Study of mass angle correlations for the reaction ^{28}Si + ^{160}Gd populating ^{188}Pt compound system

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Introduction

The study of heavy ion induced fusion-fission reactions is a thrust area of nuclear science research for – the production of super heavy elements and to understand the mechanism of fusion fission reaction dynamics. A major hurdle in the super heavy elements formation is the Quasi-Fission (QF) or non compound nucleus fission. A large number of experimental studies were performed to understand the fusion fission dynamics of heavy ion induced reactions in A ≈ 200 mass region [1–4]. Fusion fission dynamics of interacting binaries depends on various entrance channel parameters, such as, product of projectile and target charge, Z_pZ_t, entrance channel mass asymmetry, N/Z ratio of reaction parteners, projectile – target deformation etc. These entrance channel parameters play a key role in deciding the path of a heavy ion induced fusion fission reaction starting from interaction phase till it scissions. Fission fragment mass distribution, angular distribution and mass angle correlation are considered as the sensitive tools to investigate the presence or absence of QF in a given reaction. In the present work, we have performed mass angle correlation study of fission fragments produced in the reaction ^{28}Si + ^{160}Gd populating ^{188}Pt compound system at various excitation energies.

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Experimental Details

The experiment was performed using the General Purpose Scattering Chamber (GPSC) facility at Inter University Accelerator Centre, New Delhi. Pulsed beam of ^{28}Si from Pelletron accelerator, in the laboratory energy range of 120 – 140 MeV, was bombarded on ^{160}Gd target having thickness of 220 $\mu g/cm^2$. The target was fabricated on 20 $\mu g/cm^2$ carbon backing. Fission fragments were detected using two large area (16 cm x 11 cm) multiwire proportional counters (MWPCs), mounted on each arm of the chamber. Complete details of the experimental setup are given in ref. [1].

Analysis and Results

The calibrated position and time of flight (TOF) information from the two MWPCs were used to obtain the emission angles of the fission fragments. The time difference method was used to extract the masses of complementary fission fragments [5],

$$m_1 = \frac{(t_1 - t_2) + t_0 + m_{CN}(d_2/p_2)}{(d_1/p_1) + (d_2/p_2)}, \quad (1)$$

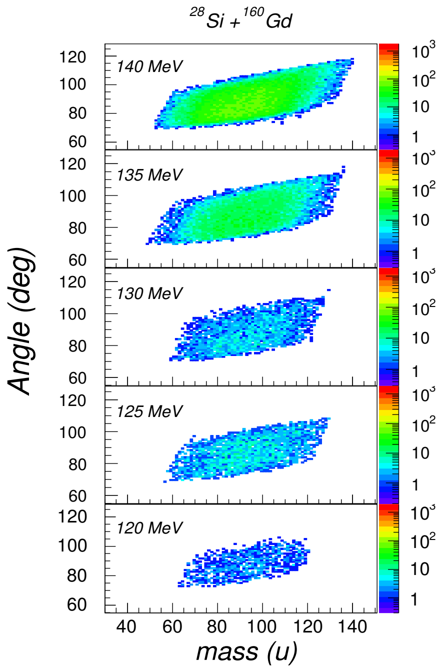

FIG. 1: Mass angle correlations for the reaction ^{28}Si+ ^{160}Gd at different lab energies.

$$m_2 = m_{CN} - m_1 \quad (2)$$

where t_1 and t_2 are the time of flight of complementary fission fragments, t_0 is the electronic delay between the TOF signals of the two MWPCs, d_1 and d_2 are the flight paths of the fission fragments having masses m_1 and m_2, and momentum p_1 and p_2, respectively.

Mass ratio is given by equation

$$M_R = m_2/(m_1 + m_2) \quad (3)$$

The experimentally extracted mass-angle correlations for the reaction ^{28}Si + ^{160}Gd populating CN ^{188}Pt at different lab energies are shown in Fig. 1. The uniformity of observed plots indicate that no significant mass-angle correlation was observed at all energies in the studied energy domain, which further points to the absence of any fast Quasi Fission (QF) in the reaction under consideration. In the case of fast QF, a correlation between mass and angle of fission fragments is expected as the composite system breaks apart before a complete rotation after contact, whereas, in case of slow Quasi Fission, no mass angle correlation is expected because of relatively longer interaction time between the reaction parteners leading to mass equilibration [6, 7].

Experimentally measured fission fragments mass ratio distribution [1], for the same reaction system, is symmetric around $M_R = 0.5$ and well reproducible with a single Gaussian. However, width of measured mass distribution is relatively broader than theoretically calculated mass width, indicating the presence of a small contribution of slow QF or non compound nucleus fission. Therefore, results of experimental mass angle correlations are in reasonably good agreement with the findings of mass distribution analysis for the fission of ^{188}Pt compound system populated via ^{28}Si + ^{160}Gd reaction.

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