The optimal shape of rotating and fissioning nuclei within the liquid drop model

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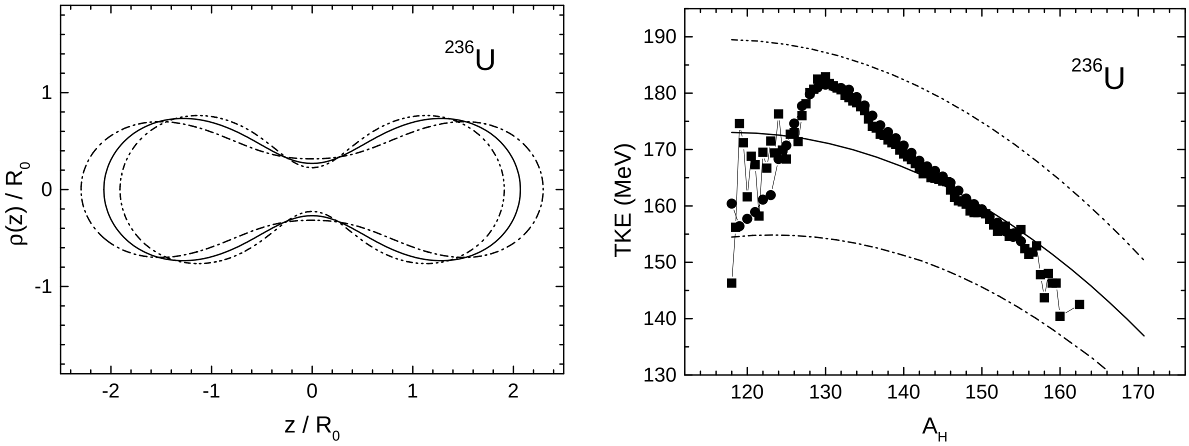
The shape of nuclear surface is a basic notion in many theoretical models of the nuclear structure and reactions. A good choice of the shape degrees of freedom reduces substantially the computation time and often is a key to the success of the theory, especially by the description of the fission process or fusion-fission reactions.

In past a lot of shape parameterizations was introduced. All these shape parameterizations are restricted to a certain class of shapes. In all these cases the question arises whether the given class of shapes is complete enough to represent the essential properties of investigated process.

A method to introduce the shape of nuclear surface which does not rely on any shape parameterization was suggested by V. Strutinsky already in [1]. But only recently [2] it turned out possibly to solve the variational problem of [1] in a broad region of deformations ranging from a disk to the two touching spheres. The fission barriers calculated by this method [3] were found to be in a reasonable agreement with the experimental results. In [4-5] the Jacobi transitions and Poincaré instability of rotating nuclei were examined within the optimal shape method.

In the present work the potential energy landscape is investigated for larger deformations - at the scission point (line). The scission of nucleus into two fragments is at present the least understood part of the fission process, though the most important for the formation of the observables.

For the accurate description of the mass-asymmetric nuclear shape at the scission point it turned out necessary to construct an interpolation between the two sets of constrains for the elongation and mass asymmetry which are applied successfully at small deformations (quadrupole and octupole moments) and for the separated fragments (the distance between centers of mass and the difference of fragments masses). Besides, the constrain on the neck radius was added, what makes it possible to introduce the so called super-short and super-long shapes at the scission point and consider the contributions to the observable data from different fission modes, see the Figure.



Left: Examples of super-short(dash-dot-dot), normal (solid) and super-long (dash-dot) scission shapes for the symmetric splitting of ^{236}U. Right: The comparison of the total kinetic energy of the fission fragments (■ and •) with the Coulomb repulsion energy of the fragments "immediately after the scission" for the super-short(dash-dot-dot), normal (solid) and super-long (dash-dot) fission modes.

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