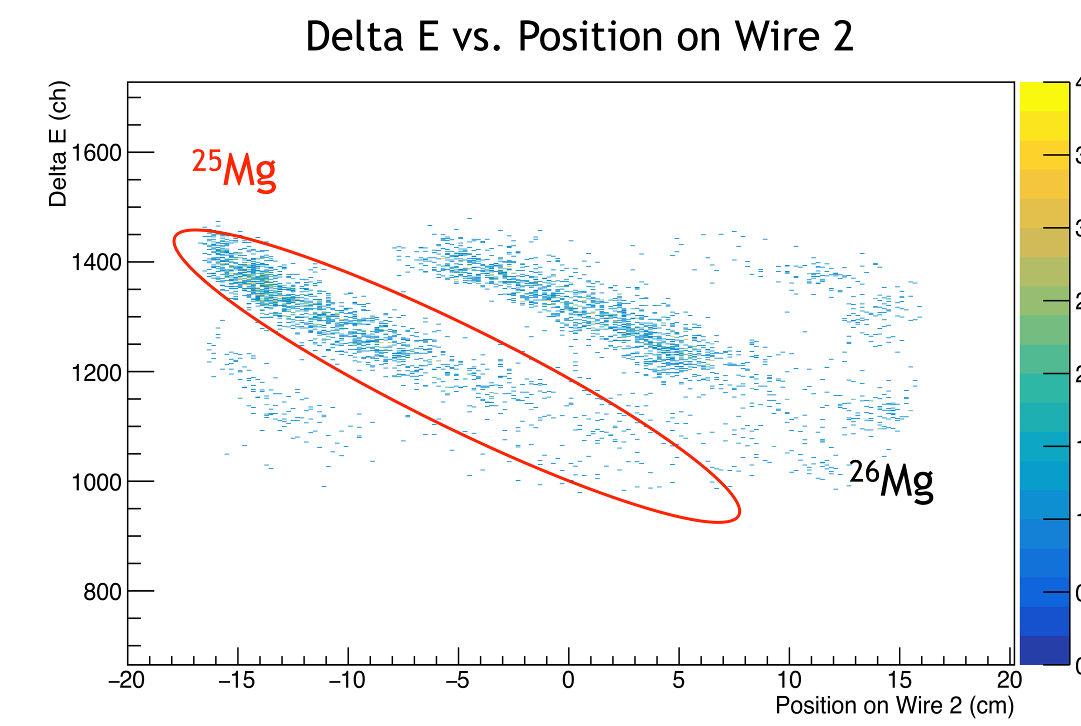

Figure 4: Delta E vs. Position on Wire 2 of some runs. This is used to gate on ^{25}Mg.

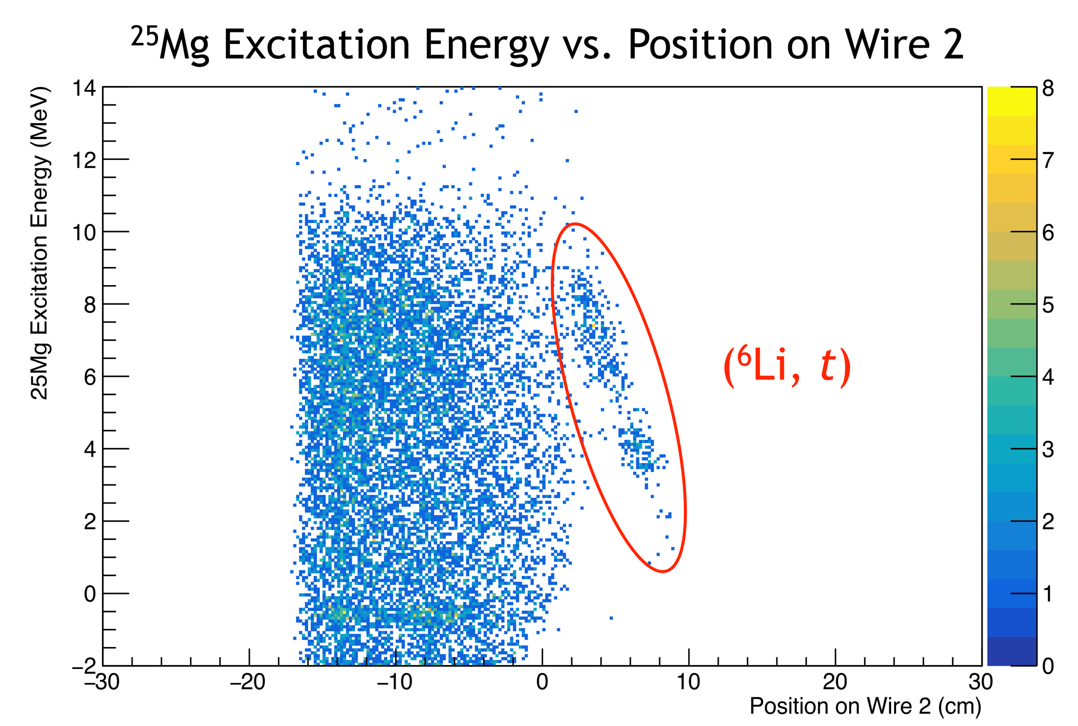

Figure 5: ^{25}Mg Excitation Energy vs. Position on Wire 2 of some runs. This is used to gate on (^{6}Li,*t*).

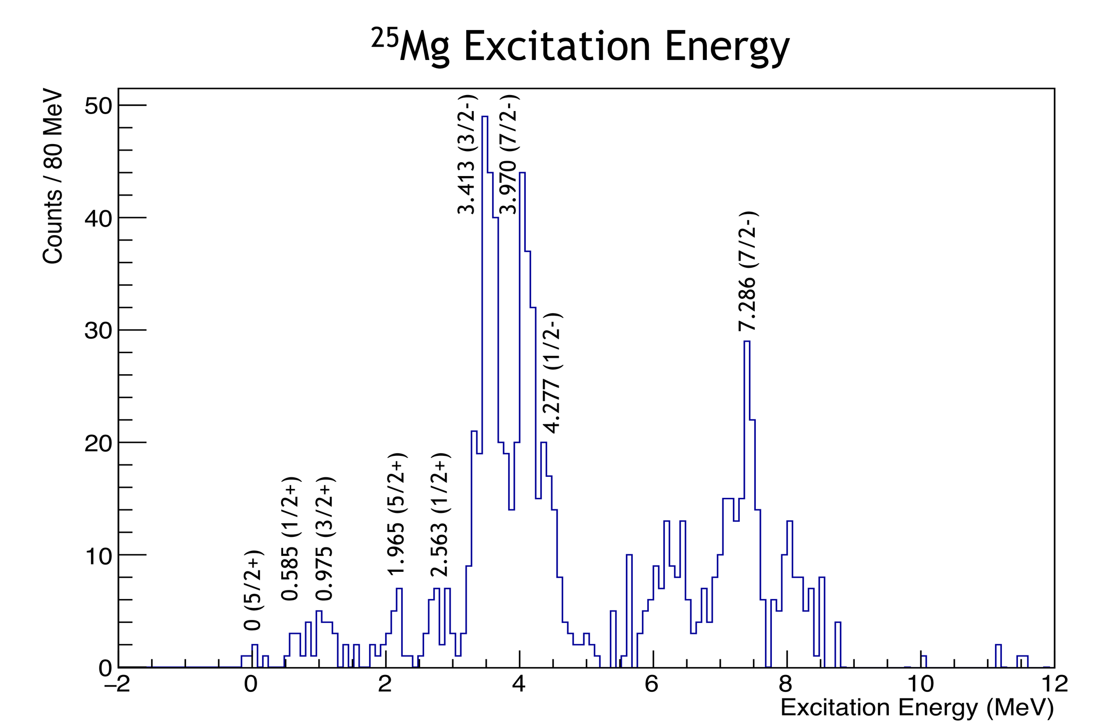

Figure 6: ^{25}Mg Excitation Energy of all runs. This shows the populated states of ^{25}Mg.

Results

Figs. 3-6, sequentially, show how the populated states of ^{25}Mg are identified through various gates on Delta E and the x-position of the data. To better distinguish the highest peak from 3.405 MeV (9/2+) and 3.413 MeV (3/2-), an angular distribution plot is compared with theoretical calculations using FRESCO [6] shown in Fig. 7. From Fig. 7, it seems to be that the highest peak corresponds to 3.413 MeV (3/2-). After normalization, the spectroscopic factor is determined to be 0.22 ± 0.04 for this state. This process helps to conclude that other peaks have negative spin parities as well [1,7].

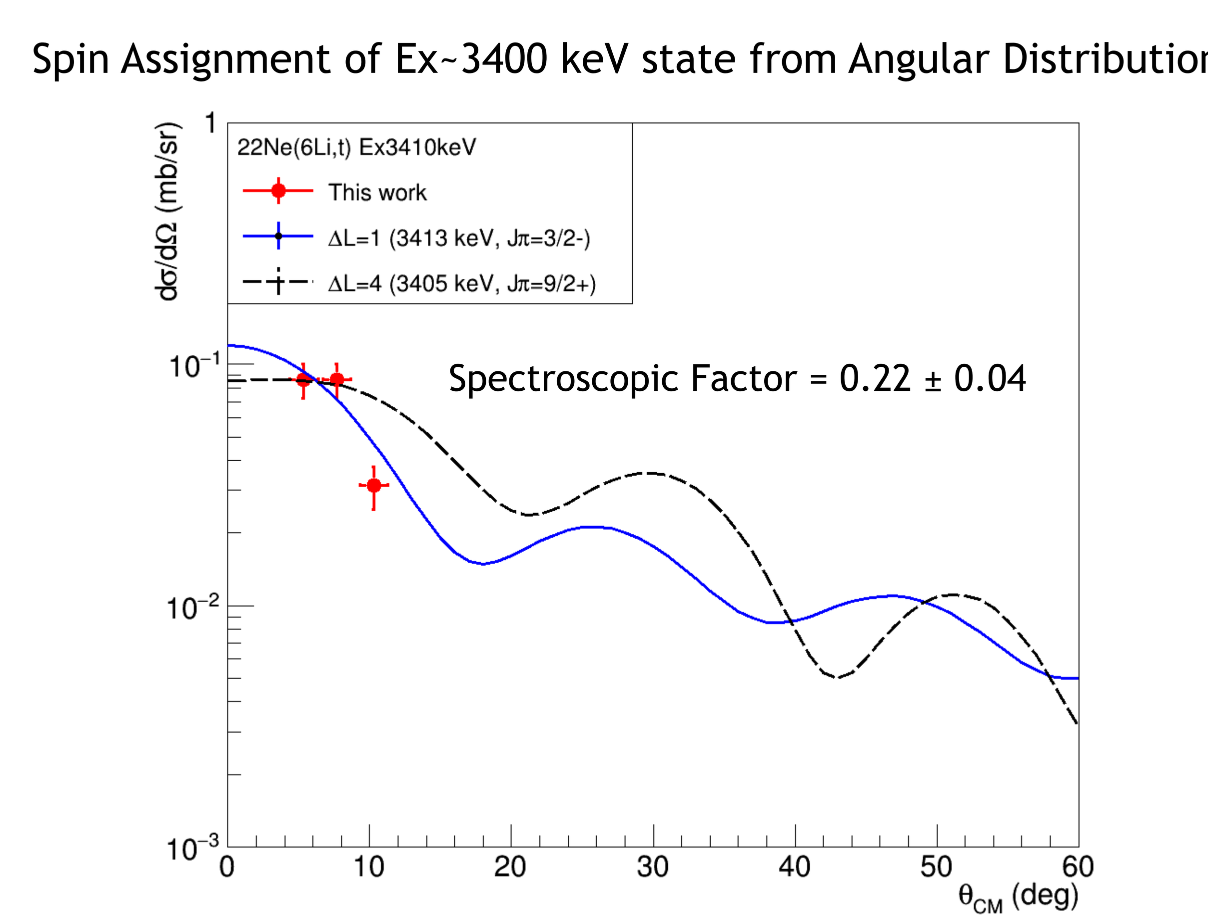

Figure 7: Angular distribution of 3400 keV state in ^{25}Mg with theoretical plots J=9/2+ and J=3/2- created by FRESCO [6].

Conclusion

This study provides unique insight to the structure of the states that are populated by $^{22}Ne(^{6}Li,t)^{25}Mg$. Furthermore, by constructing an angular distribution of the 3.4 MeV state of ^{25}Mg and comparing it to theoretical calculations [6], the spin is extracted along with the spectroscopic factor of 0.22 ± 0.04. It then seems clear that the states being populated by ^{25}Mg have negative spin parities [1,7]. Evidently, future analysis will help to improve knowledge about $^{22}Ne(^{6}Li,t)^{25}Mg$.

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