Competition between d/t-capture and α-capture in ^{6,7}Li+^{124}Sn and ^{6,7}Li+^{159}Tb reactions

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Introduction

In our recent work, we have shown some remarkable differences in individual ICF channel cross-sections in ^{6,7}Li induced nuclear reactions [1]. It is observed that the cross-sections for deuteron-capture are of similar magnitude as the α-capture, in case of ^{6}Li projectile, while the triton-capture is dominant than α-capture in case of ^{7}Li projectile. Intuitively, we expect this behavior as triton while approaching the target sees lower Coulomb barrier compared to alpha particle approaching the target, hence the cross-section for t-capture is more compared to α-capture in case of ^{7}Li but this argument does not hold with limited ^{6}Li data with ^{209}Bi and ^{197}Au targets. For further investigation of this behavior in individual ICF data, we have performed experiment with ^{6,7}Li on ^{124}Sn target and utilized the available data for ^{6,7}Li on ^{159}Tb target.

Experimental details

The online and offline gamma ray measurements were carried out at 14UD BARC-TIFR Pelletron-Linac accelerator facility, Mumbai. The targets of ^{124}Sn were bombarded with ^{6,7}Li beams while ^{159}Tb was bombarded with ^{6}Li beam. In the online gamma measurement, a Compton suppressed clover detector placed at a distance of 25 cm from the target centre, at 125°, was used for the estimation of absolute cross section of populated reaction channels. In the offline gamma measurement, the targets with Al catcher ($\sim$ 1 mg/cm^2 thick) were placed normal to the beam direction so that the recoiling residues are stopped in target-catcher assembly and irradiated for 7-18 hrs. The irradiated target-catcher assembly was then sticked to the perspex sheet and the sheet was kept at a fixed distance ($\sim$ 10 cm) in front of the HPGe detector. The HPGe detector was surrounded by 2 mm thick Cu and Cd sheets and 5 cm thick Pb sheets to reduce the background. The energy calibration and absolute efficiency of both Clover and HPGe detector was carried out by using a set of calibrated radioactive ^{152}Eu, ^{133}Ba and ^{241}Am sources placed at the same geometry as the target.

Results

The extracted cross-sections for α-capture and d-capture/t-capture for ^{6,7}Li+^{124}Sn are plotted in Figs. 1 (a-d). The available α-capture and t-capture data for ^{7}Li+^{159}Tb is taken from Ref. [2] and plotted in Figs. 2(a) and (c). The d-capture data was available for ^{6}Li+^{159}Tb in Ref. [3]. For α-capture, we have extracted the cross-sections from measured offline gamma data and plotted in 2 (b) and (d).

In Figs. 1 and 2, we have plotted the results for ^{6,7}Li+^{124}Sn and ^{6,7}Li+^{159}Tb reactions. As can be seen from the figures, (a) and (b) the α-capture is less than the t or d-capture at all the measured energies. In Figs. (c) and

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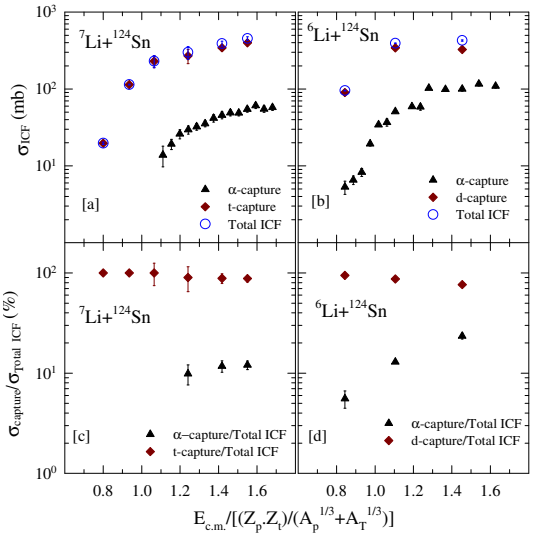

FIG. 1: (a) Comparison of α-capture and t-capture cross-sections in ^{7}Li+^{124}Sn reaction (b) Comparison of α-capture and d-capture cross-sections in ^{6}Li+^{124}Sn reaction. Individual percentage contributions of α-capture and t-capture in ^{7}Li and d-capture ^{6}Li is shown in (c) and (d) respectively.

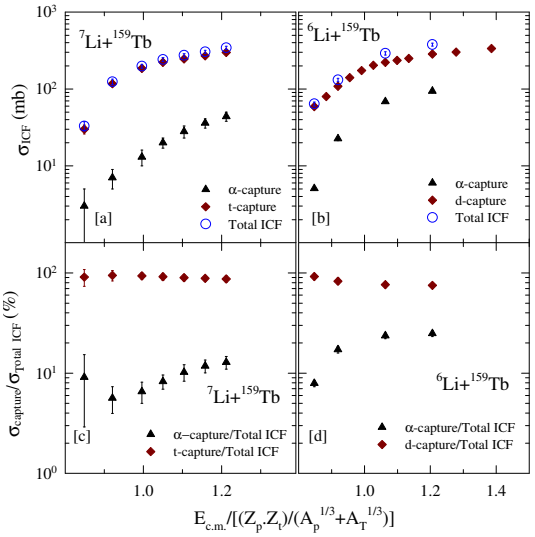

FIG. 2: Same as Fig. 1 but for ^{6,7}Li+^{159}Tb reaction.

(d), we have plotted the percentage contribution of α-capture and t-capture/d-capture. It is observed that for ^{7}Li, t-capture is almost constant at all the energies and consumes 90 % of Total ICF while α-capture only contributes 10 %. For ^{6}Li, d-capture contribution in Total ICF decreases with increasing energy while α-capture increases with energy. Also the d-capture contribution varies from 92-76 % in Total ICF from lowest to highest energy. This feature is not seen with heavy targets like ^{209}Bi and ^{197}Au, where α-capture and d-capture have similar contribution in Total ICF [1]. More α-capture and d-capture data is required with ^{6}Li projectile for detailed understanding.

Summary and Conclusion

In summary, from the available experimental data, we have highlighted the differences in individual ICF cross-sections for ^{6}Li and ^{7}Li projectiles on ^{124}Sn and ^{159}Tb targets. The individual ICF cross-sections imply that the d/t-capture cross-section is more than α-capture cross-section for both the targets contrary to observation made with ^{209}Bi, ^{197}Au and ^{198}Pt [1]. It is also observed that the t-capture cross-section is consuming more than 90% of total ICF for ^{7}Li+^{124}Sn and ^{7}Li+^{159}Tb reactions at all the measured energies. In the case of ^{6}Li+^{124}Sn and ^{6}Li+^{159}Tb reactions, d-capture cross-section decreases from 92% to 76 % while α-capture cross-section increases from 8% to 24 % from below to above barrier energies. More data of d-ICF, α-ICF and t-ICF simultaneously for various systems is required for systematic understanding of ICF.

References

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