De-excitation of ^{220}Th*

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1. Introduction

Fusion between two heavy nuclei is the only means to synthesize the super-heavy elements (SHE) [1–3] in the laboratory. It has been observed that formation of a heavy and equilibrated compound nucleus (CN) is hindered by non-compound nuclear fission (NCNF) processes. Such processes cause reduction of evaporation residue (ER) formation cross section. Plenty of experimental evidences confirm that entrance channel properties (like the charge product, $Z_p Z_t$ and mass asymmetry, $\frac{|A_p - A_t|}{A_p + A_t}$, symbols carry their usual meaning here) and structural properties (like shell closure and deformation of the collision partners) affect the probability of NCNF processes [4–6]. Decay of the CN is described within the framework of the statistical model (SM). Presence of NCNF processes, in case of fusion between massive nuclei, makes analysis of observables quite challenging. Ambiguity in the choice of parameters in model calculation add to the difficulty.

2. Methodology

In the present work, we have studied decay of the CN ^{220}Th*, formed via four different entrance channels, using the statistical model code VECSTAT [7]. Similar studies, albeit with somewhat different approaches, were reported in recent years [8, 9]. The most asymmetric reaction is expected to be the least affected by NCNF processes. Since our model does not account for any NCNF processes, a comparison between data and model predictions may be helpful in revealing the presence of NCNF processes in a given reaction. The model includes the shell effect in the level density, shell correction in fission barrier, the effect of orientation degree of freedom of the CN spin, collective enhancement of level density and the dissipation in fission. Banerjee *et al.* [10] showed that incorporation of all these effects provided a consistent picture of decay of the fissile CN. Reduced dissipation coefficient β is the only adjustable parameter in the calculations in our effort to reproduce the data.

3. Results

We have considered here formation of ^{220}Th* via different entrance channels, *viz.*, (a) ^{16}O+^{204}Pb, (b) ^{40}Ar+^{180}Hf, (c) ^{82}Se+^{138}Ba and (d) ^{124}Sn+^{96}Zr. Experimental data for ER cross section (σ_{ER}), fission cross section (σ_{fis}), sum of xn cross sections (σ_{xn}) and pre-scission neutron multiplicity (ν_{pre}) [11–18] are compared with model calculations. Figure 1 shows the experimental data along with results of our calculations for different values of β. Our calculations show that the value of β required to fit σ_{ER} and σ_{xn} for the four reactions forming the same CN rises with increase in the entrance channel mass asymmetry. Model calculations with $\beta = 0$ overestimate the experimental data for the least asymmetric system, *viz.*, ^{124}Sn+^{96}Zr. According to Bohr's hypothesis, decay of the CN is independent of how the same is formed. Hence, for a given CN at a given excitation energy, β should be independent of the entrance channel. Different values of β, required to fit the experimental data, indicate difference in the formation stage of the CN. If we consider NCNF contribution to be the least in the most asymmetric reaction, *viz.*, ^{16}O+^{204}Pb, more symmetric reactions

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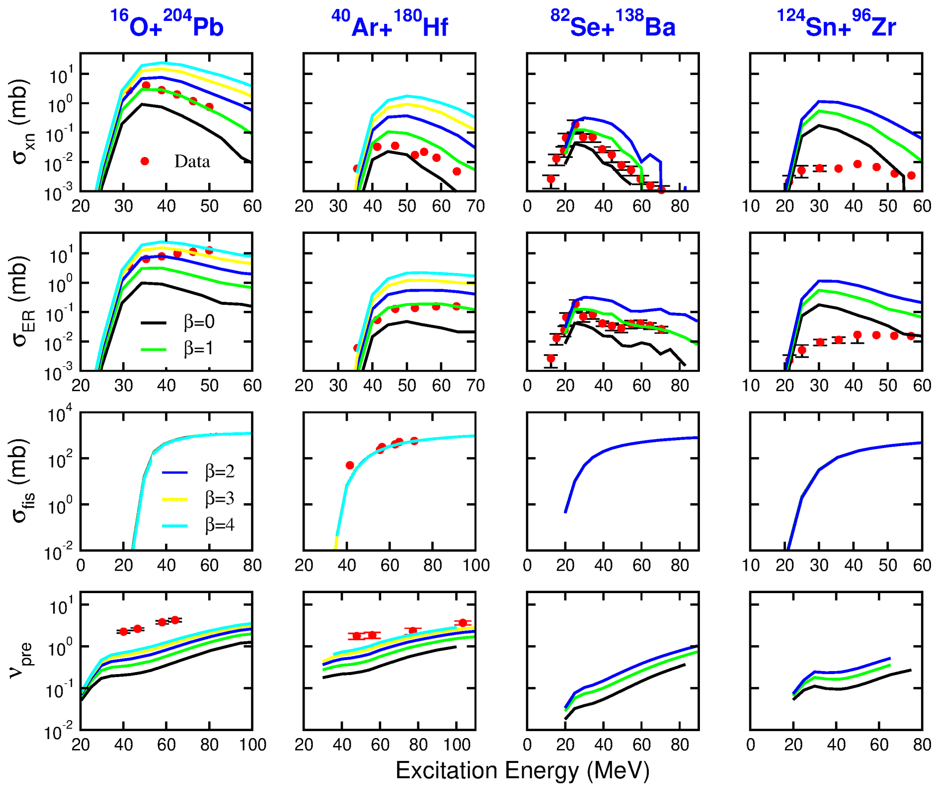

FIG. 1: Comparison between predictions of the statistical model and data from four reactions forming the CN ^{220}Th*.

seem to reveal presence of NCNF processes. Studies performed by Mandaglio *et al.* [8] and Hinde *et al.* [11] also reported similar conclusions.

Calculated v_{pre}, even with $\beta = 4$, underestimates the experimental data for ^{16}O+^{204}Pb and ^{40}Ar+^{180}Hf. Similar discrepancy was also observed by Banerjee *et al.* [10] for CN heavier than 200 amu. The current model includes emission of neutrons during transition from ground state to saddle and from saddle to scission stages only. Refinement of the model as well as analysis of data from more systems are needed for deeper understanding of the reaction mechanism.

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