Interesting features in systematics of α production for ^{6,7}Li induced reactions

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Introduction

Enhanced production of α particles observed in reactions with weakly bound projectiles has been utilized extensively for studies of clustering in light nuclei and investigations into breakup and transfer reaction mechanisms. For projectiles, especially for those having $\alpha + x$ cluster structure, copious emission of α particles with cross sections, sometimes as large as the reaction cross section has been observed. A large number of studies have been performed using ^{6,7}Li projectiles with the aim of disentangling various reaction mechanisms contributing to the large α emission and understanding the systematics for different target systems [1]. The d and t capture reactions are expected to be one of the most dominant channels that contribute to the α production in reactions induced by ^{6}Li and ^{7}Li nuclei respectively. In the present work, we provide a systematic study of d and t capture reactions and study their relative importance in the inclusive α production.

The projectile fragment-target reactions

The calculations using the Continuum Discretized Coupled Channels(CDCC) based CDCC-Absorption method have been performed for ^{6,7}Li+^{124}Sn systems. The details of the method is given in Refs. [2, 3]. In this method, the projectile fragment-target capture cross sections are calculated as the difference of absorption cross sections with different choices of fragment-target imaginary potentials. Two short-range imaginary potentials are employed to account for the absorption of projectile fragments and the target besides another imaginary potential in the incident channel to calculate the total fusion. Separate calculations are then performed with only one of the fragment-target imaginary potentials to calculate the individual fragment-target capture contributions by subtraction from the calculated total fusion. This formalism includes both the coupling effects due to breakup and the absorption effects due to capture simultaneously in a single framework. The results of the calculations for the d and t capture for ^{6}Li + ^{124}Sn and ^{7}Li + ^{124}Sn systems are shown in Fig. 1a and Fig. 2a, respectively by dashed lines. These calculations have been compared to the experimental data measured for various target systems. The calculations provide a good description of the data for all ^{6,7}Li projectile-target systems. It also shows a systematic universal behaviour of the d capture for ^{6}Li projectile-target systems and t-capture cross sections for ^{7}Li projectile-target systems.

Systematics derived from inclusive α production

Large data sets exist for the the inclusive α measurements with ^{6,7}Li projectile systems. The separate contribution from the direct mechanisms can be extracted by subtracting the α-particles arising due to the CF component. The contribution due to the CF part has been estimated from the statistical model calculations using code PACE2 [4] and the

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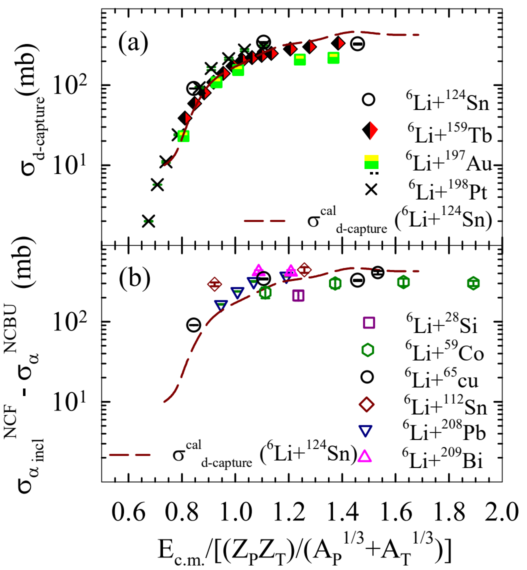

FIG. 1: (a) Measured d capture cross sections for ^{6}Li projectile with different target systems as a function of reduced energy. The dashed line is result of d capture calculations performed for ^{6}Li+^{124}Sn system. (b) Difference between measured $\sigma^{NCF}_{\alpha_{incl}}$ and σ^{NCBU}_{α} with ^{6}Li projectile for various targets as a function of reduced energy.

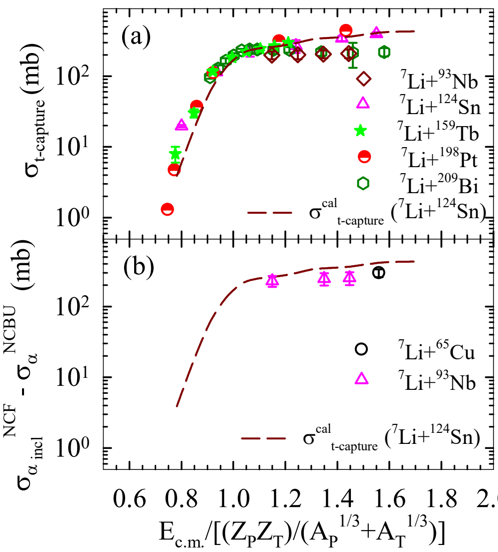

FIG. 2: (a) Measured t-capture cross sections for ^{7}Li projectile with different target systems as a function of reduced energy. The dashed line is result of t-capture calculations performed for ^{7}Li+^{124}Sn system. (b) Difference between measured $\sigma^{NCF}_{\alpha_{incl}}$ and σ^{NCBU}_{α} with ^{7}Li projectile for various targets as a function of reduced energy.

non-CF inclusive α production cross sections ($\sigma^{NCF}_{\alpha_{incl.}}$) has been determined. The α contribution from the evaporation processes subsequent to CF is not significant. The projectile breakup and transfer of nucleon(s) from the projectile may take place in several ways and it contributes significantly to the inclusive α production.

An important process is the non-capture breakup process (NCBU) process, measured in the exclusive measurements, where the α particle is detected in coincidence with the complementary fragment. The difference between the $\sigma^{NCF}_{\alpha_{incl}}$ and the NCBU cross sections (σ^{NCBU}_{α}) have been determined using the experimental data measured for various ^{6,7}Li projectile-target systems. This quantity is plotted in Fig. 1b and Fig. 2b respectively along with the results of d and t capture calculations obtained for ^{6}Li + ^{124}Sn and ^{7}Li + ^{124}Sn systems. The data matches very well with the result of the d and t capture calculations. It can be concluded that the difference between the measured quantities ($\sigma^{NCF}_{\alpha_{incl.}}$) and σ^{NCBU}_{α} provides an interesting way to estimate the d and t capture cross sections for a large range of ^{6}Li and ^{7}Li projectile-target systems. In a similar way, one can estimate the α capture cross sections by using non-CF inclusive d/t cross sections and corresponding NCBU cross sections for ^{6,7}Li projectile-target systems.

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