Understanding nature of average total kinetic energy for symmetric fission within the framework of Random Neck Rupture Model

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Introduction:

Fission fragment average total kinetic energy is an important observable of the fission process that results from shape evolution dynamics of fissioning nucleus. The average total kinetic energy is related to length of shape at the time of scission. This is in general true for fission induced by any projectile such as neutron, proton, or heavy ions. It is known that the observables of fission process in a fully equilibrated compound system is independent of projectile or entrance channel and depends on the excitation energy and spin of the fissioning nucleus. Studies on the fragment average total kinetic energy provide valuable information about the scission shape of the fissioning nucleus and based on the shape the complex fission mechanism exhibiting several effects such as symmetric or asymmetric mass distributions, peak to valley ratios, fission fragment angular anisotropy, fragment kinetic energies, emissions such as neutrons, γ and α during or after scission process known as pre-scission or post-scission multiplicities. These multiplicities and other fission observables are important for understanding the fissioning system shape evolution upto the point of scission by means of scission point models such as Brosa model or Langevin dynamics.

Shape evolution in Brosa model

According to Brosa et al., Random Neck Rupture Model (RNRM model) [1], the compound nucleus undergoes a shape change from

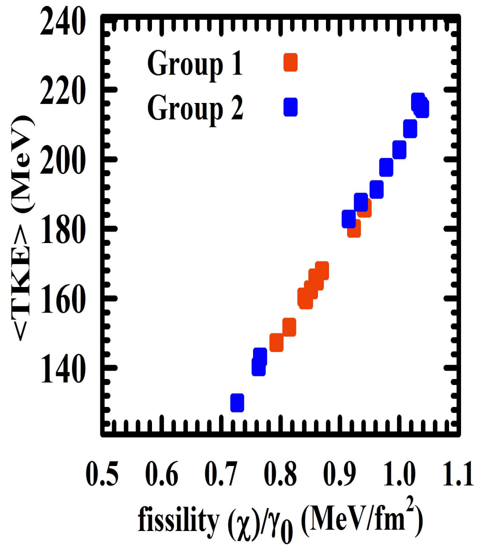

FIG. 1: Average total kinetic energy of fragments $< TKE >$ vs χ / γ_0

a near spheroidal shape at the saddle point to an elongated deformed shape, called a prescission shape, which is the last stage before the neck ruptures. This shape is normally described by a long flat neck connecting two spherical heads. In this model, during the motion of the fissioning nucleus towards scission, a dent is developed in the neck region and is deepened by the capillary force finally leading to fission. During this transition when the neck becomes flat, there can be a large shift in the position of the dent without size-

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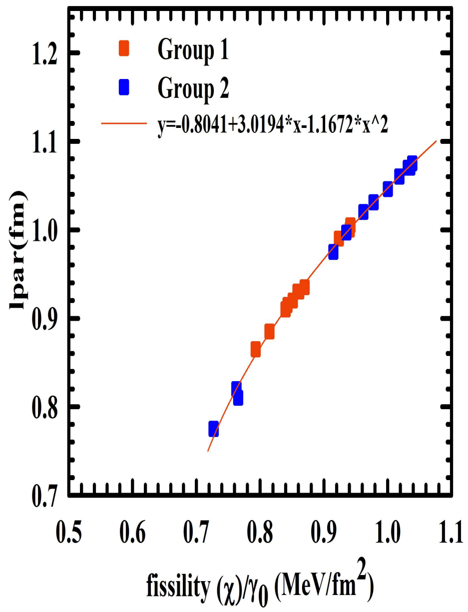

FIG. 2: lpar representing scission semilength (l) vs χ / γ_0

able physical mass where motion, which finally leads to large mass fluctuations in the fission process. In the RNRM model [1] the pre-scission shape of fissioning nucleus is characterised by different parameters such as scission shape semilength (l) and neck radius (r_{neck}) The parameters 'l' is related to reproduce the experimental average total kinetic energy $< TKE >$.

Systematics of scission length parameters of Brosa Model

The average total fragments kinetic energy strongly depends on total elongation length '2l' and here we introduce a parameter lpar = l/18.3735)[2]

In the present RNRM calculations, the elongation 'lpar ' of the pre-scission shape was varied to reproduce the experimental average total kinetic energy $< TKE >$. The lpar values have been analysed as a function of fissility (χ) and γ_0 (i.e. surface energy coefficient) and other parameters. However, it is observed that the quantity, (lpar $*\gamma_0$) versus fissility shows very good systematic trend validating systematics approach and this quantity falls into two groups, as shown in Fig. 1. The detail study has been described in Ref. [2]. Further lpar studied as a function of (χ / γ_0), as shown in Fig.2 The nice systematic behavior has been seen which further fitted with curve of equation lpar=-0.8041+3.019*(χ / γ_0) -1.1672$(\chi/\gamma_0)^2$

Conclusion:

When lpar studied as a function of (χ / γ_0) , we found trend like Viola systematics which shows behavior of $< TKE >$ as function of fissility. Study indicates that two groups of systems seen in the for $< TKE >$ vs (χ / γ_0), in the fissility region 0.6 to0.95, follow different scission dynamics resulting in different types of scission lengths (i.e. short and long scission lengths) and this two groups merge together when 'lpar' studied as a function of (χ / γ_0) and this is useful in predicting scission shape length.

References

[1] U. Brosa, S. Grossmann, A. Muller **Phys. Rep.**,197 (1990),167.
[2] Y. Sawant et al.,**Pramana** In Press.