Measurement of the Fission Cross Sections for the $^{16,18}O+^{194,198}Pt$ Systems

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Introduction

Study of heavy-ion induced fission fragment angular distributions is a rich source of information. These reactions are sensitive to the entrance channel of the interacting heavy ions forming the compound nucleus and also to the other aspects of the intermediate composite system, as it equilibrates in energy, mass, angular momentum and shape degrees of freedom. The measured fission anisotropies depends on the entrance channel, the deformation and the spin of the target, the mass of the projectile, the bombarding energy with respect to the fusion barrier, and the fission dynamics (fission delay)[1]. It is also found that Fission fragment angular distribution is a sensitive probe to investigate the contribution from non-compound nuclear (NCN) fission. Investigation of the contribution from NCN fission for systems with low Z_PZ_T (Z_P and Z_T are the atomic number of projectile and target respectively) has been an active area of study in the recent past. In the present experiment angular distribution of fission fragments and fission cross section has been measured experimentally by populating the compound nuclei $^{210,212,214,216}Rn$ (fissility=0.735,0.732, 0.729, 0.726 respectively) having same Z (proton number) and different N (neutron number).

The fission dynamics as a function of '(N-Z)/A' or N/Z (compound nucleus), (i.e the effect of the neutron excess from the reaction system chosen) and the contribution coming from near scission configuration is not yet studied systematically [2]. This experiment has been performed to study the effect of N/Z (CN) in fission dynamics. We report here the results of fission cross section measurements for $^{16,18}O+^{194,198}Pt$ reactions at different set of excitation energies which populate the compound nuclei with same Z (Z=86, Rn) but different value of N (i.e different N/Z. This is a part of our programme to study the effect of N/Z in the fission dynamics through fission, evaporation residue (ER) and Neutron multiplicity measurements [2].

Experimental Arrangement

The experiment was carried out in General Purpose scattering chamber (GPSC) at IUAC, New Delhi, using $^{16,18}O$ DC beam of energies in the range of 85-107 MeV from Pelletron accelerator. Self-supporting targets of ^{194}Pt having a thickness around 1.7 mg/cm^2 and ^{198}Pt having thickness 2.15 mg/cm^2 were used for the measurement of the angular distribution of fission fragments. Single fission fragments were detected in the angular range of 54^o to 168^o in the laboratory frame using two Si-detector telescopes (T1,T2) and three ΔE-E gas-surface barrier hybrid detectors (T1,T2,T3) [3]. The thickness of the Silicon Surface barrier detector (SSBD) (T1,T2) was about 300μm. The E detectors were backed by 10μm thick E (SSBD) detectors. The thickness of the E detectors in ΔE-E gas-surface barrier hybrid detectors was 100μm. The distance of the telescopes (SSBD) from the target were about 13.3 cm and the distance for ΔE-E gas-surface barrier hybrid detectors T3, T4 and T5 were 28.7, 27.6 and 28.5cm respectively. Each detector had an angular coverage of about $\pm 1^0$. The detector (Gas ΔE-E) was operated at 100 mbar gas pressure which corresponds to an equivalent Silicon thickness of 2.5µm [3]. Two monitors Si-detectors (M1, M2) with 1 mm collimator were kept at $\pm 10^{o}$ with respect to the beam at a distance of about 70 cm form the target position to monitor the Rutherford scattering and beam incidence. The relative solid angles of the telescopes were taken into account by measuring the data at overlapping angles.

Analysis

The measured fission fragment angular distributions were transformed from laboratory to centre-of-mass frame using Viola systematics for symmetric fission [4]. The differential fission cross section was calculated using the expression

$$\frac{d\sigma_{fis}}{d\Omega} = \frac{1}{2}\frac{Y_{fis}}{Y_{mon}}\left(\frac{d\sigma}{d\Omega}\right)_R \frac{\Omega_{mon}}{\Omega_{fis}}$$

Where, Y_{fis} and Y_{mon} are the yields recorded by the fission detector and monitor (Rutherford) detector, respectively. Ω_{fis} and Ω_{mon} are the solid angles subtended by the fission detector and monitor detector, respectively. $(d\sigma/d\Omega)_R$ is the differential Rutherford cross section in the laboratory system. The angular distributions were fitted to the sum of even Legendre polynomials up to the fourth order to extract the fission fragment angular distribution. The fitted angular distribution was integrated to get the absolute fission cross section. The experimentally measured fission cross section are in consistent with the fissility of the concerned compound nuclei populated ^{210}Rn (fissility=0.735) shows largest fission cross section and ^{216}Rn (fissility=0.726) shows the least value of fission cross section among all the CN populated. The Fission fragment angular distribution at different beam energies for ^{18}O + ^{198}Pt reaction is shown in the Fig.1.

Results and Discussion

PACE2 calculations were performed to fit the experimentally extracted fission cross sections. In the calculations the Sierk fission barrier B_f and the a_f/a_n values were changed to fit the fission cross section as shown in the Fig. 2. Fission cross section for ^{16}O+^{194}Pt measured at few overlapping lower energies with the earlier published data of Prasad et al, is consistent with each other [5]. Also it is clear from the Fig. 2 that the fission cross section decreases with the increases of the N/Z value of the compound nuclei.

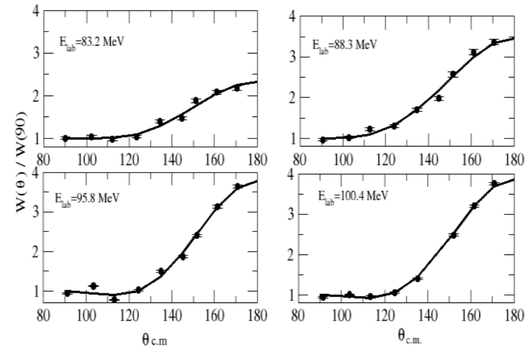

Fig. 1: Fission fragment angular distributions at different beam energies for ^{18}O + ^{198}Pt Solid lines are the fits using Legendre polynomial as described in the text.

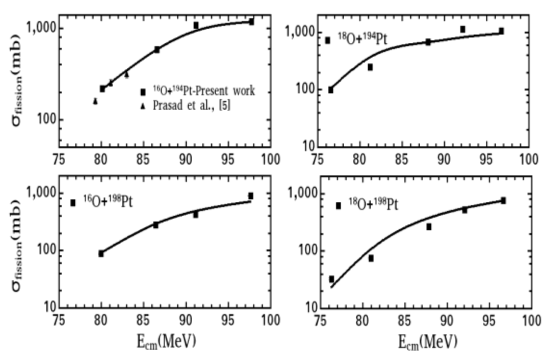

Fig. 2: Experimental fission cross section (solid squares) for ^{16,18}O+^{194,198}Pt reactions (Solid lines shows the calculated values from PACE2).

References

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