Measurement of fission fragment angular anisotropy and level density parameter in $^{18}O+^{209}Bi$ reaction

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Many studies on fission angular distributions were carried out theoretically an experimentally over the years with the heavy ion induced fission fragment angular distributions around the Coulomb barrier which yield information about the fission dynamics. The fission anisotropies depend 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.

Deviation from the predicted angular anisotropy is due to non-equilibrium processes or a Non Compound Nucleus (NCN) fission in the heavy ion induced fission. Anisotropy values is also used as a tool to deduce the level density parameter of the compound nucleus.

The experiment was performed at the BARC-TIFR Pelletron-LINAC facility (PLF) using 100.5, 110.9 and 125.3 MeV ^{18}O beam on ^{209}Bi to measure the anisotropy values and subsequently extract the level density parameter of the compound system. Self supporting ^{209}Bi targets of thickness 300 $\mu g/cm^2$ were used. The experimental setup consist of two monitor detectors, placed at $\pm\ 20^0$ from the beam direction forward angles in order to normalize the data with the Rutherford cross section. The fission fragment folding angular distribution measurements were performed by employing two E (300 μm)-ΔE (25-30 μm) silicon detector telescopes. Data was recorded in VME acquisition system.

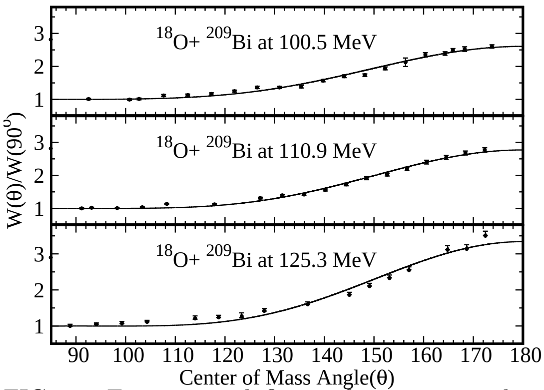

FIG. 1: Experimental fission fragment angular distribution for the $^{18}O+^{209}Bi$ reactions. Each data set is labeled with beam energy. Errors bars indicate statistical errors.

The measured fission fragment angular distributions obtained at laboratory angles with respect to beam direction are shown in Fig. 1. The lab angle has been transformed into the center of mass (c.m.) angle using Viola systematics[2]. The normalized fission fragment yield has been plotted as a function of

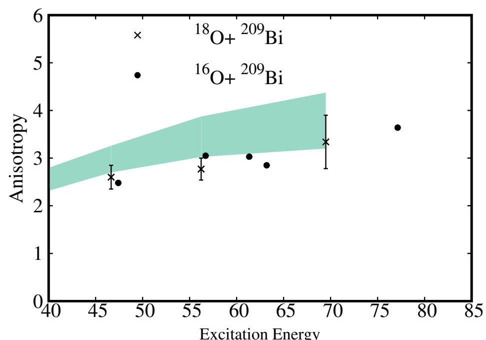

FIG. 2: Comparison of anisotropy values as a function of excitation energy with ^{16}O and ^{18}O projectiles on ^{209}Bi and SSPM calculations. Anisotropie values for ^{16}O on ^{209}Bi is taken from [1] quoted without error bars in Ref.

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TABLE I: Summary of the experimental and theoretical anisotropy values for ^{18}O+^{209}Bi system. a=$A_{CN}/14\ MeV^{-1}$ level density parameter have been used.

System	Energy MeV	E_x MeV	$\langle\ell^2\rangle$	$\langle k_0^2\rangle$ $\hbar$	J_{eff} $(MeV)^{-1}$	A SSPM	A Exp
$^{18}O+^{209}Bi$	125.3	69.49	1436	210.57±44.29	133.31	3.78±0.58	3.34±0.56
	110.9	56.23	1255	182.37±31.61	125.48	3.44±0.42	2.77±0.23
	100.5	46.65	1272	163.99±23.18	120.61	2.97±0.27	2.60±0.25

c.m. angle in Figs.1 for the ^{18}O+^{209}Bi reactions at three energies 100.5, 110.9, 125.3 MeV respectively. The fission fragment anisotropy values are extracted by least square fitting to the experimental data using the formula A=a + $b(\cos\theta)^2$ + $c(\cos\theta)^4$ shown in Table. I. Here a, b, c are the constants and θ is the fission fragment angle in C.M frame.

Experimentally measured and theoretically calculated by the SSPM model angular anisotropy is shown in TableI. The fission fragment anisotropy is given by the following equation,

$$A = 1 + \frac{\langle\ell^2\rangle}{4k_0^2}$$

where k_0^2 is given by,

$$k_0^2 = T\frac{J_{eff}}{\hbar^2}$$

Here T , J_{eff} and ℓ^2 are the temperature, effective moment of inertia at the saddle point and the mean square angular momentum of the fissioning system respectively. The ℓ^2 values have been obtained using the coupled channels calculations code for heavy-ion fusion reactions (CCFULL)[3, 4]. The saddle point temperature is give by,

$$T = \sqrt{\frac{E^*}{a_f}}$$

where, E^* is the excitation energy of the fissioning system and a_f is level density parameter at the saddle point. The excitation energy E^* is written as,

$$E^* = E_{cn} - B_f(\ell) - E_{rot}(\ell) - E_n$$

where E^* is the excitation energy of the compound nucleus, $B_f(\ell)$ is the spin dependent fission barrier and $E_{rot}(\ell)$ is the spin dependent ground state rotational energy are evaluated using the the rotating finite range model (RFRM). The values of $B_f(\ell)$ and $E_{rot}(\ell)$ are calculated by using a RFRM. E_n is the average energy removed by the evaporated pre-fission neutrons. In the SSPM calculation,the pre-saddle neutron numbers were calculated from prefission data of Saxena *et al*

Table.I shows the experimental and calculated anisotropy values. Phenomenological level density parameter of a=$A_{CN}/14\ MeV^{-1}$ were considered to evaluate the theoretical anisotropy values. The potential parameter were taken to be V=53 MeV, r_0=1.21 fm, a=0.64 fm, R_b=11.82 fm, V_b=76.12 MeV and $\hbar\omega$=4.34 MeV with standard notation taken from Ref.[5]. Experimentally observed anisotropy values of ^{18}O compared to the ^{16}O induced fission anisotropy on ^{209}Bi are plotted in Fig.2 from Ref. [1]. Anisotropy value obtained from SSPM calculations shown with a band which denotes uncertainaty in the calculations. Similar range of anistropy values were observed in case of fission induced on ^{209}Bi and ^{208}Pb by ^{18}O and ^{16}O projectiles from Ref. [1] Table 2. Requirement of large value of the lavel density parameter to fit the experimental data is of theoretical interest and needs further incestigation.

References

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