Study of decay dynamics of the compound nucleus ^{160}Er* formed via ^{16}O induced reaction

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Introduction

The field of nuclear reaction dynamics is advancing rapidly and continual efforts are being made in both experimental and theoretical domains. In the past few decades, the measurement and analysis of heavy-ion fusion cross-sections has become a fascinating topic of research. Essentially, such data yield information about the nucleus-nucleus potential [1]. For a comprehensive understanding of different nuclear properties, nuclear structure, and related reaction dynamics the study of complete fusion dynamics is important. In view of this, a theoretical attempt has been made in the framework of Dynamical cluster-decay model (DCM) [2] to explore the decay patterns and properties of a hot and rotating compound nucleus ^{160}Er* formed via ^{16}O+^{144}Nd reaction within 3.75-4.7 MeV/A [3] energy range.

Methodology

The DCM is based on the Quantum Mechanical Fragmentation Theory, and it considers the collective clusterization approach in which light particles, intermediate mass fragments and fission fragments (FF) are treated in unique set of calculations. DCM uses the collective coordinates of mass (and charge) asymmetry ($\eta = \frac{A_1-A_2}{A_1+A_2}$ and $\eta_Z = \frac{Z_1-Z_2}{Z_1+Z_2}$), and the relative separation R to which the multipole deformations $\beta_{\lambda i}$ and orientations θ_i ($i = 1, 2$) of daughter(A_1, Z_1) and cluster(A_2, Z_2) nuclei are added. The decay cross section of the compound nucleus is calculated as

$$\sigma = \frac{\pi}{k^2}\sum_{\ell=0}^{\ell_{max}}(2\ell+1)P_0 P; k = \sqrt{\frac{2\mu E_{c.m.}}{\hbar^2}} \quad (1)$$

The cluster preformation probability P_0 is obtained by solving the stationary Schrödinger equation in η-coordinate at fixed R=R_a. The structure information of the decaying nucleus is contained in P_0 via the fragmentation potential defined as:

$$V_R(\eta, T) = \sum_{i=1}^{2} V_{LDM} + \sum_{i=1}^{2}[\delta U_i]\exp(-T^2/T_0^2) + V_C + V_P + V_\ell \quad (2)$$

where V_{LDM}, δU_i, V_C, V_P and V_ℓ are, respectively, liquid drop potential, shell correction term, Coulomb, nuclear proximity and centrifugal potentials, T is the temperature. The normalized function (P_0) at a fixed R (=R_a=R_t+ΔR, the first turning point) reads as:

$$P_0 = |\psi[\eta(A_i)]|^2 \frac{2}{A_{CN}}\sqrt{B_{\eta\eta}}, \quad (3)$$

P in Eq. 1 is the barrier penetrability which is calculated using WKB approximation at a fixed η as

$$P = \exp[-\frac{2}{\hbar}\int_{R_a}^{R_b}[2\mu(V(R) - Q_{eff})]^{1/2}dR], \quad (4)$$

Q_{eff} is the effective Q-value of the decay process.

Results and discussion

In order to look for the reaction dynamics and the relative fragmentation of decay products from compound nucleus ^{160}Er* formed

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by the reaction ^{16}O+^{144}Nd, we have applied DCM in reference to data of [3]. In the present analysis, the calculations have been performed using quadrupole deformed choice of fragmentation with the equatorial compact orientations, where the interaction radius is smallest and barrier height is highest [4]. In Fig.1, the preformation probability P_0 is plotted as a function of fragment mass A_i, for the decay of ^{160}Er* compound system and it is evident from the figure that the lower l-values favor the emission of light charged particles with $A_2 \leq 4$ as they have higher P_0 values and when we proceed towards l_{max} values, the fragments corresponding to the heavy mass fragment (HMF) and FF region show an elevation in the preformation factor which suggest that HMF and FF also contribute in the decay mechanism of ^{160}Er*.

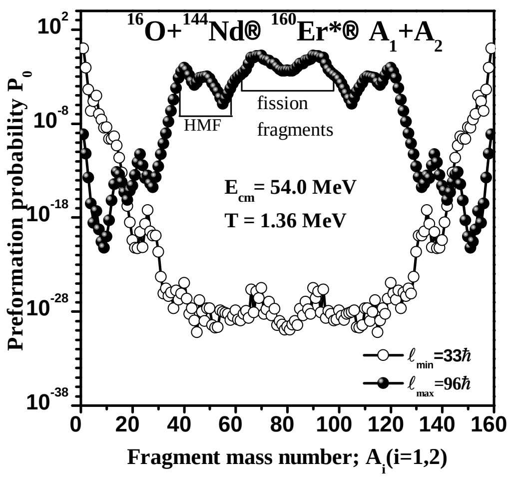

FIG. 1: The distribution of P_0 as a function of fragment mass number A_i in the decay of ^{160}Er* at ℓ_{min} and ℓ_{max}

At l=l_{max}, the potential energy surface signifies the asymmetric fission in the decay of compound nucleus. Further, the total fusion cross sections [3] calculated using Eq.1 reproduce the experimental data and shown in Fig.2 for quadrupole deformations using the only parameter of the model, the neck length parameter $\triangle R$ [2]. The fusion cross sections calculated from DCM agree well with the re-

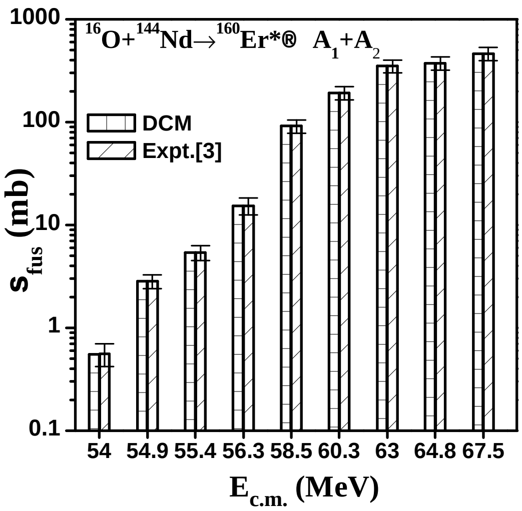

FIG. 2: Comparison of experimental σ_{fus} and the same obtained from the DCM for ^{16}O+^{144}Nd reaction.

ported data [3]. However, it would be of further interest to investigate the decay patterns of the same compound system by taking the higher order deformations and different orientations into account.

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