Measurement of fission fragment angular distribution for ^{13}C+^{198}Pt system

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Introduction

According to the Statistical Saddle Point Model (SSPM), the fission fragment angular distribution depends on the angle momentum (J) distribution, effective moment of inertia ($\Im_{eff}$) and temperature (T) at the saddle point of the fissioning nuclei [1]. Difficulties in calculating the fission fragment angular distributions lie in the estimation of the angular momentum distributions and the temperature appropriate for each fissioning nucleus. In heavy ion induced reaction compound nucleus is formed at a fixed excitation energy with a broad range of angular momentum. Due to the multichance nature, fission can occur after emission of one or more neutrons, which reduces this temperature from that of the initial compound nuclei and brings in a spread.

It has been observed that the measured fission fragment anisotropy (A) values, defined as W(180°)/W(90°), are significantly larger than those predicted by SSPM using average values of E* and J for ^{12}C+^{198}Pt (N_c = 126) system [2]. Good agreement is found between the data and the SSPM calculation when multichance nature of fission is taken into account [3]. It is of interest to extend the measurement to some more systems to investigate the correlation between the compound nucleus shell closure and anomalous anisotropy.

With this motivation, measurement of fission fragment angular distribution for ^{13}C+^{198}Pt (N_c = 127) has been carried out. Since, the average prefission neutron multiplicity is ∼ 1 for the present system over the energy range studied, more fissioning nuclei is expected to have N_c = 126

Measurement Details

The fission fragment angular distribution for the above-mentioned system have been measured using the BARC-TIFR 14 UD Pelletron accelerator at Mumbai. The measurements have been carried out in the laboratory energy range from 60 to 80 MeV, using self-supporting rolled foils of ^{198}Pt (95.7% enriched, 1.4 mg/cm^2 thick). Fission fragment angular distributions were measured from 80° to 170° in laboratory. Three ΔE-E telescopes consisting of Si surface barrier detectors (thicknesses ΔE 10-22 μm, E 300 μm) were used to detect the fission fragments. The Si telescopes were operated deriving the trigger signal from the ΔE detectors. Most of the fission fragments were stopped in ΔE detector while fragments reaching the E detector were well separated from the direct reaction products and evaporated particles in the two dimensional ΔE vs E plot. Two Si surface barrier detectors, kept at 30° and 40° to monitor Rutherford scattering, were used for absolute normalization of fission cross sections.

Angular distributions in center of mass (W(θ)) were fitted with the standard expression for angular distribution [3]. Typical angular distributions along with the fits are shown in Fig. 1. Measured fission fragment anisotropies (A) are shown in Fig 2. For comparison, fission fragment anisotropy data for ^{12}C+^{198}Pt system is also shown in Fig. 1. Fission cross sections are obtained by integrating the angular distributions.

Results and discussion

Statistical model calculations are performed using the code PACE with a shell corrected fission barrier and level density prescription [4].

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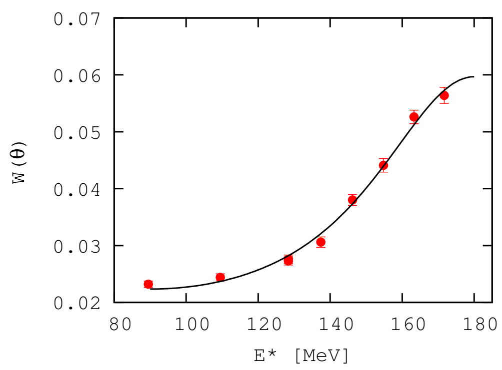

FIG. 1: Fission fragment angular distribution for ^{13}C+^{198}Pt system at E_{lab} = 67.3 MeV. The continuous line is the fit using the standard expression discussed in the text

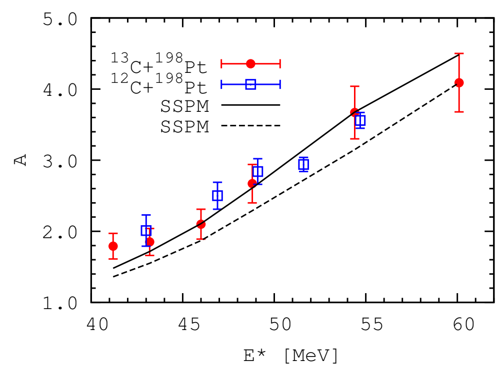

FIG. 2: The fission fragment angular anisotropy (A) values plotted as a function of excitation energy for ^{12,13}C+^{198}Pt systems.The continuous and the dashed lines represent the SSPM calculations using the distribution of fissioning nuclei in (E*,J) space and using average values of (E*,J) of the fissioning nuclei from the statistical model calculations for ^{13}C+^{198}Pt system, respectively

Fusion spin (J) distributions, required for Statistical model calculations, were generated using the coupled channels code CCFUS. Fusion cross section of the present system is not available. Hence, the depth of the nuclear potential, required for CCFUS calculation, was fixed using the fusion excitation for ^{12}C+^{198}Pt system [2]. Measured fission cross sections were divided by the predicted fusion cross sections from CCFUS to obtain the fission probability values. Prefission neutron multiplicity values are obtained from the Baba *et al.* systematics [5].

Fission probabilities and prefission neutron multiplicity values are reproduced by varying the fractional shell correction at the saddle point (k_f) and the ratio of the asymptotic value of the level density parameter at the saddle point to that at the equilibrium configuration ($\tilde{a}_f/\tilde{a}_n$) [4]. The best fit parameters are k_f = 0.80 and $\tilde{a}_f/\tilde{a}_n$ = 0.973. It should be noted that a significant fraction (0.80) of the ground state shell correction persists at the saddle point for the present system as observed for other systems in this mass region [4].

The statistical model is used to predict the (E*,J) distribution of the fissioning nuclei at each chance, after fixing the parameters as described above. SSPM calculations for fission fragment anisotropy are carried out using the (E*,J) distribution of the fissioning nuclei for each chance. The exact expression for angular distribution has been used to calculate fission fragment anisotropy values. $\Im_{eff}$ values are taken from Ref. [6]. As can be seen from Fig. 2, the measured anisotropy values can be reproduced well in the entire energy range by the SSPM calculation taking into account the multichance nature of fission.

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