Effect of entrance channel magicity on fission dynamics.

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Introduction

Entrance channel effect on quasi fission has been studied for last few decades. Deformation of heavy reaction partner, $Z_P Z_T$ and entrance channel mass asymmetry are few of the known parameters that influence the quasi fission and inhibits formation of compound nucleus. In a few recent studies, it was observed that higher entrance channel magicity results in more symmetric fission [1, 2] for Ca and Cr induced reactions on Pb isotopes. A later study on Ti induced reactions on Pb target showed effect of magic number on fusion hindrance [3]. All these studies were carried out for reactions where fast quasi fission is significant resulting in a strongly correlated mass angle distribution and mass asymmetric quasi fission. Increased symmetric fission due to shell closure might come from slow quasi fission or fusion fission. To investigate the effect of shell structure on mass symmetric slow quasi fission, four reactions ^{35,37}Cl+^{206,208}Pb were studied in the present work.

Experiment

The experiment has been performed at BARC-TIFR Pelletron LINAC facility using pulsed beams of ^{35,37}Cl. Enriched targets of ^{206}Pb and ^{208}Pb having thickness 150 μg/cm^2 were used. Two position sensitive multiwire proportional counters were placed at folding angles to detect the fission fragments in coincidence. The time of flight of each fragment were recorded with respect to the RF signal of the beam pulsing system.

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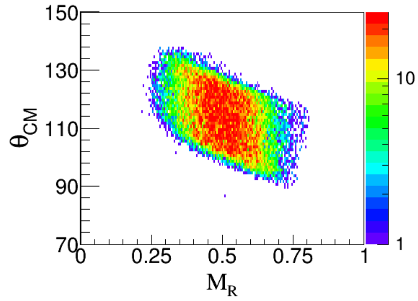

FIG. 1: Fission fragment mass angle correlation for reaction ^{35}Cl+^{208}Pb at excitation energy of 44 MeV.

Results and Discussion

Fission fragment mass ratio has been extracted from experimental time of flight and position information for the four reactions ^{35,37}Cl+^{206,208}Pb in the excitation energy range of 25 − 45 MeV. The fission fragment mass ratio is defined as $M_R = m1/(m1+m2)$, $m1$ and $m2$ being the masses of the fission fragments 1 and 2. From conservation of mass and linear momentum, M_R can be expressed as $M_R = v2/(v1 + v2)$, where $v1$ and $v2$ are velocities of fission fragments 1 and 2 in the centre of mass frame. Fission fragment mass angle correlation was obtained for all the reactions. A typical mass angle correlation spectrum is shown in Fig.1 for the reaction ^{35}Cl+^{208}Pb at excitaion energy 44 MeV. It is seen from the figure that there is no correlation within the small angular range, covered in this experiment. To avoid the effect of finite detector geometry, a central angular cut of

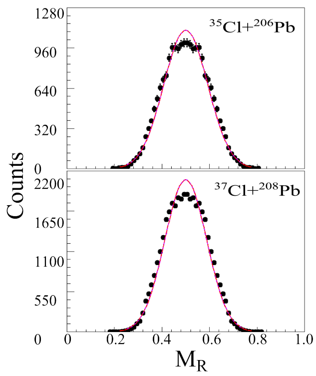

FIG. 2: Fission fragment mass distributions for reactions ^{35}Cl+^{206}Pb and ^{37}Cl+^{208}Pb at excitation energy of 35 MeV.

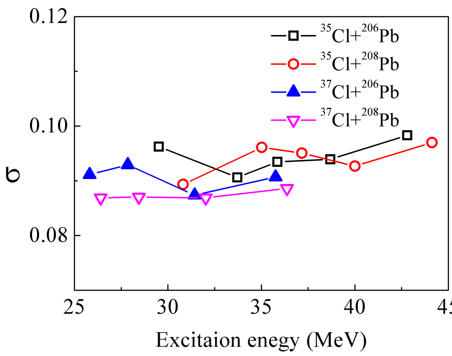

FIG. 3: Root mean square deviation of fission fragment mass distribution as a function of excitation energy.

10° was applied while obtaining the mass ratio distributions. Fig.2 shows mass distributions for two reactions ^{35}Cl+^{206}Pb and ^{37}+^{208}Pb at similar excitation energy of 35 MeV. The solid lines represent Gaussian fit for the distributions. It can be seen from the figure that experimental peaks are flatter than the Gaussian prediction. Such deviations from Gaussian distribution were reported by Khuyagbaatar *et al.* [4] for S induced reactions on Pb. In the mass region of $A \sim 240$, fission at low excitation energy is mass asymmetric. At high excitation energy the mass distribution is symmetric but when fission takes place after a few particle evaporation, contribution from asymmetric mass distribution causes flat top mass distribution.

Fig. 2 shows that the mass distribution for ^{35}Cl+^{206}Pb is wider than that of ^{37}Cl+^{208}Pb. Root mean square deviations (σ) of mass distributions for all the four reactions are shown in the fig.3 as a function of excitaion energy. It can be seen that though the charge product, entrance channel mass asymmetry and deformation for all the four reactions are same, they have different fission mass width. The reaction ^{35}Cl+^{206}Pb and ^{35}Cl+^{208}Pb show largest values of σ whereas, ^{37}Cl+^{208}Pb shows lowest value of σ. Calculation using angular momentum and temperature predicts similar mass width for all the four reactions in this energy region. Higher value of σ indicates more contributions from quasi fission. Reactions ^{35}Cl+^{206}Pb and ^{37}Cl +^{206}Pb form same compound nucleus but show difference in mass widths at similar excitation energy indicating effect of entrance channel. Different mass widths for these reactions can be explained in terms of magicity (N_M) which is defined as the total magic number involved in the entrance channel. Reaction with $N_M = 3$ shows minimum mass width. ^{35}Cl+^{206}Pb has minimum magicity of $N_M = 1$ and shows high value of σ. ^{35}Cl+^{208}Pb despite having $N_M = 2$ shows high width which is due to high mismatch in N/Z between target and projectile. Similar results were reported earlier for Ca and Cr induced reactions [1, 2]. So it can be concluded that for these reactions entrance channel magicity influences the presence of quasi fission in the near barrier energy region.

References

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