Competing intermediate mass fragments in the decay of $^{26-29}Al^{*}$ compound nuclei

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Introduction

In recent works, we investigated the decay of light mass compound system ^{28}Al*, formed through ^{18}O+^{10}B and ^{19}F+^{9}Be reactions, which compared nicely with the experimental data on the fusion fission (FF) process for intermediate mass fragments (IMFs; Z=3, 4, 5 and 6). The effects of deformations, orientations, angular momentum and entrance channel independence have been studied within the dynamical cluster-decay model (DCM)[1, 2]. In an experimental study [3], the comparative analysis has been made for $^{26-29}$Al* composite systems (CS) through the emission of IMFs. We intend to study the decay of a set of these isotopes of Al^{*},,i.e., ^{27,28,29}Al* for a comparative analysis of IMFs emissions from $^{26-29}$Al* formed in ^{16,18}O+^{10,11}B at an excitation energy E^{*}_{CN}~44MeV. As observed in the experimental data [3], the IMFs contain only the FF process; the contribution of non-compound nucleus (nCN) effects has not been observed. We have also investigated the effect of increasing neutron number in the decay of light mass CS $^{26-29}$Al*, within the DCM approach.

In the decay of CS, the decaying fragments are first preformed with certain probability P_0, and then tunnel the interaction barrier with penetrability P. The preformation probability P_0 carries the information about the competition of various decaying fragments, which in turn depends upon their minimized fragmentation potential. This means that P_0

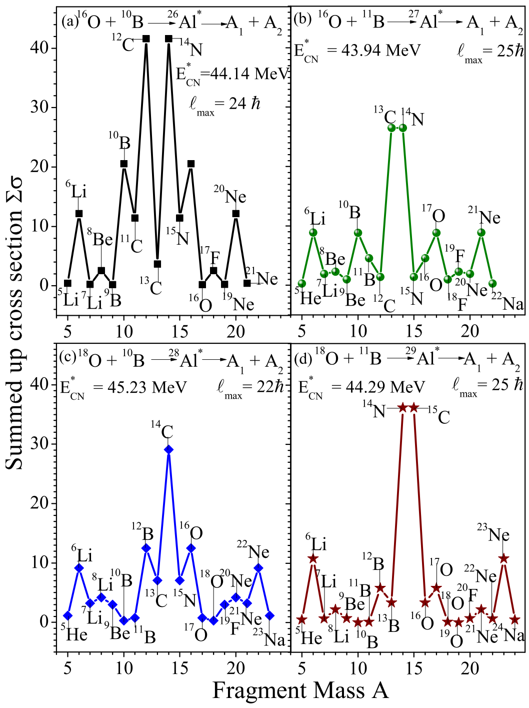

FIG. 1: The variation of summed up cross section $\sum\sigma$ (mb) with fragment mass (A) for the decay of CS a) $^{26}Al^{*}$, b) $^{27}Al^{*}$, c) $^{28}Al^{*}$ and d) $^{29}Al^{*}$.

carries the very significant nuclear structure information which is missing in the statistical models. Furthermore, P affects the decay cross section of IMFs emissions. In the framework of DCM, it is relevant to note that P_0 and P are the main contributors towards the calculation of decay cross section.

Methodology

The DCM of Gupta and collaborators [1, 2, 4], worked out in terms of collective coordinates of mass (and charge) asymmetries,

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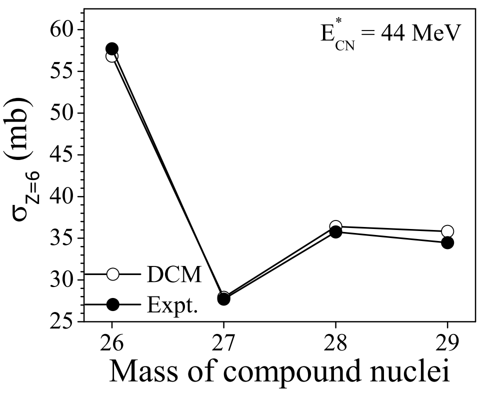

FIG. 2: The variation of IMF cross section $\sigma_{Z=6}$ corresponding to Z = 6, with increasing mass of Al^* CS, compared with experimental data.

for ℓ-partial waves, gives the compound nucleus (CN) decay cross-section as

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

where, $\mu = [A_1A_2/(A_1+A_2)]m$ is the reduced mass, with m as the nucleon mass and ℓ_{max} is the maximum angular momentum. P is penetrability of interaction barrier (of the preformed clusters with preformation probability P_0), calculated as the WKB tunneling probability, around the Interaction barrier.

Calculations and discussions

Fig. 1 shows the variation of summed up cross section $\sum\sigma$ (mb) for the IMFs. In case of CS ^{26}Al*, ^{27}Al*, ^{28}Al* and ^{29}Al* contributing IMFs for Z=3 are $^{5,6,7}Li$, $^{6,7}Li$, $^{6,7,8}Li$ and $^{6,7,8}Li$, for Z=4 are ^{8}Be, $^{8,9}Be$, ^{9}Be and ^{9}Be, for Z=5 are $^{9,10}B$, $^{10,11}B$, $^{10,11,12}B$ and $^{10,11,12,13}B$, for Z=6 are $^{11,12,13}C$, $^{12,13}C$, $^{13,14}C$ and ^{15}C, respectively. Evidently, Z=6 (carbon) fragments are strongly favored of all the IMFs in case of all the isotopes of Al^*. Despite the common features in the decay of the CS $^{26-29}$Al* the neutron addition effect in the Al^* is quite evident from the structure of $\sum\sigma$ plots. The change in contributing IMFs corresponding to Z=3, 4, 5 and 6 for ^{26}Al* to ^{29}Al* is due to the neutron addition with increase in mass of CS. We see that α like fragments (^{8}Be, ^{12}C, ^{16}O and ^{20}Ne) appear in case ^{26,27}Al* (Fig. 1(a-b)), but these α fragments start disappearing as the mass of CS increases. It is to be noted that, only one alpha like fragment i.e. ^{16}O and ^{20}Ne and ^{16}O are observed in the decay profile of ^{28,29}Al* (Fig. 1(c-d)), respectively.

Fig. 2 shows the IMF cross section $\sigma_{Z=6}$ corresponding to Z = 6, with the increasing mass of Al^* CS. As evident from Fig. 1 also, the value of $\sigma_{Z=6}$ is largest in the decay of compound nucleus ^{26}Al* and smallest in the case of compound nucleus ^{27}Al*. These results are in good agreement with the experimental data [3].

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