Breakup/Transfer induced Fission Fragment Angular Anisotropy for ^{6}Li $+^{238}$ U

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Introduction

The study of nuclear reaction mechanism involving weakly bound stable nuclei has been a topic of interest because of the observation of projectile breakup channels due to low breakup threshold compared to those involving strongly bound projectiles. The investigation of fission reactions involving weakly bound projectiles is important from the point of view of production of super heavy element (SHE) using radioactive ion beams.
Due to low breakup threshold, the projectile ^{6}Li can breakup into α and d and one of these breakup fragments may get captured by the target forming a composite system which finally breaks into two fission fragments (FF). Since the breakup fragment of the projectile carries only a fraction of the total energy, the composite system formed by the capture of one of these fragments (incomplete fusion, ICF) acquires lower excitation energy compared to those of the compound nucleus (CN) formed by complete capture of the projectile by the target (i.e. complete fusion, CF). The change in the excitation energy may affect FF angular anisotropy because of its dependency on temperature of the compound nucleus at the saddle point.
The anisotropy 'A' increases with the decrease of the CN temperature 'T' as $\left(A = 1 + \frac{\langle \ell^2 \rangle}{4K_\circ^2}\right)$, where $\langle \ell^2 \rangle$ is the mean square angular momentum and $K_\circ^2 = \frac{I_{eff}T}{\hbar^2}$ where as I_{eff} is the effective moment of inertia of the CN. Thus a non-negligible contribution from breakup fragment induced fission may lead to a significant change in 'T' which in turn will change the value of FF angular anisotropy 'A'. Similar effect can also be observed due to transfer induced fission where a few nucleons are first transferred from the projectile to the target nucleus which then breaks into two fission fragments. In an earlier work [1], the FF anisotropy for ^{6}Li $+^{238}$ U has been observed to be larger in comparison to SSPM prediction. It has been concluded that the observed larger anisotropy may be due to the contribution of breakup/transfer events along with CN fission. In order to exclusively determine anisotropy values for various breakup/transfer channels, measurements on FF anisotropy has been carried out for ^{6}Li $+^{238}$ U system for α and d transfer channels along with inclusive measurements.

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Measurements and Analysis

Fission fragment angular distribution measurements were carried out in coincidence with light charged particles for ^{6}Li $+^{238}$ U reaction at energies around the Coulomb barrier using pulsed beam from BARC-TIFR Pelletron facility. Targets of ^{238}U of thickness $\sim$ 280 $\mu g/cm^2$ were prepared by electro deposition on $\sim$ 750 $\mu g/cm^2$ Al foil. For the detection of FF two large-area ($20cm \times 6cm$) MWPC detectors [2] were placed at 23 cm and 27.5 cm, respectively from the target with a total angular coverage of $68^\circ - 115^\circ$ and $131.5^\circ - 171.5^\circ$. For light charged particles, two sets of telescopes ($\Delta E - E$) consisting of 4 silicon strip detectors (with 16 strips each)

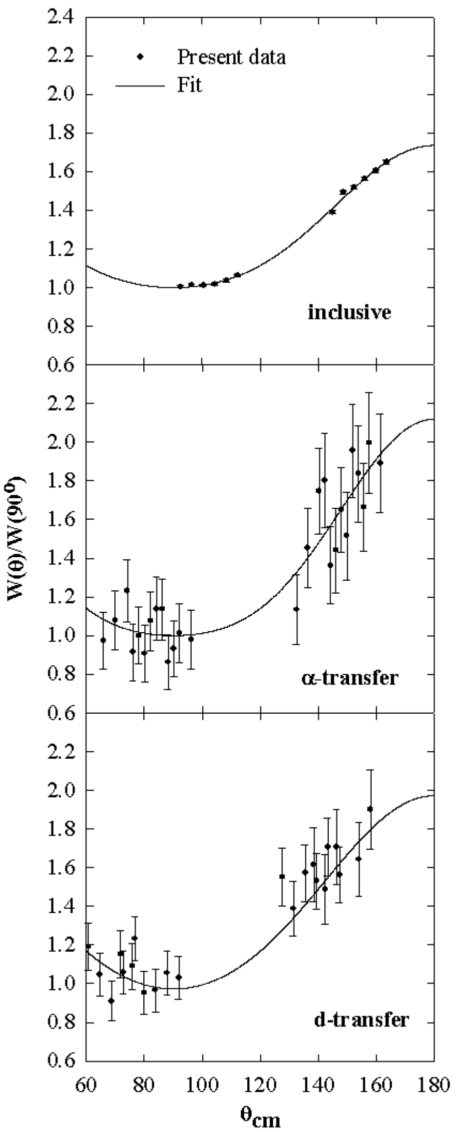

FIG. 1: Fission fragment angular distributions for reaction ^{6}Li + ^{238}U at energy E_{beam} = 36 MeV for (a) inclusive (total-fusion fission) (b) α-transfer and (c) d-transfer. Solid lines correspond to the fit to data to obtain FF angular anisotropy.

of thickness 50 μ for ΔE and 1500 μ for E were placed at fixed angles covering $112.5° - 137.5°$ and $145.0° - 170.0°$ scattering angles.

The position information is obtained from TDC signal. The start of TDC was given from the position signals and a common stop was given from anode signal. These position information was converted into angles for further analysis. For transfer channels recoil angle correction has been done. Fission fragment angular distributions for ^{6}Li +^{238} U along with the theoretical fits at 36 MeV are shown in Fig.1. These measured angular distributions in the centre-of-mass frame 'W(θ)' were fitted by Legendre polynomials (shown by solid lines) to derive the angular anisotropy [$W(180)°/W(90)°$] values. The FF anisotropy at 36 MeV for inclusive (CF+ICF), α-transfer and d-transfer are found to be 1.74 $\pm$ 0.01, 2.12 $\pm$ 0.2 and 1.97 $\pm$ 0.2, respectively. This anisotropy data has been normalized dividing by a factor of 1.41 to make anisotropy value of Ref.[1] for inclusive data consistent with present measurement. The normalized values are 1.23 $\pm$ 0.01, 1.50 $\pm$ 0.15 and 1.39 $\pm$ 0.14 for inclusive, α and d transfer channels. It is observed that the anisotropy values for transfer induced fissions are always higher than the inclusive data. This may be one of the reason we observed higher anisotropy in Ref.[1] in comparison to SSPM prediction.

Acknowledgments

One of the authors (A.P) gratefully acknowledges the financial support from UGC-DAE-CSR, Kolkata Centre.

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