Fission Fragment Mass Distribution of ^{256}Fm

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Abstract Fragment mass distribution is one of the major, measurable characteristics of fission. The shape of the observed yield allows to determine type of fission and—indirectly—to investigate structure of the mother nucleus. It has been proven, that basic properties of nascent fragments are preliminary determined by the configuration of pre-scission point. We assume, that the shape of a nucleus obtained in its pre-scission point provides information about the possible fragment mass asymmetry.

1 The Model

Detailed analysis of a nuclear structure in a pre-scission point allows to deduce some information about the fission fragments properties [6]. To obtain fully microscopic description of the pre-scission configuration the self-consistent calculations of Potential Energy Surface (PES) were performed. The Hatree-Fock-Bogolubov (HFB) model with the Gogny type interactions (parametrization D1S) was used. The fission path, leading to the scission point, was found by minimization of the total energy of the system. The HFB equations were solved with constraints on quadrupole and octupole moments. Precise localization of the pre-scission point was determined after application of the Dubray's method [4].

At the end of the fission path nucleus assumes a molecular shape—two preformed fragments are connected by the neck, containing 10–20 nucleons. The final mass division depends mostly on the mechanism of sharing these neck's nucleons between fragments during scission. After Brosa [2, 3], the probability P of the rupture of a neck, leading to fragmentation A_1/A_2 is given by:

$$P(A_1/A_2) = \exp\left[\frac{-2\gamma\sigma(z)}{T}\right], \qquad (1)$$

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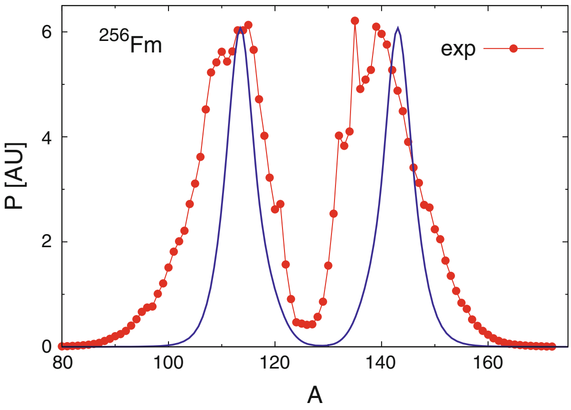

Fig. 1 Fragment mass distribution for the spontaneous fission of ^{256}Fm isotope in comparison to the experimental data, taken from [5]

where $T = \sqrt{12E^{sc}/A}$ is temperature of the pre-scission deformation, which depends on the excitation energy $E^{sc} = E_{g.s.} - E^{sc}_{def}$ and $\gamma = 0.9517[1 - 1.7826(1 - 2Z/A)^2]$ is a surface tension coefficient [1]. The cross section of a neck is equal to $\sigma(z) = 2\pi \int_0^\infty r_\perp \rho(z, r_\perp) dr_\perp$ [7].

2 Results and Conclusions

^{256}Fm represents asymmetric type of fission. The mass yield, obtained using presented method, is shown in Fig. 1.

As one may observe the most probable masses of fragments are quite well reproduced. The peak of the heavier fragment is slightly shifted in comparison with the experimental one. The presented experimental yield was measured after emission of prompt neutrons, what causes the discrepancy. Also the random neck rupture mechanism proposed by Brosa neglects the shell effects, which play an important role during fragmentation. We have shown, that fission mass yields may be partially reproduced by the analysis of the pre-scission shape of a nucleus. The inclusion of dynamic effects should allow to obtain the required broadness of distribution.

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