Onset of quasifission in ^{30}Si+^{180}Hf reaction.

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Introduction

Study of onset of non-equilibrium processes in less fissile systems at near barrier energies is of great research interest in the recent years. Quasifission [1–3] is a non-compound nucleus (NCN) process that dominates at lower excitation energies, just above the fusion threshold and compete strongly with evaporation residue (ER) formation. It is a major hurdle in the formation of superheavy elements and shows strong dependence on entrance channel parameters [4–7]. Experimental signatures of this process include a strong reduction in ER cross section, anomalous fission fragment angular anisotropies, broadened fragment mass distributions and mass-angle correlations.

Experimental Details

The experiment was performed at the 15UD Pelletron accelerator facility of Inter University Accelerator Centre (IUAC), New Delhi, using the general purpose scattering chamber (GPSC).^{30}Si beam (dc) was used to bombard isotopically enriched ^{180}Hf target of thickness 150 μg/cm^2 on 40μg/cm^2 thick carbon backing. Fragment mass measurements were performed at laboratory beam energies (after correcting for the loss in the half thickness of the target) of 127.9, 131.9, 134.9, 137.5, 139.9, 141.9, 143.9, 145.9 and 147.9 MeV. Two large area, position sensitive, Multi Wire Proportional Counters (MWPCs) with an active area

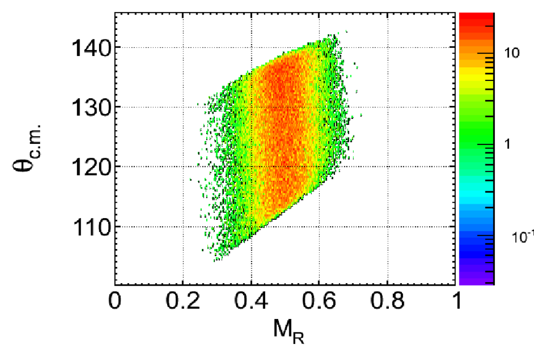

FIG. 1: Mass ratio (M_R) verses centre-of-mass angle ($\theta_{c.m.}$) for the reaction ^{30}Si+^{180}Hf at E_{cm} = 126.7 MeV.

of 20 cm × 10 cm [8] were used for fission fragment measurement. The forward detector was centred at polar angle θ=40° (azimuthal angle ϕ=90°) and backward detector centred at θ=105.5° (azimuthal angle ϕ=270°). The nearest distance to the forward detector from the target was 58 cm and that to the backward detector was 36 cm. Time difference method was used for obtaining the mass ratio distributions of the complimentary fragments [9]. The delay δt_0 in ref.[9] was obtained using ^{16}O +^{197}Au reaction at 90 MeV beam energy.

Analysis and Results

The mass angle correlations and the mass ratio distributions of the fragments were obtained at energies above and below the Coulomb barrier. The mass ratio plotted against centre-of-mass angle of the fragments at E$_{c.m.}$=126.7 MeV for ^{30}Si+^{180}Hf reaction

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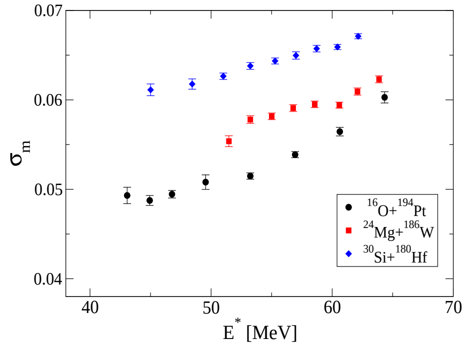

FIG. 2: Mass ratio widths of ^{30}Si+^{180}Hf at different excitation energies compared with that of ^{16}O+^{194}Pt and ^{24}Mg+^{184}W, forming the same CN ^{210}Rn.

is shown in FIG.1. No mass-angle correlation has been observed in this reaction, in the entire energy range studied. The symmetric fragment mass ratio distribution may be easily represented using the Gaussian distribution with the standard deviation (σ_m) representing the width of the experimental mass ratio distributions. In FIG.2 we compared the σ_m-values of the three reactions ^{16}O+^{194}Pt, ^{24}Mg+^{186}W [7] and ^{30}Si+^{180}Hf, all the reactions forming the same CN ^{210}Rn. It may be noted that at similar excitation energies the magnitude of σ_m-values for the ^{30}Si+^{180}Hf reaction is much higher than that of the other two reactions.

In the case of an equilibrated CN, the variance of the mass distribution (σ_m^2) is linearly related to the saddle point temperature and $< l^2 >$. Model calculations were performed for CN excitation energies above 50 MeV. In FIG. 3 we compared the experimental mass widths with the calculations using the fitting constants obtained in our earlier work [7]. The substantial difference between the experimental mass ratio width from the calculated values is a clear signature of the onset of quasifission process in this reaction. The increased mass ratio widths of ^{30}Si+^{180}Hf ($Z_P Z_T$=1008, mass asymmetry α=0.714) reaction in comparison with ^{24}Mg+^{184}W ($Z_P Z_T$=888, α=0.771) and ^{16}O+^{194}Pt ($Z_P Z_T$=624, α=0.847) reactions also reveals the dependence of quasifission on entrance channel parameters such as mass asymmetry, $Z_P Z_T$ etc.

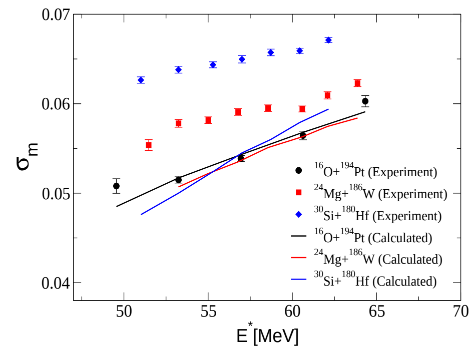

FIG. 3: Experimental mass ratio widths of ^{30}Si+^{180}Hf at different excitation energies compared with the calculations assuming CN formation. Calculations were restricted for excitation energies above 50 MeV. The results of our previous measurements are also shown in figure for a comparison.

Acknowledgements

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