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, ZpZT 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, 37Cl+206, 208Pb were studied in the present work.

Experiment

The experiment has been performed at BARC-TIFR Pelletron LINAC facility using pulsed beams of 35,37Cl. Enriched targets of 206Pb and 208Pb having thickness 150 μg/cm² were used. Two position sensitive multwire 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.

Results and Discussion

Fission fragment mass ratio has been extracted from experimental time of flight and position information for the four reactions 35,37Cl+206, 208Pb in the excitation energy range of 25 - 45 MeV. The fission fragment mass ratio is defined as MR = m1/(m1+m2), m1 and m2 being the masses of the fission fragments 1 and 2. From conservation of mass and linear momentum, MR can be expressed as MR = 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 35Cl+208Pb at excitaion energy 44 MeV.

FIG. 1: Fission fragment mass angle correlation for reaction 35Cl+208Pb at excitation energy of 44 MeV.
10° was applied while obtaining the mass ratio distributions. Fig.2 shows mass distributions for two reactions 35Cl+206Pb and 37Cl+208Pb 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 35Cl+206Pb is wider than that of 37Cl+208Pb. Root mean square deviations (\( \sigma \)) of mass distributions for all the four reactions are shown in the fig.3 as a function of excitation energy. Root mean square deviations (\( \sigma \)) of mass distributions for all the four reactions are shown in the fig.3 as a function of excitation 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 35Cl+206Pb and 35Cl+208Pb show largest values of \( \sigma \) whereas, 37Cl+208Pb shows lowest value of \( \sigma \). Calculation using angular momentum and temperature predicts similar mass width for all the four reactions in this energy region. Higher value of \( \sigma \) indicates more contributions from quasi fission. Reactions 35Cl+206Pb and 37Cl+206Pb 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. 35Cl+206Pb has minimum magicity of \( N_M = 1 \) and shows high value of \( \sigma \). 35Cl+208Pb 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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