Evaporation residue cross-section of ^{201}Bi* formed in ^{20}Ne+^{181}Ta reaction at $E_{c.m.}$=135 MeV

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Introduction

In low energy regime, there are several possibilities of Non-Compound Nucleus (NCN) contributions through processes like, Incomplete Fusion (ICF), Deep-Inelastic Collision (DIC), Quasi-Fission (QF),etc.,which start competing with the fully equilibrated compound nucleus (CN) states depending on various factors like choice of reaction partners, angular momentum, beam energy and entrance channel mass asymmetry etc. Just like CN process, the NCN process also contributes to provide worthy information regarding nuclear structure and nuclear reactions.Therefore, it becomes mandatory to investigate the behavior of NCN component for overall understanding of nuclear dynamics. The main interest in studying the decay of ^{201}Bi* formed in ^{20}Ne+^{181}Ta reaction is that, it provides handful information regarding decay processes such as fission, evaporation residue (ER), and the NCN process which is predominantly ICF in the present case. The experimental data for reaction cross-sections of CN and NCN for ^{20}Ne+^{181}Ta→^{201}Bi*→A_1+A_2 reaction has been reported at two energies [1] and the same is tested in the framework of Dynamical Cluster Decay Model DCM [2].The results are shown only for one energy here i.e. at $E_{c.m.}$=135 MeV or equivalently at E_{Lab}=150 MeV.

The Dynamical Cluster-decay Model (DCM)

The DCM model, carries distinct advantage over available statistical models as it treats the Evaporation Residue (ER), intermediate mass fragments (IMFS) and fusion fision (ff) on equal footing[2]. The missing nuclear structure information of the Compound Nucleus in statistical models enters the DCM via the preformation probability P_0 of the fragments. It is calculated by solving stationary Schrödinger equation in η co-ordinate. For the competing non-compound ICF channel, a part of projectile interacts with target, so P_0 is calculated in same way as that for CN process with only difference that ICF leads to different composite system depending on break-up of the projectile nucleus. On the contrary P_0 is taken as unity for quasi-fission process. For ℓ- partial waves, the compound nucleus decay cross-section is given by

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

where $\mu=[A_1A_2/(A_1+A_2)]m$ is the reduced mass, with m is the nucleon mass, and ℓ_{max} is the maximum angular momentum. The angular momentum ℓ_{max} is fixed for the vanishing of the fusion barrier of incoming channel η_i or light particle cross-section $\sigma_{LP}=0$. The preformation probability P_0 refers to η motion and the penetrability P to R motion, both depending on angular momentum ℓ and temperature T of compound nucleus state.

Calculations and Discussions

In order to investigate various decay mechanisms in ^{201}Bi* formed in ^{20}Ne+^{181}Ta reaction, the Evaporation Residue (ER),and fission cross-sections have been measured at E_{Lab}=150 MeV and E_{Lab}=180 MeV [1]. The ER is shown to have contribution from CN as well as NCN process and we intend to concen-

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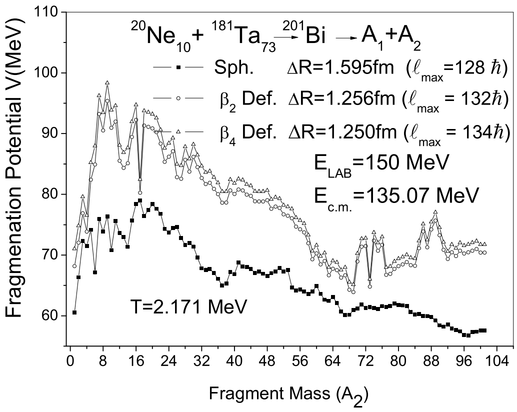

FIG. 1: Variation of fragmentation potential with Fragment Mass A_2 at $\ell = \ell_{max}$.

trate only on ER part in the present study.

At E_{Lab}=150 MeV the CN based ER cross-section is 15 mb and the same is fitted within one parameter, ΔR, the neck-length parameter of the model. The value of ΔR at which the ER cross-section of 15 mb is fitted is different for different choices of fragmentation i.e. spherical, β_2 deformed and β_2-β_4 deformed. The neck-length parameter ΔR is highest (ΔR=1.595 fm) for spherical consideration and it decreases significantly with inclusion of deformations and we get ΔR=1.256 fm and 1.250 fm respectively for β_2 deformed and β_2-β_4 deformed case. The fragmentation path is almost independent of deformation effects for $\ell=0\hbar$ at E_{Lab}=150 MeV. However at $\ell=\ell_{max}$, the potential energy surfaces are greatly influenced with the inclusion of deformation and orientation effects as shown in FIG.1. It may be noticed that the available CN based ER data is fitted for all the three choices of spherical, β_2 deformed and β_2-β_4 deformed and hence the fragmentation path shown in FIG.1 exhibits the exclusive role of deformations in reference to reaction under consideration. Besides this, DCM has been applied for the first time in an ICF process. In present case, ^{20}Ne projectile breaks into four dominant ICF channels (^{16}O transfer reaction, ^{14}N transfer reaction, ^{8}Be transfer reaction and ^{4}He transfer reaction) which in turn interact with the target ^{181}Ta to account for NCN (ICF) based ER cross-sections. The ER formed in these four channels (at ΔR=1.460 fm and β_2 deformed case) are accumulated to account for reported ICF cross-sections of 139mb.

In summary DCM based σ_{ER}(CN) and σ_{ER}(NCN) compare nicely with experimental data. The deformation effects are shown to be important in the decay of ^{201}Bi* formed in ^{20}Ne+^{181}Ta reaction specifically at $\ell=\ell_{max}$. The fragmentation path changes from symmetric to asymmetric with inclusion of deformations, which remain intact even for ICF process. The fragments in mass range 181-197 seem to contribute towards ICF and ^{4}He transfer reaction alone contribute about 57 % of total ICF cross-section at $E_{c.m.}$=135 MeV.

Acknowledgments

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