Investigation of measured fission fragment mass–angle and mass ratio distributions of ^{30}Si+^{197}Au reaction using different theoretical formalisms

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Introduction

Fission fragment mass–angle distributions (MAD) offer a sensitive probe into heavy-ion–induced fission dynamics, providing insight into the mechanisms differentiating compound-nucleus fission from quasi-fission [1, 2] and the evolution of mass asymmetry during scission. The dynamical evolution of the dinuclear system after capture to quasi-fission or fusion-fission is very interesting. This evolution is highly sensitive to multiple parameters of the projectile-target combinations.

In the present work, we report MAD measurements for the reaction ^{30}Si+^{197}Au. The data are analyzed within the framework of 3 theoretical approaches: The GEF model [3] is a semi-empirical code that incorporates systematics of fission observables and provides reliable predictions for fragment mass, charge and kinetic energy distributions over a wide range of nuclei, the scission point model [4], which emphasizes the statistical partitioning of mass-asymmetric modes at scission, and the dinuclear system (DNS) model [5, 6], which explicitly incorporates the dynamics of nucleon exchange and quasi-fission competition.

The experiment was performed using the 15 UD Pelletron accelerator facility of the Inter University Accelerator Centre (IUAC), New Delhi. Pulsed beams of ^{30}Si from the Pelletron accelerator were further boosted in energy using the SCLinac, with a pulse separation of 250 ns used in the experiment to bombard ^{197}Au target of thickness 300 μg/cm^2. Measurements were performed at the laboratory energies of the range 140.0 - 186.4 MeV (E*= 33.4 to 74.1 MeV). The complimentary fission fragments were detected using a pair of identical position-sensitive multiwire proportional counters (MWPCs) having active areas of 11 × 16 cm^2.

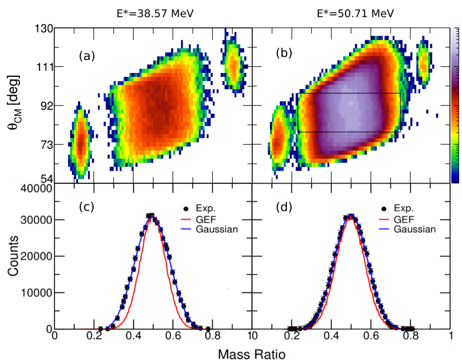

FIG. 1: Panel (a) and(b): MAD scatter plots for the ^{30}Si+^{197}Au reaction at E* = 38.57 MeV and 50.71 MeV respectively. Panels (c) and (d): Corresponding mass distributions for the same reaction, Gaussian fit to the data and GEF M_R distributions.

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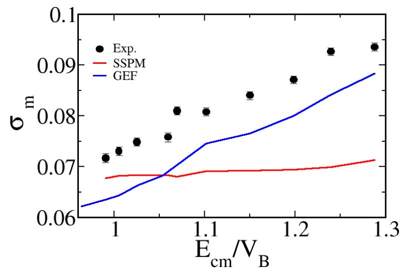

FIG. 2: Experimental σ_m values compared with theoretical calculations.

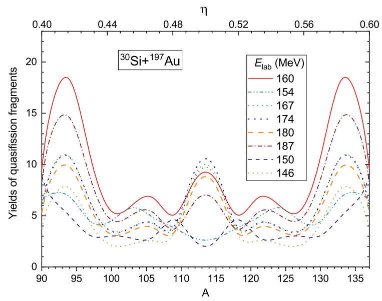

FIG. 3: The mass distributions of the quasi-fission products for the $^{30}Si+^{197}Au$ reaction as functions of the beam energy E_{lab} calculated by the framework of the DNS model.

Analysis and Result

The mass angle distributions (MAD) were created using the position and timing signals obtained from the MWPC detectors [7]. Kinematic coincidence method has been used for this purpose [8]. Fig. 1 shows the MAD plot for the reaction $^{30}Si+^{197}Au$ at $E^*= 38.57$ and 50.71 MeV. Corresponding mass ratio (M_R) distribution is shown in the lower panel along with M_R distribution generated using GEF [3]. Experimental σ_m values are compared with GEF [3] and scission point model [4] calculation are shown in Fig. 2. Here, the M_R width is found to be higher than the model calculation which could be a signature of QF. However, we don't see mass-angle correlation in this reaction which hints that the major quasifission component present in this reaction is the slow quasifission.

Also the experimental results were analyzed in the frame work of DNS model [5, 6]. The yields Y_A of the quasifission products have been calculated by solving the transport master equations for the charge distribution of

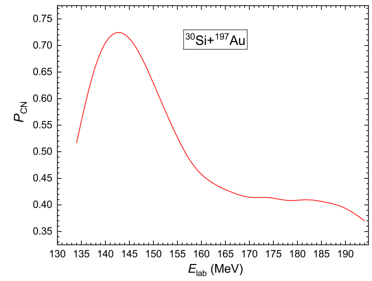

FIG. 4: The fusion probability P_{CN} calculated in this work for the $^{30}Si+^{197}Au$ reaction as a function of the beam energy E.

the DNS fragments [9]. The results of these calculations are presented in Fig. 3. It may be noticed that the contribution of the yields of the quasifission products causing the increase in σ_m is large for the beam energy E = 160 MeV. The increased quasifission yields along with the mass symmetric fusion-fission products hence explains the (Fig. 3)increased width at this energy, where η represents the mass asymmetry in fission fragments. Calculated values of P_{CN} are presented in Fig. 4. Approximately 40-60% of P_{CN} is obtained in this reaction in the present analysis. The decrease of P_{CN} above $E^* = 43$ MeV related to the increased angular momentum at high E^*.

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