Mass-angle distributions analysis for $^{12}C+^{178}$Hf reaction system

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Introduction

Nuclear fission is one of the most convoluted processes of a compound nucleus decay, in which a heavy nucleus, formed in a heavy ion-induced fusion reaction, splits into two nearly symmetric or equal masses fragments. Quasi-fission (QF) is a major competing processes of fusion-fission, which hinders the formation of a compound nucleus [1–3]. It strongly depends on the entrance channel parameters like entrance channel mass asymmetry (α), projectile-target charges product, deformation of the colliding nuclei etc. [1, 3, 4]. In quasifission, the composite system splits into fission like fragments before complete equilibration in mass and shape degrees of freedom, leading to anisotropic mass-angle distribution. Fission fragment mass distributions (FFMDs) and mass-angle correlation are considered as significant tools to investigate the presence or absence of fission events having originated from Quasi-Fission (QF) or non-compound nucleus fission (NCNF) processes. A large number of fission fragment mass distributions and mass-angle correlations studies have been performed to understand the fusion-fission dynamics of heavy ion induced reactions in sub-Pb region [3–6]. Their findings indicate the presence of Quasi-Fission or non-compound nucleus fission events in these reactions. The role of entrance channel parameters on fusion-fission dynamics in the relatively neutron deficient isotopes, especially in sub-Pb region, is still not fully understood.
In the present work, we have performed mass-angle correlation study of fission fragments produced in the reaction ^{12}C + ^{178}Hf populating ^{190}Pt compound nuclei in the excitation energy range of 49 - 67 MeV.

Experimental Details

The experiment was carried out at Inter University Accelerator Centre, New Delhi. A 260 $\mu g/cm^2$ thick ^{178}Hf target on 30 $\mu g/cm^2$ thick carbon backing was placed inside the 1.5 m diameter general purpose scattering chamber (GPSC). Pulsed beam of ^{12}C from Pelletron accelerator, in the laboratory energy range of 70 – 88.2 MeV, was bombarded on the target. Fission fragments were detected using two large area (16 cm x 11 cm) position-sensitive multiwire proportional counters (MWPCs), mounted on each arm of

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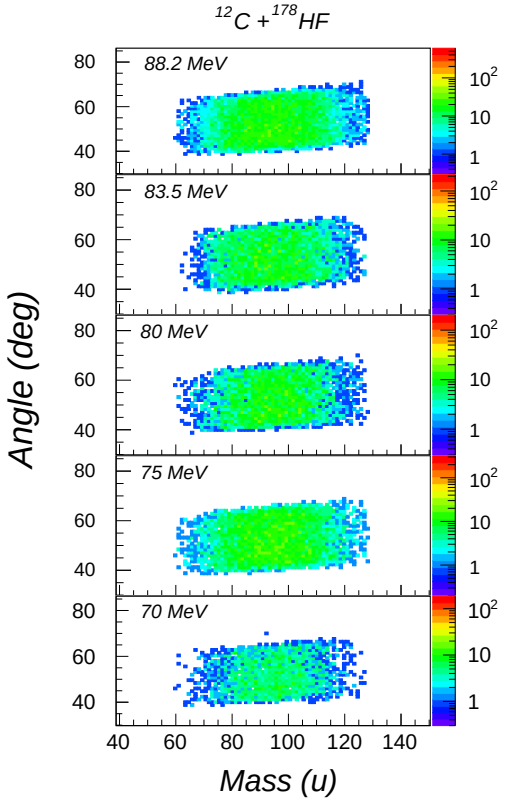

FIG. 1: Mass-angle distributions for reaction $^{12}C+^{178}$Hf at different lab energies.

the chamber.

Analysis and Results

The calibrated position and time of flight (TOF) information from two MWPCs were used to obtain the emission angles (θ) of the fission fragments, using kinematic reconstruction method. The time difference method was used to obtain the masses of complementary fission fragments as described in ref. [4].

The measured mass-angle distributions for reaction ^{12}C + ^{178}HF populating CN ^{190}Pt at different excitation energies are shown in Fig. 1. The measured mass-angle correlation spectra are isotropic in nature. Here, no mass-angle correlation was observed at all studied excitation energies, indicating the absence of any contribution of fission events originated from Quasi Fission (QF) of NCNF process. As in case of Quasi Fission, a correlation between mass and angle of fission fragments take place as the composite system breaks apart before a complete rotation after contact; whereas in case of fusion-fission, no mass-angle correlation takes place as their is complete equilibration in mass and shape degrees of freedom. Experimentally measured fission fragments mass distribution [3], for the this reaction system, is symmetric around half of CN mass ($A_{CN}/2$) and well fitted with a single Gaussian, which is consistent with the expectation of CN fission based on LDM predictions. Therefore, Our results of mass-angle correlation measurements are also in good agreement with the observation of fission fragment mass distribution measurements from the fission of CN ^{190}Pt, populated via reaction channel ^{12}C + ^{178}Hf [3].

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References

[1] S. Gupta et al., Phys. Lett. B **803**, 135297 (2020).
[2] G. N. Knyazheva et al., Phys. Rev. C **75**, 064602 (2007).
[3] Kavita et al., Phys. Rev. C **100**, 024626 (2019).
[4] R. G. Thomas et al., Phys. Rev. C **77**, 034610 (2008).
[5] A. Chaudhuri et al., Phys. Rev. C **94**, 024617 (2016).
[6] E. Prasad et al., Phys. Rev. C **81**, 054608 (2010).