Decay of compound system $^{179}Re^*$ formed in $^{20}Ne + ^{159}Tb$ reaction using dynamical cluster decay model

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Introduction

The dynamical cluster decay model (DCM) of Gupta and collaborators have been successfully applied to study the dynamics of heavy ion induced reactions forming extremely and very light, light, medium, heavy as well as superheavy composite systems [1]. These studies established that the composite systems formed in light mass region (A_{CN}<80) predominantly decays via light particles, LPs (A$\leq$ 4, Z$\leq$ 2) emissions or equivalently evaporation residue (ER) and, medium mass composite system (A_{CN}>100) decays by emission of LPs ,intermediate mass fragments (IMF) and fusion-fission (FF) process. The heavy and superheavy composite systems decays mainly via FF and in addition some non compound nucleus processes (quasi fission) may also contribute. In other words, different mass regions of compound nuclei show different combinations of these three processes (ER, IMF and FF) or any one of them as a dominant mode. A lot of efforts have been made to check the role of entrance channel in the decay dynamics of same composite system formed in different reactions [1].

We intend to study that how the reaction dynamics is affected by choosing the same projectile (^{20}Ne) on two different targets ^{159}Tb and ^{189}Au at same beam energies E/A= 8, 10, 13, 16 MeV [2]. In the present work, we take up the study of medium mass compound system $^{179}Re^*$ formed in ^{20}Ne+^{159}Tb reaction at E^*_{CN} = 112 MeV. We have presented here the preliminary results, with quadrupole deformation and hot/ compact orientation of nuclei, indicating the FF and ER as the equally probable decay modes of $^{179}Re^*$.

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Dynamical Cluster decay Model (DCM)

The dynamical cluster decay model, based on Quantum mechanical fragmentation theory, is worked out in terms of collective coordinate of mass asymmetry η = (A_T-A_P)/(A_T+A_P), relative separation (R), multiple deformations $\beta_{\lambda i}$ (λ=2,3,4..., i= 1,2,3..) and orientation θ_i of two nuclei/fragments. In terms of these collective coordinates, using the ℓ- partial waves, the decay cross-section is defined as

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

where preformation probability P_0 refers to η motion and is given by sol. of stationary Schrodinger eq. in η, using the fragmentation potential V (MeV). Penetrability P refers to R motion and is calculated using WKB approximation, μ is the reduced mass, ℓ_{max} is the maximum angular momentum defined for LPs cross-section $\sigma_{LP}\rightarrow$ 0. The only parameter of the model is the temperature dependent neck length parameter $\Delta R(T)$. Within DCM, the fusion cross-section is defined as σ_{fus}= σ_{ER}+σ_{IMF}+σ_{FF} where σ_{ER}, σ_{IMF}, σ_{FF} refers to evaporation residue, intermediate mass fragments, fusion-fission cross-sections, respectively.

Calculations and discussions

Fig. 1(a) shows the calculated fragmentation potential V (MeV) for the decay of $^{179}Re^*$ as a function of light fragment mass A_2 at two extreme ℓ = 0 and ℓ_{max} values using quadrupole deformations and hot/compact orientation of emerging fragments. We note

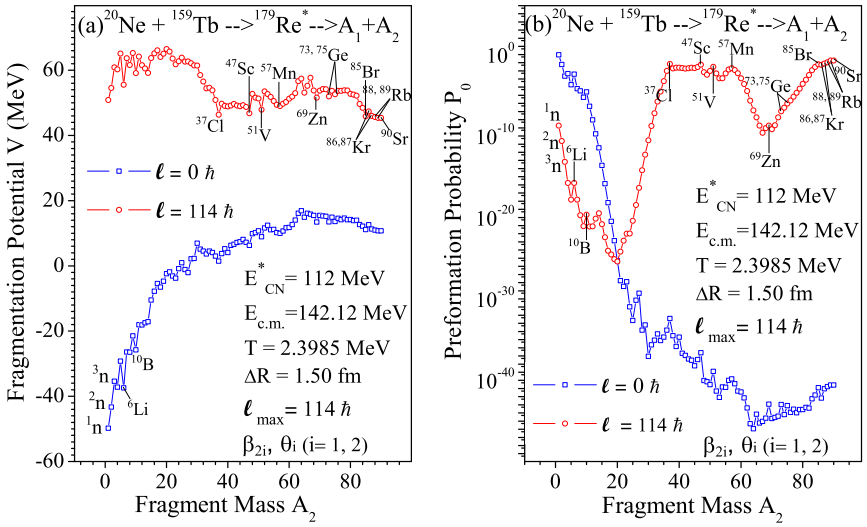

FIG. 1: (a) Fragmentation potential V (MeV) as a function of light fragment mass A_2, for the decay of ^{179}Re* formed in ^{20}Ne+^{159}Tb reaction at $E_{c.m.}$ = 142.12 MeV for ℓ =0 and 114 $\hbar$. (b) Same as (c) but for Preformation probability P_0.

that the LPs are favored at ℓ= 0$\hbar$, but at higher ℓ values the symmetric fragments become more favored alongwith ^{37}Cl, ^{47}Sc, ^{51}V and ^{57}Mn. At ℓ=114$\hbar$, a strong minima is obtained for symmetric fragments A = 85-89, denoted as the symmetric fission (SF) window of mass $A_{CN}/2 \pm 5$, as observed in the experiment also [2].

Fig. 1(b) shows variation of preformation probability P_0 with light fragment mass A_2 for the decay of $^{179}Re^{*}$ at two extreme ℓ-values. We find that LPs dominate/ strongly preformed at lower ℓ value but at higher ℓ values ^{37}Cl, ^{47}Sc, ^{51}V, ^{57}Mn are also strongly preformed along with the symmetric fragments A = 85-89. These preliminary results for decay of $^{179}Re^{*}$ indicate the strong presence of IMFs alongwith FF and ER. Here, calculations are done using quadrupole deformation only while consideration of higher order deformations will be matter of interest. Moreover, dynamics of $^{179}Re^{*}$ at higher incident energies and comparative analysis with decay of ^{189}Au formed in ^{20}Ne+^{169}Tm reaction will also be a matter of interest in further study.

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