Fission mass widths in ^{213}Fr compound nucleus

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Introduction

Observations of the presence of quasi-fission(QF) in less fissile systems is a matter of intense research in recent years[1, 2]. Evidence of onset of quasi-fission even in asymmetric reactions forming less fissile systems appear to be a very puzzling phenomena. Earlier dynamical models predict that the QF occurs when $Z_pZ_t \geq 1600$. However recently QF has been observed with fusion of asymmetric systems like ^{19}F + ^{197}Au ($Z_pZ_t \sim 632$)[3]. Later the same system was investigated through fission fragment angular distributions and there was no evidence of non compound nucleus fission (NCNF). It seems mass distribution of fragments produced in these reactions showed evidence of QF while their angular distributions showed no evidence of non-equilibrium fission. In one of our earlier work, we have studied fission fragment angular distributions for the system ^{18}O + ^{197}Au which is having entrance channel mass asymmetry very much similar to ^{19}F + ^{197}Au and observed that there is no evidence of NCNF[4]. Further, recent results show that the onset of quasi fission starts at nearly $Z_pZ_t \sim 1000$. It is important to understand the onset of QF as a function of fissility, Z_PZ_T value, entrance channel mass asymmetry and deformation of target and projectile. In this context we have carried out measurement on mass angle correlations and fission fragment angular distributions for the two systems ^{16}O + ^{197}Au and ^{27}Al + ^{186}W around the Coulomb barrier energies, leading to the same compound nucleus ^{213}Fr. Here we present investigation of mass angle correlations data.

Experimental Details

The Experiment was performed at 15 UD Pelletron facility at IUAC, New Delhi. Beams of ^{16}O and ^{27}Al were bombarded on ^{197}Au, ^{186}W targets of thickness 150 and 110 μg/cm^2 respectively at different beam energies. Fission fragments were detected by two multi wire proportional counters (MWPC) placed at a distance of 40 and 55 cm on the rotatable arms inside the 1.5m diameter general purpose scattering chamber. These two detectors were kept at folding angles to detect the complementary fragments in coincidence. The detectors were rotated to cover the angular range of 80° to 180°. Two Si surface barrier detector of thickness 300 microns with a collimator of 1mm was placed at ±10° to the beam direction, at a distance of 70 cm from the target. These detectors were used for normalization of the fission yields to obtain the absolute differential cross sections for angular distribution measurement and also for aligning the beam on the center of the target. The angular calibration of the MWPC‘s were done by taking elastic scattering data at an energy below the Coulomb barrier. We have used DC beam in this experiment and adopted the time difference method to extract the mass ratios assuming that only binary reaction takes place[5].

Results and Discussion

The positions information of the fission fragments entering the detectors were obtained from the delay line read out of the MWPC wire planes. The central foil of both the MWPC's recorded the timing and energy loss signals. The position calibration (x,y) and solid angle of both the detectors

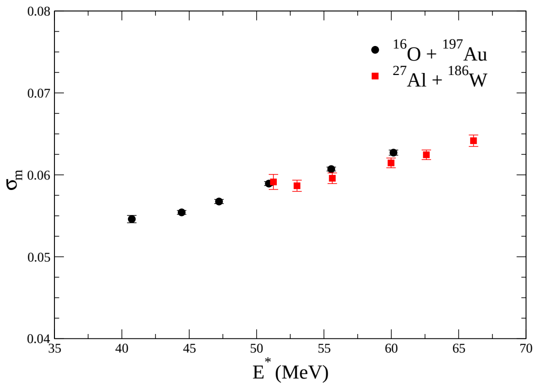

FIG. 1: The standard deviation of mass distribution for the two systems $^{16}O + ^{197}Au$ and $^{27}Al + ^{186}W$ as a function of Excitation energy.

were determined by taking elastic scattering data in singles mode below the Coulomb barrier. These (x,y) position information were later converted to θ and ϕ. The time of flight information was taken from the TAC signal, by taking start signal from the anode signal of back detector and stop from the delayed anode signal from the front detector. The velocities of the fission fragments were reconstructed by using the (θ,ϕ) information with the time of flight information. The time difference calibration for the studied systems was achieved by imposing the condition that the mass ratio distribution is reflection symmetric about 0.5 at $\theta_{c.m.} = 90$, a condition true for both the reactions. By application of proper kinematic transformations and conservation of linear momentum, the mass ratios (M_R) was obtained by using the relation

$$M_R = \frac{m_2}{(m_1 + m_2)} = \frac{v_{1c.m.}}{(v_{1c.m.} + v_{2c.m.})}$$

where m_1, m_2 and $v_{1c.m.}$, $v_{2c.m.}$ are the masses and center of mass velocities of the fission fragments. The extracted mass ratio widths for the two systems $^{16}O + ^{197}Au$ and $^{27}Al + ^{186}W$ as a function of excitation energy is shown in the Fig. 1.

From the systematic analysis of mass variance based on angular momentum and temperature dependence of the CN, there is no evidence of NCNF for the two systems in the energy range which we had studied, indicating that they evolve through true CN fission. The present observation is consistent with the recent measurements on the variance of fission fragment mass and angular distribution in the fission of $^{24}Mg + ^{178}Hf$[1] and $^{28}Si + ^{176}Yb$[6] systems, which are having $Z_P Z_T$ values less than 1000.

Acknowledgments

We thank the pelletron group for giving good stable beams. We thank Dr. H. J. Wollersheim for providing ^{186}W targets. We also acknowledge the support received from R. Kumar, target lab and vacuum lab at IUAC. Financial assistance from IUAC and DAE-BRNS is also acknowledged.

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