Fission fragment mass distributions from the statistical decay of compound nuclei in 200 mass region

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Introduction

One of the main objectives of heavy ion induced fusion reactions is to synthesize super heavy elements. In heavy ion induced reactions, Fusion-Fission (FF) and Quasi-Fission (QF) or non compound nucleus fission processes are the competing processes at energies around the Coulomb barrier. The QF process, in which composite system breaks apart before attaining the mass and shape equilibration, is a major hurdle in the formation of super heavy elements (SHEs). The dynamics of these non compound nucleus fission processes should be understood to choose the suitable target-projectile combinations in order to synthesize super heavy elements.

Amongst others, fission fragment mass distribution is considered as a significant tool which helps us to distinguish between FF and QF processes [1–4]. In both the cases, full momentum transfer from projectile to target takes place. Anomalous change in the width of mass distributions with excitation energy is considered as the signature of QF or fusion hindrance. The width of mass distributions depends upon various entrance channel parameters, such as, entrance channel mass asymmetry ($\alpha = \dfrac{A_T - A_P}{A_T + A_P}$, where, A_T and A_P are the mass number of the target and projectile, respectively), projectile-target charges Z_pZ_t, collision energy and projectile/target deformations etc. These parameters are often intercorrelated with each other. The role of these entrance channel parameters in fusion fission dynamics is still not fully understood. Relative value of α w.r.t. Businaro-Gallone mass asymmetry plays a crucial role in deciding whether the mass flows will be from target to projectile or from projectile to target [4]. Further recent experimental findings suggest the presence of QF in the fission of neutron deficient systems especially in mid mass region [5].

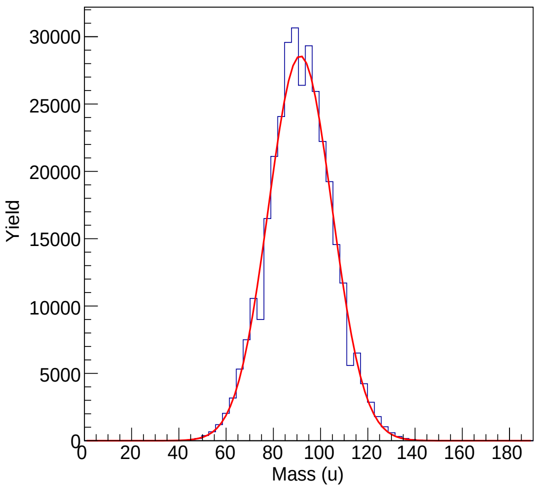

FIG. 1: Histogram of mass distribution (calculated) from the decay of ^{188}Pt at $E^* = 67$ MeV. Red line represents Gaussian fit.

In the present work, in order to have a comparison of relatively neutron deficient compound systems with the statistical fission model, we have calculated the fission fragment mass distributions of compound systems, ^{188,190}Pt, ^{191}Au and ^{202}Pb using statistical model code GEMINI [6].

Results and Discussion

Fragments mass distribution analysis from the simulated decay of excited nuclei,

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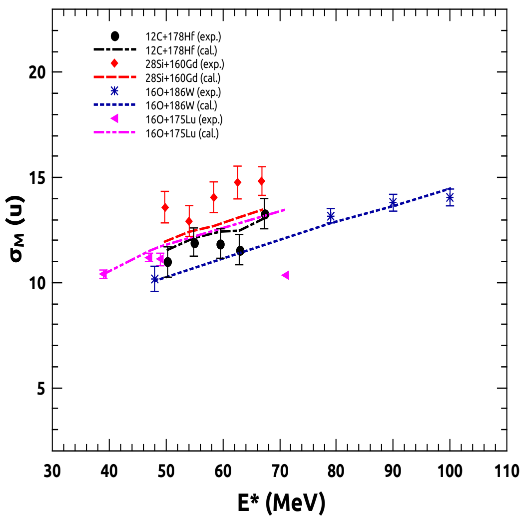

FIG. 2: Variation of the widths of mass distributions with excitation energies. Symbols are used for experimental data and dotted or dashed lines are used for widths of calculated mass distributions in present study.

^{188,190}Pt, ^{191}Au and ^{202}Pb, using statistical model code GEMINI have been performed and results were compared with the experimentally measured mass distributions. The chosen nuclei were populated experimentally via ^{28}Si+^{160}Gd, ^{12}C+^{178}Hf [1], ^{16}O+^{175}Lu [2], and ^{16}O+^{186}W [3] reactions, respectively, at similar excitation energies. The program uses Monte-Carlo technique to simulate the sequential binary decays of excited compound nuclei. It uses Bohr-Wheeler and Moretto's formalism to calculate the fission decay width [6]. For the purpose of calculations, we have used the select compound nuclei as input to the code with the excitation energy matching the experimental values and angular momentum values calculatd using CCFULL [7]. As a representative plot, calculated fragment mass distribution for CN ^{188}Pt at 67 MeV excitation energy is shown in Fig. 1. The calculated mass distributions for all studied compound systems are single peaked, symmetric and also well reproducible with a single Gaussian.

The calculated widths of fission fragment mass distributions from the statistical decay of select nuclei under study along with the experimental data are shown in Fig. 2. The widths of calculated mass distributions from simulated decay using model code GEMINI for all studied compound systems increases monotonically with excitation energy, which agrees to a reasonable extent with those of experimentally measured values but with the exception of fission widths obtained from fission of ^{188}Pt. Here, experimental data has a consistently broader distribution when compared to model calculations indicating the possible presence of small component of slow QF. Also, it is worth mentioning that model widths obtained in the present calculations are also in agreement with the mass width calculations using statistical saddle point model [3]. Therefore, though select nuclei were neutron deficient in nature, still except for slightly broader distributions in the case of ^{188}Pt, the data could be well reproduced using the statistical model calculations.

Acknowledgments

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