Systematic behaviour of alpha-production in reactions with ^{6,7}Li projectiles

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Introduction

Enhanced production of α-particles in reactions with weakly bound projectiles, especially for those having α+ x cluster structure has been investigated in several studies recently [1, 2]. The primary goal of these studies is to understand the origin of the measured inclusive α-production and to investigate the relative contribution of different processes. The α-production may have large contributions from various transfer-breakup processes, such as, the capture of breakup fragments leading to breakup-fusion or transfer of nucleon(s) to the continuum states of target. The aim of the paper is to understand the origin of inclusive α-production in the reactions induced by ^{6}Li and ^{7}Li projectiles on various target systems, investigate its systematic behaviour and compare it with results of continuum-discretized coupled channels (CDCC) calculations.

Systematic behaviour observed from data and calculations

The cross sections from all the processes that do not contribute to the complete fusion is evaluated from the difference of reaction cross sections (σ_R) and measured complete fusion cross sections (σ_{CF}) as (σ_{non-CF} = σ_R − σ_{CF}). The σ_{non-CF} for ^{6}Li and ^{7}Li projectiles with different target systems is shown in Fig.1 and Fig.2 respectively. The reaction cross sections are evaluated using the global potential for ^{6}Li and ^{7}Li projectiles. A systematic behaviour of σ_{non-CF} that is independent of targets is seen for both the ^{6}Li and ^{7}Li projectiles. The σ_{CF} values for the ^{6}Li + ^{209}Bi and the ^{7}Li + ^{209}Bi systems have been calculated using the CDCC method as explained in Ref. [3] and σ_{non-CF} values are determined. The result of calculations are shown by solid lines in Fig.1 and Fig.2, respectively. It is remarkable that the experimental σ_{non-CF} values for different target systems is well described by the calculations

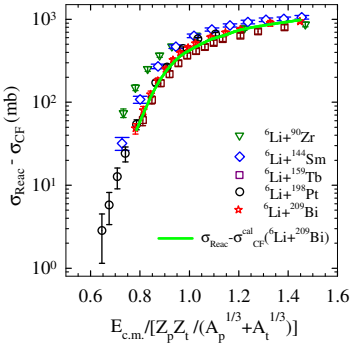

FIG. 1: The difference of reaction cross sections (σ_R) and experimental complete fusion cross sections (σ_{CF}) for different target systems with the ^{6}Li projectile compared with the CDCC calculations. The data is taken from literature.

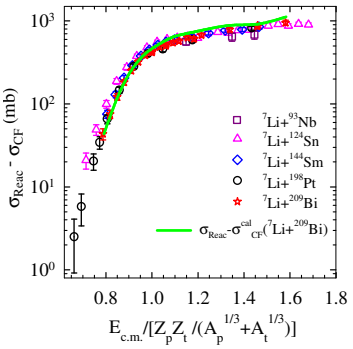

FIG. 2: Same as Fig.1 with the ^{7}Li projectile

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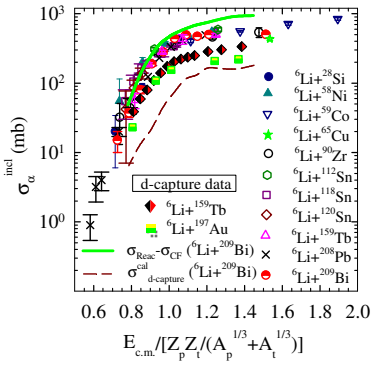

FIG. 3: Inclusive α-production data for different target systems with the ^{6}Li projectile comapred with the calculated σ_{non-CF} values. In addition, the d-capture data for some of these systems along with the calculation for the ^{6}Li + ^{209}Bi system is also shown.

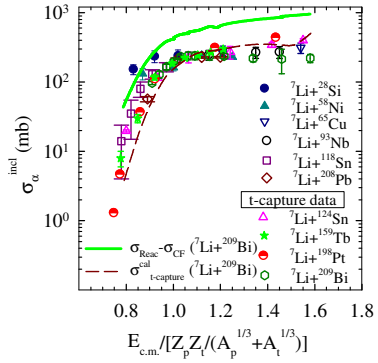

FIG. 4: Same as Fig.3 with the ^{7}Li projectile. The t-capture data for some of these systems along with the calculation for the ^{7}Li + ^{209}Bi system is also shown.

performed only for the ^{6}Li + ^{209}Bi and the ^{7}Li + ^{209}Bi systems. The available data for the cross sections of inclusive α-production ($\sigma_\alpha{}^{incl}$) with ^{6}Li and ^{7}Li projectiles at energies around the Coulomb barrier are shown in Fig.3 and Fig.4 respectively. A comparison with the calculated σ_{non-CF} shows a reasonably good agreement with the $\sigma_\alpha{}^{incl.}$ for the ^{6}Li system, while $\sigma_\alpha{}^{incl.}$ values are quite small compared to σ_{non-CF} for the ^{7}Li projectile target systems. The fact that the contributions from the compound nuclear processes are reaction cross section to the inclusive α-production is small, implies that the σ_R is dominated by the α-production channels for the ^{6}Li projectile systems while there are significant contributions from other direct processes which do not lead to α-production in case of ^{7}Li induced reactions.

The d-capture cross section (σ_{d-cap}) for the ^{6}Li projectile systems and t-capture cross sections (σ_{t-cap}) for the ^{7}Li projectile systems are also shown in Fig.3 and Fig.4 respectively. The σ_{d-cap} are less compared to the $\sigma_\alpha{}^{incl.}$, which imply that there are other significant sources of α-production. Indeed the $1n$-transfer is found to be quite dominant in ^{6}Li induced reactions [1]. We also note that our model CDCC calculations of d-capture for the ^{6}Li + ^{209}Bi system fail to explain the data, which needs to be investigated. The σ_{t-cap} are equal to the $\sigma_\alpha{}^{incl.}$, showing that it is by far the most dominant mode of inclusive α-production for the ^{7}Li projectile systems. Also, our model CDCC calculations of σ_{t-cap} provide an excellent agreement with the data.

Conclusions

In summary, we have shown that only the channels leading to production of α particles contribute significantly in σ_R apart from the σ_{CF} for the ^{6}Li projectile systems, while processes other than α-production contribute in the ^{7}Li projectile systems. The inclusive α production for the ^{7}Li projectile systems are completely described by the t-capture but there are other than d-capture contributions in ^{6}Li projectile systems. The model calculations based on CDCC method give a good account of the σ_{CF} for both ^{6}Li and ^{7}Li projectile systems and t-capture for ^{7}Li projectile systems.

References

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