Effect of N/Z ratio in the decay of compound nuclei with A=60

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Introduction

We have investigated the effect of N/Z ratio in the decay of compound nuclei, CN with A=60 formed in different reactions. The N/Z ratio for the, under study, CN ^{60}Fe*, ^{60}Ni* and ^{60}Zn* is 1.3, 1.1 and 1, respectively. Isospin or N/Z effects in the decay of these CN will be explored with the comparative study of the interplay between nuclear structure and reaction dynamics, within the framework of quantum mechanical fragmentation theory (QMFT) based dynamical cluster decay model (DCM) of Gupta and Collaborators [1]. It will be highly interesting to study the particle evaporation as well as fusion-fission from these compound systems having same A(=60) but different N/Z ratio.

The fusion cross sections σ_{fus} for the CN ^{60}Fe*, ^{60}Ni* and ^{60}Zn* formed in the reactions ^{4}He+^{56}Cr, ^{4}He+^{56}Fe and ^{4}He+^{56}Ni, respectively with $E_{lab} \sim 10$ MeV, have been calculated within the DCM. Note that the projectile ^{4}He as well as bombarding energy is same in these reactions. It is relevant to mention here that very recently, σ_{fus} induced by loosely bound or stable projectiles, with the same energy, on different targets have been studied extensively [2]. In these studies, the value of neck length parameter ΔR is fixed empirically for the given projectile at a given choice of projectile energy. The σ_{fus} for all other reactions induced by the same projectile at fixed incident energy on different targets are calculated/ predicted using the same value of ΔR^{emp}.

In the present work, we have utilised predictability of the DCM, to study the CN ^{60}Fe*, ^{60}Ni* and ^{60}Zn*. In order to fix the value of ΔR^{emp} for the given choice of projectile and bombarding energy, we have fitted the avaialble data for the σ_{fus} of the ^{4}He+^{40}Ca, ^{4}He+^{44}Ca and ^{4}He+^{64}Zn reactions [3].

Methodology

The DCM [1], worked out in terms of collective co-ordinates of mass (and charge) asymmetries, 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 Coulomb barrier.

Calculations and Discussions

Fig. 1 shows the calculated fragmentation potentials at ℓ=0 $\hbar$ and the ℓ_{max}=40 $\hbar$ values for the decay of ^{60}Fe*, ^{60}Ni* and ^{60}Zn* formed in the ^{4}He induced reactions at E_{lab}∼10 MeV. Here, common observation is that at ℓ=0 $\hbar$, light particles, LPs fragmentation is prominent while this trend is reversed by including the angular momentum effects and intermediate mass fragments, IMFs starts competing with LPs at higher ℓ values. However, when N/Z ratio approaches 1 (i.e. for ^{60}Zn*), we see that symmetric or near symmetric fragments are minimized strongly in comparison to LPs at higher ℓ values. Whereas for ^{60}Fe* and ^{60}Ni* (having N/Z=1.3 and 1.1 respectively) LPs are still

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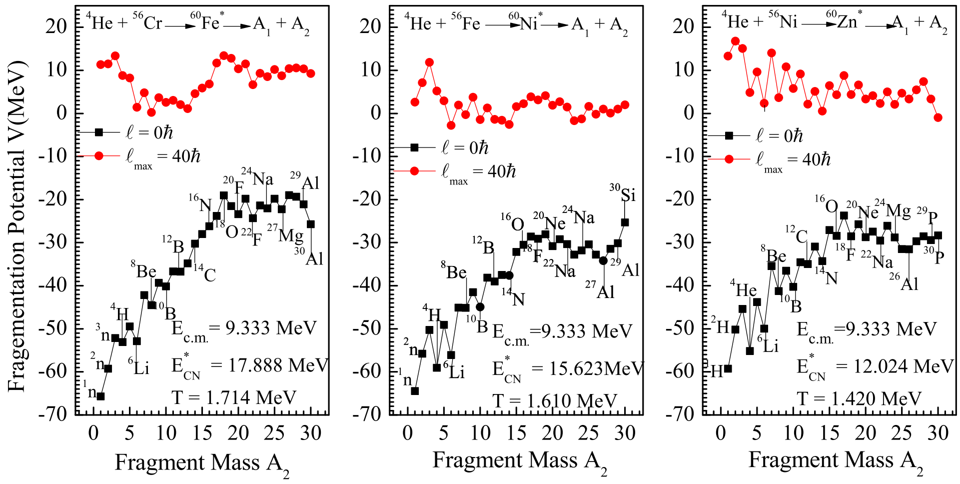

FIG. 1: (Color online) Variation of fragmentation potential with fragment mass A_2 for the decay of (a) ^{60}Fe*, (b) ^{60}Ni* and (c) ^{60}Zn*, for ℓ=0 $\hbar$ and ℓ_{max}=40 $\hbar$ values, with ΔR^{emp}=1.06 fm.

TABLE I: The DCM calculated σ_{fus} ^{4}He induced reactions on different targets at incident energy $E_{lab} \sim 10$ MeV and for ΔR^{emp}=1.06 fm, and their comparison with the available data [3].

Reaction	$E_{c.m.}$ (MeV)	E^*_{CN} (MeV)	T (MeV)	ℓ_{max} ($\hbar$)	$\sigma_{fus.}$ (mb) DCM	Expt.
^{4}He+^{40}Ca→^{44}Ti*→$A_1 + A_2$	8.854	13.98	1.796	31	413.98	378.85 ± 26.78
^{4}He+^{44}Ca→^{48}Ti*→$A_1 + A_2$	8.91	18.357	1.953	35	388.24	355 ± 52.07
^{4}He+^{56}Cr→^{60}Fe*→$A_1 + A_2$	9.333	17.888	1.714	40	214.41	-
^{4}He+^{56}Fe→^{60}Ni*→$A_1 + A_2$	9.333	15.623	1.610	40	180.10	-
^{4}He+^{56}Ni→^{60}Zn*→$A_1 + A_2$	9.333	12.024	1.420	40	145.67	-
^{4}He+^{64}Zn→^{68}Ge*→$A_1 + A_2$	9.617	13.016	1.381	44	89.7	90.60

in strong competition with symmetric fragments even at the higher ℓ values.

Moreover, among LPs the effect of N/Z ratio is quite evident for these CN. Fig. 1 shows that in case of ^{60}Zn*, ^{4}He is emitted, whereas in case of ^{60}Fe* and ^{60}Ni*, ^{4}H is emitted. Moreover, n-decay with different masses from neutron rich isobars (of A=60) is quite evident i.e. neutron emission is stronger for ^{60}Fe*. Table I shows that the DCM calculated σ_{fus} are in good agreement with the available experimental data [3]. The σ_{fus} is predicted here for the reactions under study, where the experimental data is not available. The σ_{fus} for ^{60}Zn* is lowest, among A=60 CN, as the temperature T is least for the same. Study is in progress.

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