Proton evaporation yields of $^{65}Ge^*$ formed in $^{7}Be + ^{58}Ni$ reaction at near and sub-barrier energies

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Introduction

The radioactive ion beam (RIB) technique has revitalized the research on nuclear structure and reactions involving exotic nuclei both experimentally as well as theoretically. Most of the efforts with light unstable nuclei has been concentrated on halo systems like ^{6}He and ^{11}Be [1]. In recent years, the study of proton-rich systems (towards proton drip-line) has become an interesting area of research. Many reactions induced by weakly bound radioactive nuclei have been studied in the energy region near and around Coulomb barrier. Low breakup threshold and cluster structure of these nuclei enhance the importance of reaction dynamics i.e. transfer and breakup channel starts competing with usual compound nucleus process. This may influence the quantum tunneling which may effect the fusion cross-sections via modification in the barrier height and barrier position. So, the interesting feature of these studies is to address the effect of breakup of such loosely bound projectiles on the fusion cross-sections in the context of enhancement and suppression processes [2, 3].

In view of having important information regarding nuclear structure and dynamics associated with the fusion of exotic proton rich nucleus ^{7}Be with ^{58}Ni target at near and sub-barrier energies, the calculations are carried out within the framework of dynamical cluster decay model (DCM) of Gupta and Collaborators [4]. The experimental data for the proton-evaporation yield of compound system $^{65}Ge^*$ formed in $^{7}Be + ^{58}Ni$ reaction is available [3]. In view of this experiment, the proton evaporation yield is calculated at near and sub barrier energies.This study is done by spherical as well as hot compact oriented considerations at six different centre of mass energies, $E_{c.m.}$. Here, the preliminary calculations of proton evaporation yields σ_P are compared with the experiemtnal data along with relevant discussions associated with fragmentation profile and preformation behavior.

Methodology

The decay of hot and rotating compound nucleus is studied within framework of dynamical cluster decay model (DCM) [4], which is worked out in terms of collective coordinates of mass asymmetry $\eta = (A_T\text{-}A_P)/(A_T\text{+}A_P)$ and relative separation (R) with effects of temperature, deformation and orientation duely incorporated in it. 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 solution 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 and ℓ_{max}, the maximum angular momentum is fixed for vanishing light particles cross-sections σ_{LP}.

Calculations and discusions

Fig. 1(a and b) show the variation of fragmentation potential V (MeV) and preformation probability P_0 as function of fragment mass for the decay of ^{65}Ge* formed in ^{7}Be

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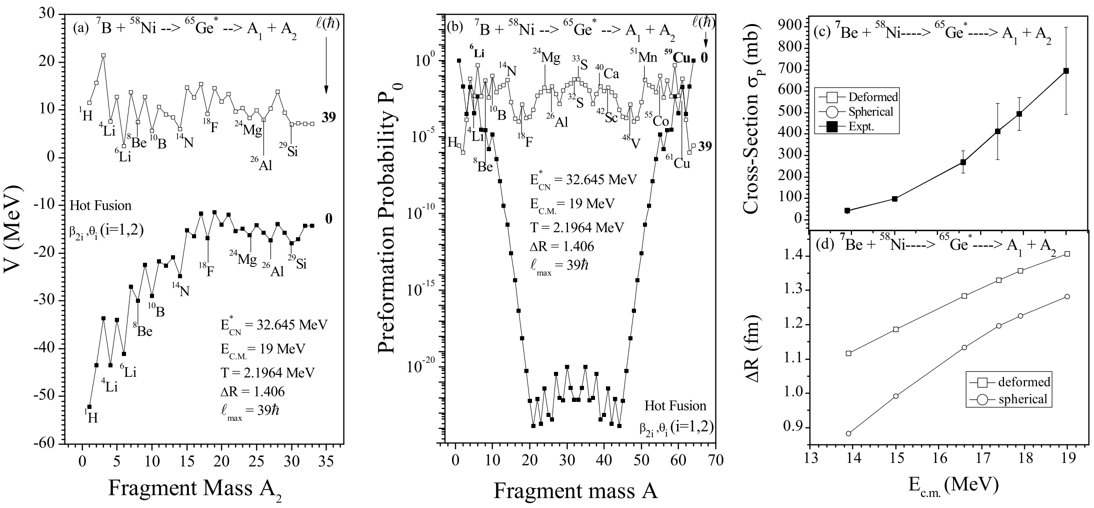

FIG. 1: (a) Fragmentation potential V (MeV) and (b) Preformation Probability P_0 as function of fragment mass, calculated for the decay of ^{65}Ge* formed in ^{7}Be+^{58}Ni reaction at $E_{c.m.}$ = 19 MeV for ℓ =0 and 39 $\hbar$. (c) DCM calculated σ_P for considerations of spherical and hot Compact orientations of nuclei, for the decay of ^{65}Ge* compared with the experimental data [3] at different $E_{c.m.}$. (d) Same as (c) but for neck length parameter ΔR.

+ ^{58}Ni at $E_{c.m.}$ = 19 MeV for ℓ =0 and 39 $\hbar$. The neck length parameter ΔR is taken as free parameter to fit the proton evaporation yield σ_P. The structure of V (MeV)/ potential energy surface (PES) and P_0 changes drastically in going from $\ell = 0$ $\hbar$ to ℓ_{max}-value. The characteristic behaviour of the light particles LPs (A≤4) and intermediate mass fragments IMFs is opposite to each other. In other words at lower ℓ-values, the LPs are energetically favoured (lower in energy or strongly preformed), whereas the same is true for IMFs or fission fragments at higher ℓ-values. Very interestingly, ^1H or proton yields are not only favoured at $\ell = 0$ $\hbar$ but seem competing even at higher ℓ-values with the IMFs $^{4,6}Li$, ^8Be and ^{10}B fragments.

Fig. 1(c) shows the proton evaporation yield as function of $E_{c.m.}$. It shows that proton evaporation residue cross-section increases with increase in energy for spherical consideration as well as hot compact oriented nuclei. The calculated yields within DCM shows good agreement with the experimental data [3]. Fig. 1(d) shows the variation of neck length parameter with $E_{c.m.}$ which is more for deformed nuclei than that of spherical considerations. These are preliminary calculations and we are in the process of exploring the dynamics of this reaction, which we hope to complete by the time of presentation.

Acknowledgement

B.B.S. acknowledges the support by the Department of Science and Technology, New Delhi, in the form of a Young Scientist Award under the SERC Fast Track Scheme, vide letter No. SR/FTP/PS-013/2011.

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