Symmetric Decay of Superdeformed Nuclei

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Recent experimental results and model calculations suggest a formation and a symmetric decay of superdeformed nuclei in the reactions: 121 MeV and 186 MeV ^{12}C + ^{40}Ca, 141 MeV ^{9}Be + ^{40}Ca and 153 MeV ^{6}Li + ^{40}Ca.

The symmetric decay of composite systems produced in these reactions has been verified by utilizing coincidence techniques.[1) The decay fragments ($A \sim 25$) are highly excited. They evaporate nucleons and alpha particles what makes impossible a simple transformation of data from the LAB to the CM system. Therefore, the primary splitting of the composite system and the subsequent velocity change due to secondary evaporation have been simulated using the Monte Carlo method. A $1/\sin\theta_{CM}$ shape of the angular distribution assumed for the primary fragments resulted in good agreement with experimental data over a quite wide range of LAB angles. E.g. for the 186 MeV ^{12}C + ^{40}Ca reaction and decay products with $Z = 11$ this range was from 20° up to 60° (45°-115°CM) - see Fig.1. In Fig. 2 a comparison of Monte Carlo simulation with data is presented for the same reaction and for fragments detected at angles θ_1 and θ_2. The Monte Carlo curves were calculated with (solid) and without (dashed) the experimental energy cutoff. Position of the maximum in Fig.2 gives simply a value of the total kinetic energy, $\langle E_{CM}^{rel} \rangle$, of fragments from a symmetric decay.

$$\langle E_{cm}^{rot} \rangle = \frac{1}{2}\,\frac{A_p}{A_p + A_T}\,E_p\,\tan^2\theta_{max}\,,$$

here A_P and A_T denote the mass numbers of the projectile and target nuclei and E_p is the incident energy..

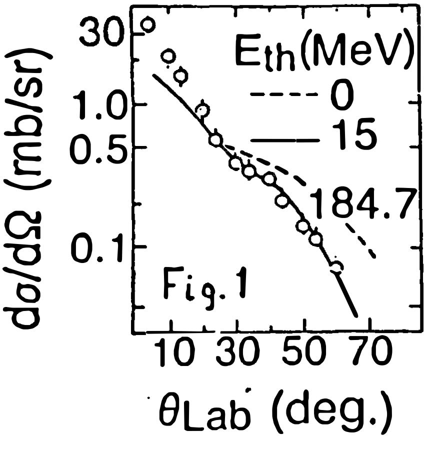

Fig.1

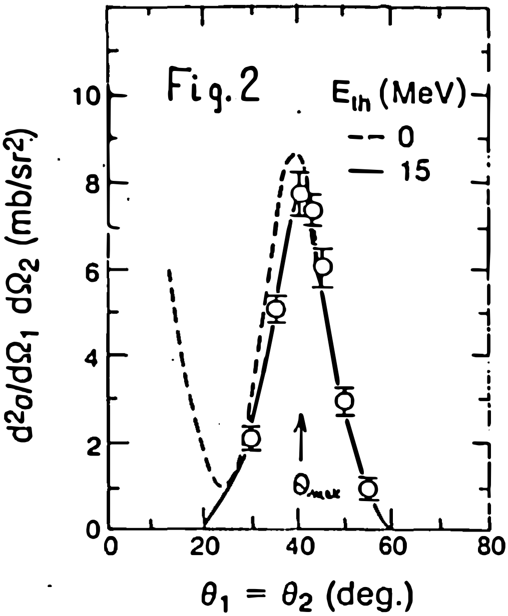

Fig.2

The kinetic energy of fragments may be expressed as a sum of the Coulomb energy and the rotation energy (for a given L) at the scission point. This energy was obtained from the coalescence and reseperation model.[2] The classical trajectories of collisions were computed using the nuclear deformation parameters ρ, λ, Δ of ref.[3]

For a symmetric splitting of nuclear systems presented here the model suggests a fusion-fission mechanism in agreement with the $1/\sin\theta_{cm}$ angular distribution given by the experiment. In Fig.3 the total kinetic energy of fission fragments, $\langle E_{CM}^{rel} \rangle$, predicted by the model[2] is compared with experimental values.[1] The calculated Coulomb

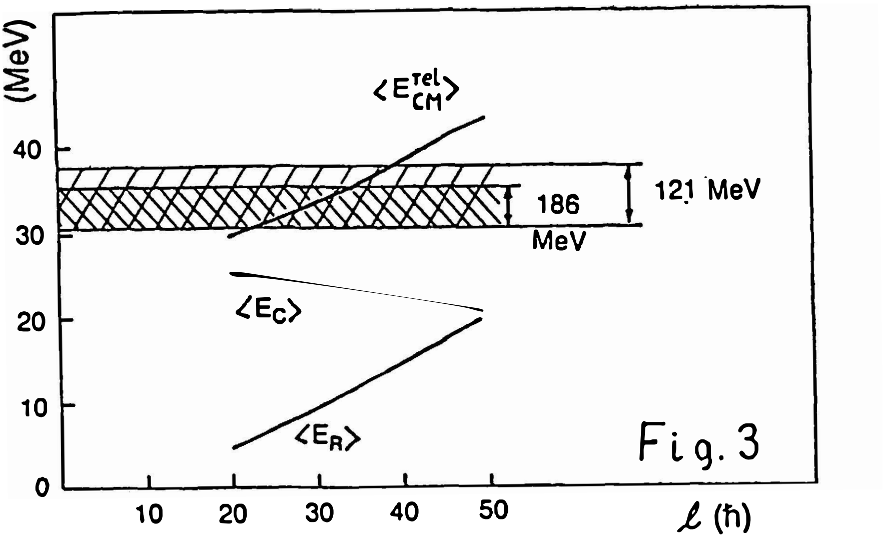

Fig. 3

and rotation parts are also shown. The total kinetic energy, $\langle E_{CM}^{rel} \rangle$, increases slightly with L and crosses the areas of experimental bands suggesting an angular momentum window for fission from about 23 ħ to about 38 ħ. The idealization of a sharp-surfaced liquid drop used here results probably in an overestimate of the energy, especially for smaller L values. Consequently the upper and especially the lower limits of the L window may turn out to be higher. The L window is located in the region of superdeformed nuclei which have the Beringer Knox shape.4)

References:

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