Light particles emissions in $^{6}Li +^{12,13} C$, $^{6,7}Li +^{16} O$ reactions

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Introduction

During the last two decades of preceding century, $^{6,7}Li$ induced reactions at low energies had been studied extensively to understand the related fusion reaction mechanism. The characteristics gamma-rays of the residual nuclei followed by the reactions these reactions had been measured at low energies around the Coulomb barrier [1, 2]. The cross sections for different exit channels are available out of which np channel was found to be the most dominant one with 40% and 30% contribution in the $^{6}Li +^{16} O$ and $^{7}Li +^{16} O$ reactions, respectively, forming compound nuclei (CN) $^{22}Na^{*}$ and $^{23}Na^{*}$ [1]. Moreover, the reactions involving both the loosely bound projectiles $^{6,7}Li$ do not show any enhancement or inhibition in the fusion cross sections. It is interesting to note that CN $^{18,19}F^{*}$ formed in the reactions $^{6}Li +^{12,13} C$ at low energies have also prominent np channel [2]. However, compound nucleus $^{19}F^{*}$ has αn as the most prominent exit channel followed by the np channel. It is also shown in these studies that the reactions followed compound nucleus reaction mechanism.
In the present decade, we have successfully studied decay of number of very light mass (A∼20-30) CN $^{20-22}Ne^{*}$, $^{24,35}Mg^{*}$, $^{26-29}Al^{*}$, Si^{*}, $^{32}S^{*}$ and $^{31}P^{*}$ quite extensively within the quantum mechanical fragmentation theory (QMFT) based dynamical cluster decay model (DCM) [3, 4]. However, the CN studied so far have not been investigated for the light particles (LPs) decays or evaporation residues (ERs), except that for CN $^{26-29}Al^{*}$, as the data for the same were not available for other nuclei. It is important to point out here that for the CN under study i.e. $^{18,19}F^{*}$ and $^{22,23}Na^{*}$ the data for LPs exit channels were measured quite extensively using gamma-ray yield as well as ER techniques [1, 2]. So, it would be quite exciting to look into LPs/ERs in different exit channels within the DCM which takes into consideration penetration of relatively preformed fragments in the decay of compound nucleus. Furthermore, present work extend the application of DCM to lighter mass region further. It is relevant to mention here that this dynamical model has been successfully applied to various mass regions including super heavy mass nuclei [5]. The next section presents the methodology in brief, followed by the calculation and discussions in the subsequent section.

Methodology

In DCM [3–5] of Gupta and collaborators, the compound nucleus decay cross-section for ℓ partial waves, is defined as

$$\sigma = \frac{\pi}{k^2}\sum_{\ell=0}^{\ell_{max}}(2\ell+1)P_0P; \qquad k=\sqrt{\frac{2\mu E_{c.m.}}{\hbar^2}} \quad (1)$$

where, P_0, the preformation probability, refers to η-motion and P, the penetrability, to R-motion. The ℓ_{max}-value in Eq. (1) is the maximum angular momentum, fixed for the vanishing of the light particles cross-section, i.e., $\sigma_{LPs} \rightarrow 0$.
The P_0 contains the structure information of compound nucleus via the fragmentation potential comprises of B_i, V_C, V_p an V_ℓ i.e., the temperature dependent binding energies of the two nuclei, Coulomb potential, nuclear proximity potential and angular momentum dependent potential, respectively. The binding energy consist of both the macroscopic (liquid drop energy) part and the microscopic

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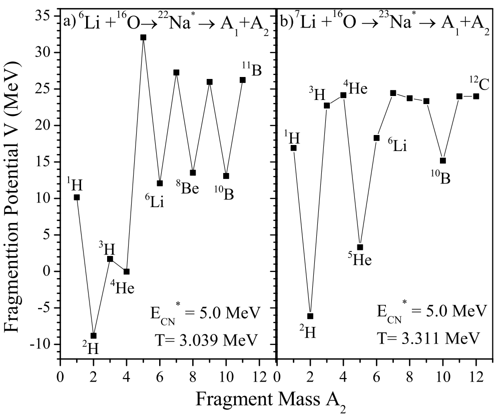

FIG. 1: The fragmentation potential as a function of fragment mass A_2 for the decay of CN (a) $^{22}Na^*$ and (b) $^{23}Na^*$ for the spherical considerations of the nuclei, at angular momentum value $\ell = 0\hbar$.

(shell correction) part, defined within the Strutinsky renormalization procedure [6].

Calculations and Discussions

Fig. 1(a and b) and Fig. 2(a and b) presents the fragmentation potential as a function of fragment mass A_2 for the decay of CN $^{22,23}Na^*$ and $^{18,19}F^*$, respectively. For $^{22}Na^*$ the calculated fragmentation potential gives minima at ^2H or equivalently pn and ^4He as shown in Fig. 1 (a). For $^{23}Na^*$ (Fig. 1(b)), the minimized fragments are ^2H and ^5He or equivalently αn. Evidently, LP ^2H is energetically more favored in comparison to other light particles in both the cases as explored in the experimental measurements which have shown maximum cross sections for the ^2H or pn exit channel [1].
However, in Fig. 2, compound nucleus $^{19}F^*$ (Fig. 2(b)) has ^5He or αn as the most prominent fragment followed by the ^2H in contrast to compound nucleus $^{18}F^*$ (Fig. 2(a)) which is having ^2H as most predominant fragment followed by the fragment ^5Li or or equivalently αp. This result is also well supported by the experimental data [2], which shows that though pn exit channel has maximum cross sections for the compound nucleus $^{18}F^*$ but for $^{19}F^*$ system it is surpassed by αn exit channel cross sections [2].

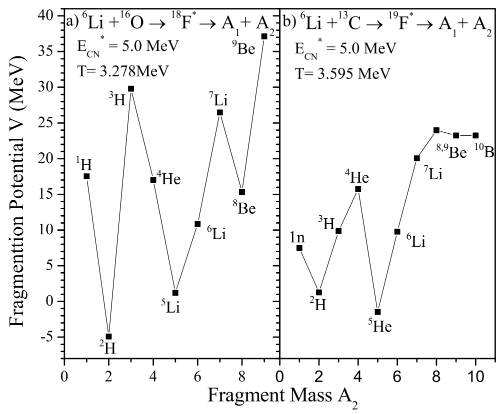

FIG. 2: Same as Fig. 1 but for CN (a) $^{18}F^*$ and (b) $^{19}F^*$.

It will be quite interesting to investigate the effects of higher angular momentum values alongwith deformation and orientation effects on the fragmentation profile of CN under study. Subsequently, the P_0 and P will be calculated with all these effects included in order to explore the underline reaction mechanism within the DCM. Moreover, the effects of different centre of mass energies will be explored for these CN alongwith the calculations of the cross sections for different exit channels and their comparison with the available experimental data. Work is in progress.

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