Study of fission fragment angular distribution for ^{19}F + $^{194, 196,198}Pt$ reactions at near and above barrier energies

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Introduction:

In the last few decades much progress has been made to understand the behavior of nuclear matter at finite temperatures (say between 1 and 5 MeV) using both experimental and theoretical techniques. The presence of the Kramers predicted dissipation effects in fusion-fission is now well established. But the effect of shell closure on dissipation is still not very well understood. To the best of our knowledge, there exists only one measurement carried out by Back *et al.* [3] to understand the effect of shell closure on the nuclear dissipation through evaporation residue(ER) measurement, and it was concluded that the shell effect results in the lowering of nuclear dissipation. But the conclusion was based on the only one observable sensitive to the dissipation; a consistent analysis was not preformed taking into account the other observables. It is possible that the statistical model parameters used to reproduce the ER cross-sections may not be able to fit the other observables like fission, ER cross-sections and neutron multiplicities etc. with the same set of parameters. With the motivation to study the effect of shell closure on nuclear dissipation, we have performed a series of experiments to measure the neutron multiplicity [4-5], fission and ER cross-sections [7] and the simultaneous fitting of all the observables by statistical model is being carried out to get a better idea of this effect. In present paper, we report the results of the fission angular distribution measurements for ^{19}F + $^{194,196,198}Pt$, resulting in the formation of the compound nucleus (CN) ^{213}Fr (N_c=126), ^{215}Fr (N_c=128) and ^{217}Fr (N_c = 130) systems at excitation energies range of ~ 45 – 72.6 MeV.

Experimental Arrangement:

The experiment was carried out at general purpose scattering chamber (GPSC), using DC beam of ^{19}F at (energy range from 90.5 to 118.7 MeV) delivered by 15 UD Pelletron at IUAC, New Delhi, bombarded on ^{194}Pt, ^{196}Pt and ^{198}Pt targets of thicknesses ~ 1.75 mg/cm^2. Fission fragments were detected using two different detector set-ups placed on both arms of the scattering chamber on the either sides of beam direction. On one arm of scattering chamber, two Si surface barrier telescope detectors (SSBD) were placed at a distance of 13 cm (collimator size 5 mm) each with angular separation of 24^o. On the other arm, three hybrid telescope (ΔE gas and E SSBD) detectors were placed at a distance of 28 cm (collimator size 10 mm) each with angular separation of 12^o between two adjacent detectors. The two SSB detectors were kept at ± 10^o with a distance of 70 cm (collimator size 1 mm) for monitoring and normalization purpose. The trigger for the data acquisition system was generated using the OR of the timing signals of two detector set-ups along with the monitor detectors.

Data analysis and results:

The experimentally measured fission yield of each detectors was normalized using the inter detector normalization, and the beam energy loss in the half target thickness were taken into account. The experimental fission fragment angular distribution was transformed from laboratory to center-of-mass frame using Viola sytsematics[4-5] for symmetric fission. The experimentally obtained angular distribution was fitted by chi-square minimization procedure using the theoretical expression for angular distribution of fission fragments given by;

$$W(\theta) \propto \sum_{J=0}^{\infty} (2J+1) T_J \frac{\sum_{K=-J}^{J} \frac{1}{2}(2J+1) \mid d_{0K}^{J}(\theta) \mid^2 \exp[\frac{-K^2}{2K_o^2}]}{\sum_{K=-J}^{J} \exp[\frac{-K^2}{2K_o^2}]}$$

where T_J is the transmission coefficient for fusion of J^{th} partial wave and K_o is the standard deviation of the K distribution. In this minimization procedure the K_o was treated as free parameter. The fitted angular distribution for ^{19}F + ^{198}Pt at beam energy of 116.8 MeV for SSB telescope detectors is shown in Fig. 1.

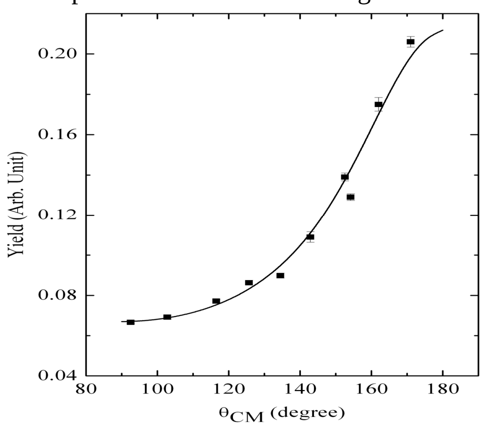

Fig. 1: Fission fragment angular distribution for ^{19}F + ^{198}Pt @ 116.8 MeV is shown (solid square) and lines are the values obtained by W(θ) fitting.

Fission cross-sections were obtained using following expression;

$$\sigma_{fission} = \frac{1}{2} \frac{Y_{fiss}}{Y_{mon}} \frac{\Omega_{mon}}{\Omega_{fis}} \sigma_{ruth}$$

where Ω_{fiss} and Ω_{mon} are solid angle subtended by fission and monitor detector respectively and σ_{ruth} is Rutherford cross-section. The fission cross-sections obtained are shown in Fig. 2. It has been observed that the fission cross-section obtained by both the detector set-ups agree within ± 5 % with each other. The measurements were also compared with the earlier low energy measurements of Mahata *et al.* [6]. The cross-sections in the overlapping energy region are found to be consistent with each other. A PACE2 calculation was performed by adjusting a_f/a_n and B_f values to fit the fission cross sections and also the measured ER cross-sections [7]. The parameters used by Mahata *et al.* [6] [B_f=1.17×B_f(Sierk), a_f/a_n=1.015 for ^{19}F+^{194}Pt system and B_f=1.17×B_f(Sierk), a_f/a_n=1.050 for ^{19}F+^{198}Pt system and B_f=1.165×B_f(Sierk), a_f/a_n=1.07 for ^{19}F+^{196}Pt system(new measurement)] is used. The extracted anisotropy values along with the old measurements of Mahata *et al.* [6] is shown in Fig.3. Detailed statistical model calculation is in progress to explain the extracted anisotropy data.

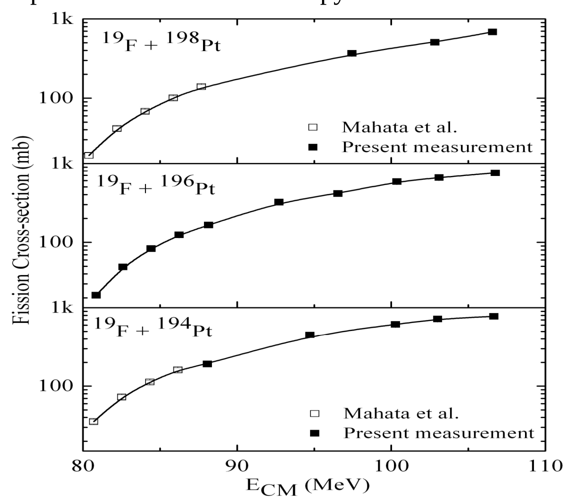

Fig. 2: Fission cross-sections of the present experiment.

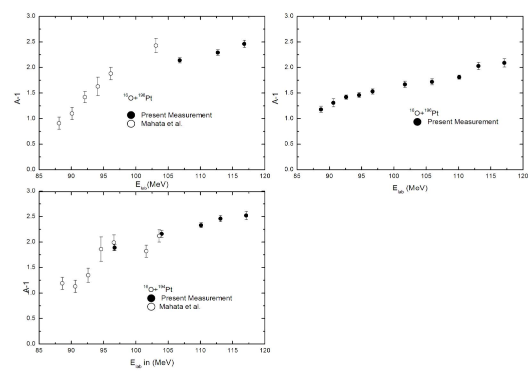

Fig 3: The measured anisotropy values for three systems.

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