Study of fusion-fission dynamics of ^{200}Pb through fission fragment mass distribution

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In heavy ion fusion reactions, the initial di-nucleus formed after capture has to traverse a long dynamical path, before it equilibrates in all degrees of freedom into a compound nuclei. In some of the cases, the di-nucleus may breaks up before equilibrating in one or more degrees of freedom, known as non-compound nuclear fission process. The significant non-compound nuclear processes which compete with complete fusion are pre-equilibrium fission wherein the composite system separates before attaining its shape equilibration and quasi-fission where both mass and shape equilibration are not attained. The dynamical properties of these processes are needed to be understood in order to pick up the right kind of target and projectile combination in order to synthesize super heavy elements.

Recently, ^{200}Pb nuclei has been populated though different entrance channels to study the effects of entrance channel dynamics on these non-compound processes. In the measured ER cross sections and gamma multiplicity distributions for ^{16}O + ^{184}W and ^{19}F + ^{181}Ta systems leading to the same compound nucleus ^{200}Pb* [1, 2], it was found that the normalised ER cross section and the second and the third moments of gamma multiplicity distribution of the system ^{16}O + ^{184}W are significantly enhanced as compared to the other system ^{19}F + ^{181}Ta indicating that in the more symmetric system fusion of higher spins are suppressed. However, a theoretical calculation based on the framework of DNS model [3] claimed that this reduction in ER cross-section at higher energies for ^{19}F + ^{181}Ta could be explained by the increase in quasi-fission and fast fission contribution at higher excitation energies. Variation of the width of the fission fragment mass distribution is an effective probe for quasi-fission, which is a dynamical process proceeding through a mass asymmetric conditional fission barrier as opposed to statistical fusion-fission. Thus any admixture of statistical fusion-fission and quasifission will effectively increase the width of the distribution. Pre-equilibrium fission on the other hand may not have any effect on the width of the mass distribution. We report here, the measurements of mass distributions of ^{16}O + ^{184}W and ^{19}F + ^{181}Ta at an excitation energy range of 55 MeV to 75 MeV.

The experiment was performed at IUAC with pulsed beam of ^{19}F and ^{16}O on enriched isotope of ^{181}Ta and ^{184}W respectively. Fission fragments were detected with two large area X-Y position sensitive MWPCs [4] which were placed at expected folding angles for complementary fission fragments. The forward and backward detectors were centered at angles of 75.4° and 74° on either side of the beam axis at a distance of 41 cm and 29 cm from the target respectively. The detectors were operated at a low pressure of 3 torr of

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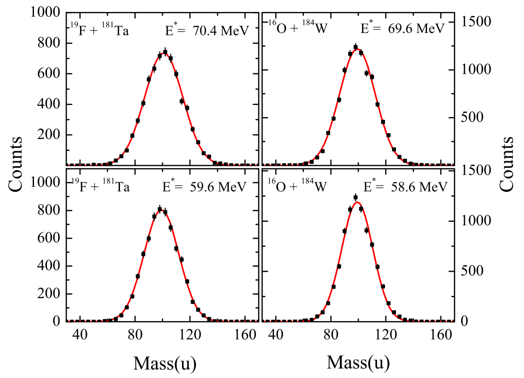

FIG. 1: Experimental mass distribution of fission fragments for the reactions ^{19}F + ^{181}Ta (left) and ^{16}O + ^{184}W (right). Single Gaussian fits are shown by full (red) lines.

iso-butane gas which improves the timing resolution of the detector and at the same time makes them almost transparent to elastic and quasi-elastic particles. The X-Y coordinates of the fragments on the detector, the time of flight difference of the complementary fragments through the fast anode pulses and the energy loss of the fragments inside the detector were measured on an event by event basis. From these measurements, the masses of the correlated fission fragments were extracted following the principle of conservation of linear momentum. Two solid state surface barrier detectors placed at $\pm 10°$ were used for beam flux monitoring and normalization. The faraday cup was also used as a means to normalize the observed fission events.

The extracted mass distributions are all found to be symmetric and thus were fitted with a single Gaussian. The mass distribution and their fits are shown in Fig. 1 at few representative energies. The standard deviation (σ_m(u)) of the fitted mass distributions increases smoothly with excitation energy for both the reactions. Any anomalous deviations in σ_m(u) at higher excitation energies for the reaction ^{19}F + ^{181}Ta are absent.

While the analysis is in its preliminary stage, it appears that quasi-fission may be absent in both the reactions at higher energies.

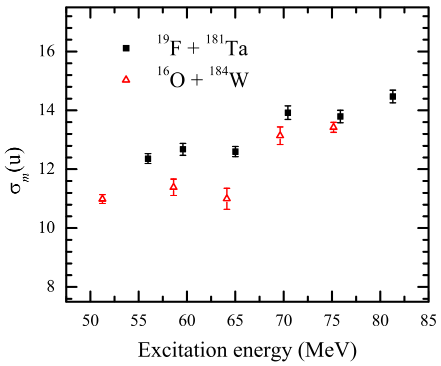

FIG. 2: Variation of the standard deviation (σ_m(u)) of the fitted symmetric mass distribution with excitation energy.

The apparent difference between the standard deviation in the mass distribution at the same excitation energy is due to the different angular momentum of the populated compound nuclei.

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