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Isotopic effects in the decay of compound nuclei $^{58,59}Cu^*$

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Introduction

For a better understanding of nuclear characteristics and behaviour, a number of low energy heavy-ion processes forming compound nuclear systems and their subsequent decay modes have been explored. It is important fact that the fundamental aspects of nuclear matter can be explored using compound nucleus (CN) mechanism while forming the same in extreme conditions of temperature and spin. The N/Z ratio of the CN plays an important role in its decay process i.e. fragment production and their mass distribution. Therefore, a detailed investigation of reaction cross-sections for a isotopic chain of compound nuclei $^{58-61}Cu^*$ will be useful to explore dynamical properties of the same.

In the present work, the dynamical cluster-decay model (DCM) [1, 2], based on quantum-mechanical fragmentation theory (QMFT), has been applied for the compound nuclei $^{58,59}Cu^*$ (at T = 2.847 MeV and 2.82 MeV) formed in low-energy heavy ion reactions ^{35}Cl $+^{23,24}$ Mg, respectively, at $E_c.m.$=32.2 MeV and 35.9 MeV. A comparison of light particles, LPs (n, p and α i.e. A$\leq$4) and fusion-fission fragments (intermediate mass fragments, IMFs 3$\leq$Z$\leq$10 and, symmetric and near symmetric fragments, SFs Z>10) emissions in the decay of $^{58,59}Cu^*$ have been made within the total fragmentation potential of the compound nulcei under study. The role of constituent potentials such as the binding energies, Coulomb potential, nuclear proximity potential, and angular momentum dependent potential, in the total fragmentation potential have been also investigated. We see that an addition of a neutron causes a significant change in the potential energy surface (PES) of the Cu compound nuclei under study.

Methodology

The DCM is based on the collective coordinates of mass asymmetry $\eta_A = \frac{A_1-A_2}{A_1+A_2}$ and relative separation R, with deformations β_2 and orientations θ_i of two fragments (i = 1, 2). In terms of these coordinates, we define the compound nucleus decay cross-section as

$$\sigma = \frac{\pi}{k^2} \sum_{\ell=0}^{\ell_max} (2\ell+1) P_0 P;\ k = \sqrt{\frac{2\mu E_{c.m.}}{\hbar^2}} \quad (1)$$

where P_0 is the preformation probability, and P is the penetrability. The values of P_0 depends on the fragmentation profile of the given compound nucleus and given by

$$V_R(\eta, T) = B_i + V_c + V_p + V_l \quad (2)$$

i.e. it is sum of binding energies of two nuclei (B_i), Coulomb potential (V_c), proximity potential (V_p), centrifugal potential (V_l) all being temperature (T) and orientations dependent.

Calculations and Discussions

The compound nuclei $^{58,59}Cu^*$ populated by ^{35}Cl $+^{24,25}$ Mg are being studied within QMFT to explore the isotopic effect in both the reactions. As it is quite evident from the Fig. 1(a,b) at $\ell = 0\hbar$ the PES drastically changed with LPs competing with SFs and near SFs for $^{58}Cu^*$. The SFs $^{29}Si^*$ and $^{29}P^*$ is highly dominating for the case of $^{58}Cu^*$. However for $^{59}Cu^*$, LPs are mostly dominating in comparison to SFs or target projectile like fragments. With addition of centrifugal potential we see that at higher angular momentum potential ($\ell = 30\hbar$) SFs further dominant with $^{29}Si^*$ in $^{58}Cu^*$ and $^{24}Mg^*$ and ^{35}Cl fragments in $^{59}Cu^*$. Whereas LPs goes into

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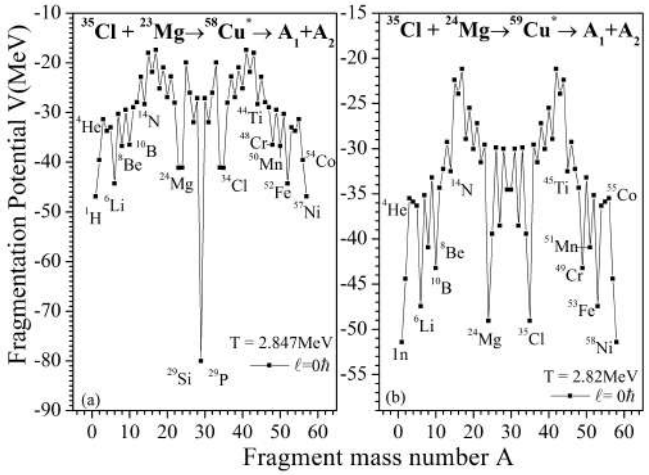

FIG. 1: The variation of total fragmentation potential V (MeV) with fragment mass number (A) for compound nucleus (a) $^{58}Cu^*$ (b) $^{59}Cu^*$ at touching configuration and for $\ell = 0\hbar$.

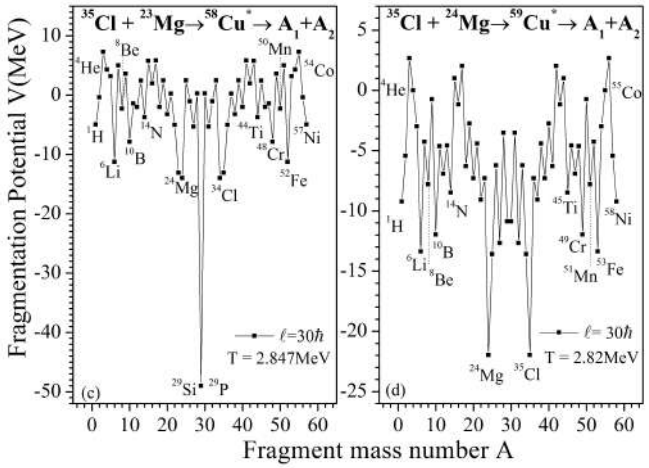

FIG. 2: Same as Fig 1(a,b) but at higher ℓ values

oblivion at higher ℓ values, while IMFs start competing with SFs and near SFs in both the cases. At $\ell = 0\hbar$ LPs dominant the target projectile like SFs for $^{59}Cu^*$ as ℓ value increases LPs start competing. But for $^{58}Cu^*$, LPs are dominant, b at higher ℓ values but $^{29}Si^*$ and $^{29}P^*$ fragment more probable.

This picture of competition among the LPs, IMFs, SFs, asymmetric fragments in $^{58}Cu^*$ and $^{59}Cu^*$ will be further analysed within their preformation probability profiles. A comparative studies of these profiles will further enhance the understanding about the process of collective clusterisation. Furthermore the penetrability of these binary fragments across the potential barrier further establish the corresponding cross section values, which will be compared with the given experimental data [3]. The results related to the isotopic chain of CN $^{58-61}Cu^*$ is under progress.

References

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