Decay of ^{196}Pt* formed in inverse kinematic ^{132}Sn+^{64}Ni reaction using the dynamical cluster-decay model

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Introduction

Evaporation residue (ER) and fission cross-sections are measured in ^{132}Sn+^{64}Ni reaction at the near and sub-barrier energies [1]. At sub-barrier energies only the ER cross-sections are measured because the fission decay of the compound nucleus (CN) is negligible. In this experiment, quasi-fission (qf) component could not be separated from fusion-fission because the reaction was in inverse kinematics and the beam intensity was several orders of magnitude lower than that of stable beams (the heaviest stable Sn-nucleus is ^{124}Sn). A coupled-channel calculation including neutron tranfer and inelastic excitation of the projectile and target (CCFULL), and a density-constrained TDHF calculation reproduce the measured excitation functions (the sum of ER and fission cross-sections as a function of centre-of-mass energy $E_{c.m.}$) very well at sub-barrier energies though there are deviations (under- and over-estimation) at the above and near Coulomb barrier energies, respectively.

In this paper, we have used the dynamical cluster-decay model (DCM) of Gupta and collaborators [2] to estimate for the first time the CN decay cross-section, as well as the possible non-compound qf content, in this reaction with inverse kinematics. In DCM, all decay products are calculated as emissions of preformed clusters through the interaction barriers, treating the ER and fusion-fission decays on equal footings, and then allowing the incoming target and projectile nuclei to keep their identity (preformation probability P_0=1) for the qf process.

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The Model

The DCM uses the collective co-ordinates of mass asymmetry $\eta = (A_1 - A_2)/(A_1 + A_2)$ and relative separation R, which allows to define the CN decay cross-section, in terms of the partial waves, as

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

with μ as the reduced mass and l_{max}, the maximum angular momentum, fixed for the vanishing of the fusion barrier of the incoming channel, or else for the light particle cross-section $\sigma_{ER}(\ell) \rightarrow 0$. P_0, the pre-formation probability, is the solution of stationary Schrödinger equation in mass asymmetry coordinate η and P is the WKB penetrability of preformed fragments or clusters in R-motion. The only parameter of the model is the temperature dependent neck length parameter ΔR(T), defining the first turning point $R_a = R_1(\alpha_1, T) + R_2(\alpha_2, T) + \Delta R(T)$ for the penetration of preformed fragment. The decay fragments are consider to be deformed with quadrupole deformation β_2 alone, having "optimal" orientations of hot configuration [3].

Calculations and discussion

Fig. 1 shows the preformation probability P_0 as a function of fragment mass for a fixed $E_{c.m.}$ and ℓ=0 and ℓ_{max} values. We notice that at ℓ=0 only the ER contribution is most prominent, whereas the same at ℓ_{max} is prominent more for the fission fragments in the symmetric fission (SF) and near symmet-

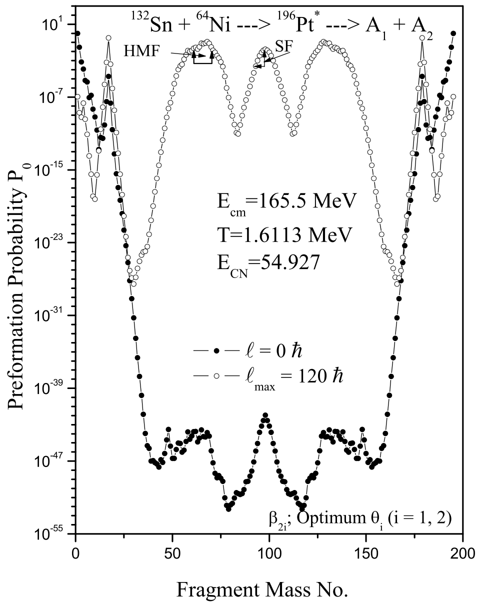

FIG. 1: Preformation probability as a function of fragment mass number for the decay of ^{196}Pt at ℓ_{min} and ℓ_{max} values.

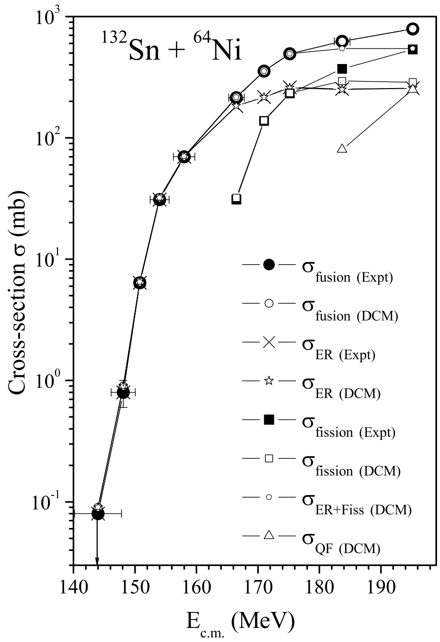

FIG. 2: The DCM calculated σ, and the individual σ_{ER}, σ_{fiss}, and σ_{qf}, compared with experimental data on σ for the ^{132}Sn+^{64}Ni reaction.

ric fission (nSF) regions. A small structure at intermediate mass fragmentation (IMF) starts appearing for ℓ=0, but gets washed at higher ℓ-values. The calculated cross-sections for the SF is very small compared to the nSF cross-section, i.e., $\sigma_{nSF} \sim 10^5 \times \sigma_{SF}$. In other words, calculation of cross-sections for the fusion-fission of $^{196}Pt^{*}$ favors asymmetric fission process, the SF contribution being almost negligible. The other component contributing to total cross-section is ER only. It may be noted that the asymmetric-fission peaks are placed around the target and projectile masses, and hence could contain a qf component, not measured in experiments.

Fig. 2 shows a comparison of our DCM calculated total fusion cross-section σ ($=\sigma_{ER} + \sigma_{fiss} + \sigma_{qf}$) for the decay of ^{196}Pt* and the experimental data for the ^{132}Sn+^{64}Ni reaction [1]. The individual contributions of ER, fission, and qf (for the highest energies) are also shown, for both the data and DCM calculations. Apparently, the comparisons between the experiments and DCM model are excellent for both the individual and total cross-sections, better than the CCFULL and density-constrained TDHF calculations (see Fig. 5 in first part of Ref. [1]), showing that a significant content of non-compound, qf process exists in this reaction, which need be measured.

References

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