Study of ^{48}Ti induced reactions in sub-barrier region forming $^{106}Cd^*$ and $^{106}Sn^*$ compound systems at $E^*_{CN} \sim 48MeV$

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Introduction

The study of the heavy ion reactions give immense information about nuclear structure and the reaction dynamics.The deformation and the orientation effects of the participating nuclei play an important role in the reaction process. Thus, a relevant difference in the nuclear structure may lead to significant change in the sub-barrier fusion excitation functions [1]. It has been observed that fusion cross section, σ_{fus} also depends on the N/Z ratio in the sub-barrier region [1].

Keeping in view such observations we intend to explore dynamics of compound nuclei (CN) $^{106}Cd^*$ and $^{106}Sn^*$ formed via $^{48}Ti^*$ induced reactions in sub barrier region with in the dynamical cluster decay model (DCM) [2]. A work in the same mass region has been carried out previously [3], within DCM, and it is observed that there is negligible contribution from the intermediate mass fragments, IMFs to the σ_{fus} and the light particles, LPs (A≤4) have larger contribution in the same. It is relevant to mention here that the missing structure information in statistical models is included in the DCM through preformation probability (P_0). The available experimental data [1] has been fitted by the only parameter of DCM, i.e. neck length ΔR, for both the spherical as well as oriented considerations. It is important to note here that one of decaying compound nucleus is magic i.e. $^{106}Sn^*$ has proton shell closure, Z = 50. In the present work, we try to investigate effect of shell closure in the reaction dynamics alongwith the N/Z dependence in sub-barrier regime (having studied the decay of CN $^{106}Cd^*$ and $^{106}Sn^*$ with N/Z = 1.2 and 1.1, respectively), within the model calculations.

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Methodology

The DCM [2, 3] of Gupta and collabrators is worked out in terms of collective co-ordinates of mass (and charge) asymmetries. In terms of above said co-ordinates, for ℓ-partial waves, the compound nucleus decay cross-section is given by

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

Where, $\mu = [A_1 - A_2/(A_1 + A_2)]m$, is the reduced mass, with m as the nucleon mass and ℓ_{max} is the maximum angular momentum. P is the barrier penetration probability and P_0 is the preformation probability at a fixed R on the decay path. The structure information in P_0 enters through the fragmentation potential $V_R(\eta, \beta_{\lambda i}, \theta_i, T)$ for hot and compact orientations, which is calculated as,

$$V_R(\eta,\beta_{\lambda i},\theta_i,T) = \sum_{i=1}^{2}[V_{LDM}(A_i,Z_i,T)] + \sum_{i=1}^{2}[\delta U_i]\exp(\frac{-T^2}{T_0^2}) + V_C(R,Z_i,\beta_{\lambda i},\theta_i,T) + V_P(R,A_i,\beta_{\lambda i},\theta_i,T) + V_\ell(R,A_i,\beta_{\lambda i},\theta_i,T) \tag{2}$$

Here V_{LDM} and δU are, respectively, the liquid drop and shell correction energies, V_c, V_P and V_ℓ are the Coulomb, proximity and angular momentum dependent potentials.

TABLE I: The DCM calculated σ_{fus} of CN $^{106}Cd^{*}$ and $^{106}Sn^{*}$, formed in the reactions ^{48}Ti+^{58}Fe and ^{48}Ti+^{58}Ni, and their comparison with the experimental data [1].

Reaction	N/Z	$E_{c.m.}(MeV)$	T(MeV)	$\ell_{max}(\hbar)$ (Sph.)	$\ell_{max}(\hbar)$ (Def.)	ΔR (fm) (Sph)	ΔR (fm) (Def.)	σ_{fus}^{DCM} (mb) Sph.	σ_{fus}^{DCM} (mb) Def.	$\sigma_{fus}^{Expt.}$ (mb)
^{48}Ti+^{58}Fe→$^{106}Cd^{*}$	1.2	72.0	2.070	72	70	1.314	1.305	34.8	35.0	34.8±6.58
^{48}Ti+^{58}Ni→$^{106}Sn^{*}$	1.1	80.0	2.075	68	67	1.170	1.366	57.0	57.2	57.2±2.95

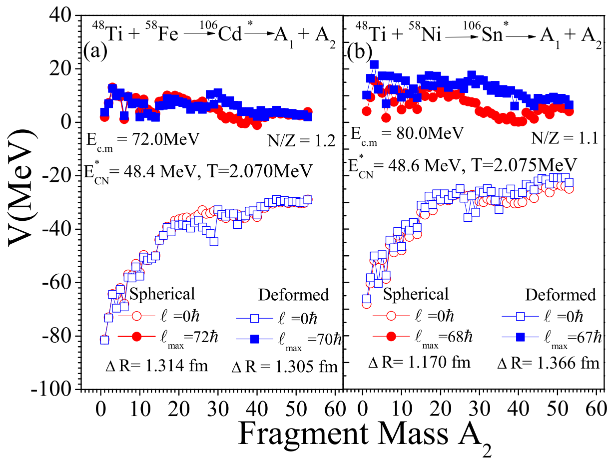

FIG. 1: The variation of fragmentation potential V (MeV) with fragment mass A_2 for the decay of CN $^{106}Cd^{*}$ and $^{106}Sn^{*}$ at $E^{*}_{CN} \sim 48MeV$ for $\ell = 0$ and the respective ℓ_{max}-values.

Calculations and Discussions

Fig.1 shows the variation of fragmentation potential with fragment mass A_2 for the decay of CN (a) $^{106}Cd^{*}$ and (b) $^{106}Sn^{*}$ at two extreme ℓ-values. It is noticed that at $\ell = 0$, the light particles (LPs) are more dominant whereas with the increase in ℓ-values the fission fragments starts competing with LPs for spherical as well as deformed configuration for the decay of both the CN under study. The fission fragments in the decay of both the CN show little prominence in comparison to the LPs at ℓ_{max}-value. They are minimized little more in comparison to the LPs (apparently, this behaviour is explicit for more number of fission fragments in case of compound nucleus $^{106}Sn^{*}$), particularly for the spherical considerations, whereas for the choice of oriented nuclei LPs regains prominence at both the extreme ℓ-values. The potential energy surface (PES) are nearly same for both the considerations for the decay of CN $^{106}Cd^{*}$ and $^{106}Sn^{*}$. However, for the magic compound system $^{106}Sn^{*}$ the change in the PES is quite evident at the ℓ_{max}-value. It is motivating to investigate the preliminary result to further explore the fact that whether this change in PES is attributed to the magicity of the compound system or the N/Z ratio.

Table I presents the preliminary results of the DCM calculated σ_{fus} and their comparison with the experimental data [1]. The calculated σ_{fus} for both the reactions are in good comparison with the experimental data, for both the spherical as well as oriented configurations of the nuclei. Here, we observe that the σ_{fus} is enhanced for the neutron deficient magic compound nucelus i.e. $^{106}Sn^{*}$ having N/Z = 1.1. Work is in progress.

References

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