Fission dynamics study in ^{243}Am* and ^{254}Fm* nuclei

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Fission dynamics study in the actinide region has enough importance as it can provide crucial informations about the formation of super heavy elements. The main hurdle to approach the super heavy region is the non-compound fission processes, which lead to fission before attaining the full equilibration in the composite system. At near barrier energies the significant non-compound nuclear processes are pre-equilibrium fission and quasi -fission. Pre-equilibrium fission occurs before the composite system attain its shape equilibration, whereas in case of quasi-fission mass and shape equilibration are not attained.

There are different models which predict the occurance of non-compound fission processes due to different initial conditions. First model is based on ground state deformation of the target and projectile nuclei [1, 2]. In particular in the actinide region most of the target nuclei are ground state deformed and they play the crucial role in deciding the contribution of non-compound nuclear fission. At sub barrier energies, fusion predominantly takes place by the collision of projectile with the tip region of the deformed target. The composite system formed after the collision, is more elongated compared to the saddle point and it may escape into exit channel without being captured within the true saddle point to form the compound nucleus, resulting in quasi fission. The second model says contribution from non-compound fission in a reaction is expected if the entrance channel mass asymmetry α for the reaction system is smaller than the Businaro-Gallone critical mass asymmetry α_{BG} [3]. The mass asymmetry α is defined as $(A_T - A_P)/(A_T + A_P)$; where A_P and A_T are the projectile and target masses respectively. The third model says ground state spin of target and projectile influences the fate of the composite system [4, 5].

Here in this paper we explore the model that suits best for the case of ^{11}B + ^{232}Th and ^{11}B + ^{243}Am systems in particular. There are previous measurements on fission fragment angular distribution in both the systems, which indicate the presence of non-equilibrium fission process [5, 6]. So it would be interesting to study the fission fragment mass distribution in these systems, as the width of the mass distribution is known as an unambiguous probe to identify the quasi-fission [7]. Using the results of two sets of measurements, one can disentangle the type of non-equlibrium fission (e.g. pre-equilibrium fission or quasi-fission) process in these systems.

The experiment was performed using ^{11}B beam from IUAC Pelletron new Delhi. 1.1 mg/cm^2 self supporting ^{232}Th and 80 μg/cm^2 ^{243}Am electrodeposited on 200μg/cm^2 Al backing foils were used as targets. The experiment was performed at beam energies ranging from 52 MeV to 74 MeV. Two multi wire proportional counters (MWPC, 20 cm $\times$ 6 cm), and four liquid scintillator based neutron detectors were used to detect the fission fragments and neutrons respectively. MWPCs

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were kept at folding angles to detect complementary fission fragments. The neutron detectors were kept at 30°, 60°, 90° and 120° with respect to the beam direction at a distance of 1 metre from the target position. Fission fragment mass distribution has been extracted from the time of flight difference of the fragments [8]. Mass distributions at different energies were found to be symmetric in nature, which were fitted with Gaussian distribution function. A typical mass distribution is shown in Fig. 1. Width of the Gaussian fitting plotted as a function of E_{cm}/V_b, is shown in Fig. 2, where E_{cm} is the centre of mass energy and V_b is the Coulomb barrier.

From figure 2 it is evident that the width of the mass distribution is monotonus in nature. Since there is no change in the width of the mass distribution at below barrier energies, we can reasonably argue that quasi fission is absent in these systems and deformation model for quasi fission is not playing any significant role for these systems. If the deformation is an important parameter, then we would have observed quasi-fission in both the systems as both the target nuclei are deformed in their ground state (^{232}Th β_2 = 0.207, ^{243}Am β_2 = 0.224). The earlier measurements of fission fragment anisotropy at near and sub barrier energies were found to be anomalously large as compared to the calculations based on statistical saddle point model [5, 6]. Since quasi-fission is absent in these systems, the above trend in angular distribution may arised from the presence of pre-equilibrium fission. However pre-equilibrium fission process is expected for systems with $\alpha < \alpha_{BG}$. In ^{11}B + ^{232}Th system α is 0.909, α_{BG} is 0.886, in ^{11}B + ^{243}Am system α is 0.913, α_{BG} is 0.903. Since both the system have $\alpha > \alpha_{BG}$, therefore probable reason for the pre-equilibrium fission in the present case may be due to the non zero spin of the projectile and/or target.

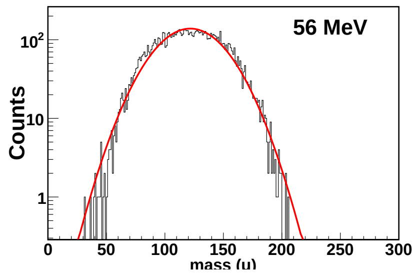

FIG. 1: Measured mass distribution for ^{11}B + ^{232}Th system at E_{lab} = 56 MeV, the Gaussian fit is shown by solid line.

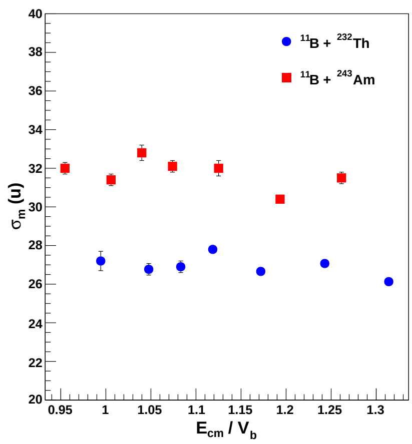

FIG. 2: Width of the mass distribution as a function of E_{cm}/V_b, for the ^{11}B + ^{232}Th (filled circle) and ^{11}B + ^{243}Am (square) systems.

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