Fission fragment anisotropy for breakup/transfer induced reactions

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Introduction

Fission fragment (FF) angular anisotropies measured for ^{6,7}Li+^{235,238}U reactions at energies around the Coulomb barrier are found to be much larger compared to the statistical model predictions [1]. It has been concluded that contribution of breakup/transfer induced fission along with the compound nucleus fission may lead to the observed difference in FF anisotropy. An attempt has also been made to explain the measured anisotropy by assuming (i) an overall 20% contribution from breakup/transfer induced fission at the measured energies and (ii) the value of $<\ell^2>$ to be same for complete fusion (CF) and incomplete fusion (ICF) fissions. To check the reality in the above assumptions and to understand the observed energy dependence of the FF anisotropy, it is proposed to measure the breakup/transfer induced fission fragments in coincidence with the complementary breakup/residual fragments of the projectile (i.e., the light charged particles) and find the anisotropy for individual breakup/transfer induced (ICF) fissions.

Measurements and Analysis

The fission fragments have been measured in coincidence with light charged particles for ^{6}Li+^{235}U reaction at several energies around the Coulomb barrier using pulsed beam from BARC-TIFR Pelletron facility. Inclusive fission fragment angular distributions have also been recorded. Two MWPC detectors[2] with a total angular coverage of 68° - 171.5° are used for detecting the fission fragments. For light charged particles, two sets of telescopes (ΔE-E) consisting of 4 Si strip detectors (with 16 strips each) are placed at fixed angles covering 112.5°-170° scattering angles. The timing signals obtained from the MWPC detectors traveling through the standard delay lines provide the position information of the detector at which the fission fragments have interacted. The start of time signal has been taken from the RF (used for producing pulsed beam) and stop is taken from the position signals. The position signals are calibrated with the time calibrator. Each of the MWPC detectors have a total delay of 200 ns. From this, the actual positions in the detectors and hence the scattering angles of the events are determined. For position dependent efficiency of each of the MWPC detectors, fission fragments are counted using a standard Californium source at the position of the target centre at the end of the run. This helped us to obtain the relative FF yield at any angle which is independent of solid angle and variation of efficiency at different position of the detector.

Typical FF angular distributions at $E_{\rm beam}$=34 MeV for CF+ICF fission (squares), alpha induced fission (circles) and deuteron induced fission (triangles) in the ^{6}Li+^{235}U reaction are shown in Fig. 1. The measured FF angular distributions in the centre-of-mass frame '$W(\theta_{c.m.})$' have been fitted with the

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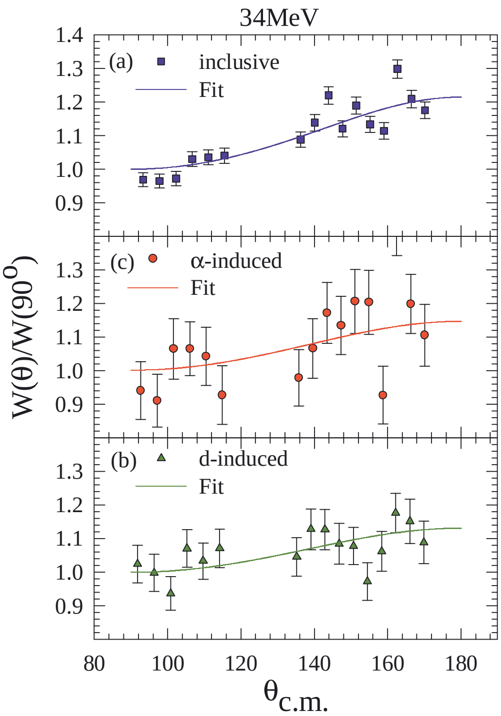

FIG. 1: Typical fission fragment angular distributions in a reaction involving ^{238}U target and ^{6}Li beam with energy E_{beam}=34 MeV for (a) inclusive total-fusion fission (filled squares) (b) α-induced fissions (filled circles) and (c) deuteron induced fission (filled triangles). Solid lines correspond to the fit to the data to obtain FF angular anisotropy.

standard expression for angular distribution as given by Vandenbosch *et al.*[3] and shown as solid lines. The fission data only for $\theta_{c.m.} \geq 90°$ have been included in the plot as well as the fit. The FF anisotropy for the above three cases for E_{beam}=34 MeV are 1.21, 1.15 and 1.13 respectively. The anisotropy for the inclusive channel is consistent with our earlier measurement [1]. It is interesting to find that the anisotropy for break/transfer induced fissions are smaller than the inclusive channel. Since ICF-fissions are more probable at grazing angle, the $< \ell^2 >$ and hence the anisotropy ($= 1+< \ell^2 >/4K_o^2$) for ICF-fissions are expected to be larger compared to the case when α and d are used as beam. Comparison of the present anisotropy values for the ICF-fissions with the ones involving direct beam will tell us about the possible effect of breakup on $< \ell^2 >$ of the composite nucleus formed in ICF. Also, from the coincidence data, we plan to find out the probabilities of deuteron induced and alpha induced fission cross sections and find the contribution due to individual ICF-fissions to the measured anisotropy for inclusive data.

References

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