Investigation of decay properties of ^{248}No formed via $^{40}Ca+^{208}Pb$ reaction at above barrier energies

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Introduction

The study of superheavy elements has been a topic of great interest in the area of nuclear physics. The search for the elements $Z>100$ explores the vicinity of the nuclear chart. Investigating the superheavy nuclei beyond Fermium has received much attention in last few decades because these nuclei belong to the class of transfermium elements whose stability is governed primarily by the shell effects. The quest for the heaviest element in the nuclear landscape has yielded many surprises and expanded our understanding of nuclear reactions. Even with the discovery of new heavy nuclides Z $\geq$ 112, the amount of information near the Z $\geq$ 102 is somewhat scarce. Persistent theoretical and experimental attempts have been made to investigate various reaction conditions and their subsequent decay mechanism. Although, the No ($Z = 102$) isotopes produced in the experiments are still neutron deficient. Recently, K.M. Kozulin *et al.*[1] has studied the mass-energy distributions of fission fragments by considering the doubly magic ^{40}Ca as the projectile and the stable ^{208}Pb as the target that leads to the formation of ^{248}No. In the present work, we aim to study the fission properties of ^{248}No compound nucleus at incident energies above the Coulomb barrier using the Dynamical Cluster-decay Model (DCM). The nucleus-nucleus interaction potential adopted in this work is obtained using the Skyrme energy density formalism (SEDF) with the GSkI parameter set. The focus of this work is to analyze the fragment mass distributions for the spherical as well as deformed choice of decaying nuclei.

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Methodology

Based on QMFT [2], the collective potential energy or the fragmentation potential is defined as the sum of the deformation and orientation dependent Coulomb (V_C), nucleus-nucleus interaction potential (V_N) and angular momentum (V_ℓ) dependent potentials, i.e.

$$\begin{aligned} V(\eta, T) &= V_C(R, Z_i, \beta_{\lambda i}, \theta_i, T) \\ &\quad + V_N(R, Z_i, \beta_{\lambda i}, \theta_i, T) \\ &\quad + V_\ell(R, Z_i, \beta_{\lambda i}, \theta_i, T). \end{aligned} \quad (1)$$

The Preformation probability (P_0) is obtained by solving the Schrodinger equation and is given as:

$$P_0 = \mid \psi(\eta(A_i)) \mid^2 \sqrt{B_(\eta\eta)} \frac{2}{A_{CN}} \quad (2)$$

Further, the interaction potential (V_N) is calculated using the extended Thomas Fermi (ETF) approach in SEDF. The nucleus-nucleus interaction potential in SEDF, based on the semi-classical extended Thomas Fermi (ETF) method [3, 4], is defined as

$$V_N(R) = E(R) - E(\infty), \quad (3)$$

Here, $E = \int H(r)dr$, where H is the Skyrme Hamiltonian density [5].

Results and Discussions

This section consists of analysis regarding the decay processes for ^{248}No formed in the $^{40}Ca+^{208}Pb$ reaction over the range of centre-of-mass energies above the Coulomb barrier, $E_{c.m.}$ = 187 - 238 MeV. In this work, we aim to explore the fragment mass distribution within the DCM framework using Skyrme energy density formalism (SEDF) with GSkI parameter sets for spherical as well as deformed choice of decaying fragments. Fig.1 (a) depicts the fragmentation potential $V(\eta, R)$ as a function of fragment mass A_2 at $E_{c.m.}$ = 187.07

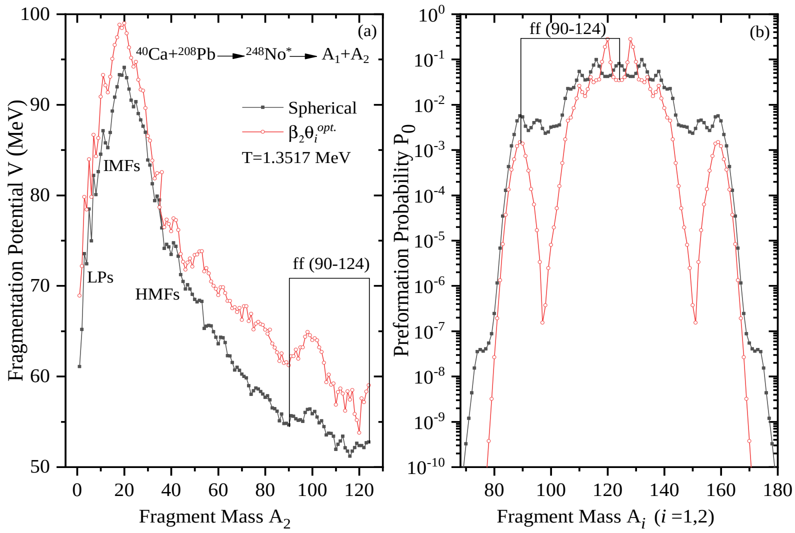

FIG. 1: (a) The fragmentation potential $V(\eta, R)$ as a function of fragment mass A_2 at the centre-of-mass energy $E_{c.m.}$ = 187.03 MeV using the best fitted ΔR for ℓ_{max} states plotted for the spherical as well as deformed choice of nucleus. (b) The corresponding preformation probability P_0 is plotted as a function of fragment mass A_i at $E_{c.m.}$ = 187.03 MeV using the best fitted ΔR for ℓ_{max} states.

MeV for the spherical nuclei and quadruple deformed choice at ℓ_{max}. The calculated T-dependent collective potential energy $V(\eta, R)$ gives the relative contribution of probable decay fragments. It may be noticed from the figure that in case of light particles (LPs), intermediate mass fragments (IMFs) and heavy mass fragments (HMFs), the overall structure remains deformation independent, with slightly higher amplitude for deformed case. Relatively more pronounced enhancement is observed in the fission region i.e. A_2 = 90-124. The variation of potential energy surface reveals an symmetric distribution. Further Fig.1 (b) shows the Preformation probability P_0 plotted as a function fragment mass $A_i(i = 1, 2)$ at $E_{c.m.}$ = 187.03 MeV at ℓ_{max} value for the spherical as well as deformed choice of nuclei. It can observed from this figure that the magnitude as well the structure of P_0 changes as we include the deformation effect of decay fragments. The mass distribution changes from near symmetric nature to relatively asymmetric nature with the inclusion of deformation effect. At the higher energies, it is observed that the fragmentation and the preformation profile remains almost similar to the ones observed at lowest energies. The above analysis will be extended further to explore decay dynamics of Z = 102 isotopes by employing phenomenological and energy density formalism (EDF) based nuclear interactions.

References

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