Abstract

The thesis is devoted to the theoretical research concerning the existence and stability of the heaviest nuclei. In its first part we focus on the exploration of the weakly known region of nuclei with proton number $Z > 126$. In order to determine, whether increased stability could be expected for some of these exotic systems, calculations for a number of even-even nuclei were performed. Two methods commonly used in nuclear physics were employed: the microscopic-macroscopic model with deformed Woods-Saxon potential and the selfconsistent method with Skyrme interaction SLy6. As a result, potential energy surfaces for 46 nuclei were obtained in both models. All calculations were performed with nonaxiality included. As we show, admitting nonaxial shapes has significant impact on the results. On the basis of obtained energy landscapes we determined possible equilibrium configurations and their corresponding fission barriers. For systems with highest barrier found we estimate the spontaneous fission and α-decay half-lives, and comment on the stability against other decay channels.

The second part of the thesis concentrates on the theoretical description of spontaneous fission, which is one of the main decay modes limiting the stability of superheavy nuclei. Starting from the imaginary time formalism we formulate the instanton method for estimation of fission lifetimes, which goes beyond adiabatic approximation and is, therefore, more general than the commonly used cranking approach. The aim is to obtain a tool, that could be applied for the estimation of stability of odd nuclei and other systems with unpaired nucleons, in the case of which the adiabatic approximation is no longer valid. The detailed studies of the instanton method are presented in the following part of this work, where we discuss its properties and behaviour of the resulting action (which translates directly to the fission lifetimes).

As an example, the method is applied for the odd ^{257}Rf isotope. We check, whether this approach is able to explain the experimentally observed fission hindrance of odd nuclei (3-5 orders of magnitude in lifetimes relative to their even-even neighbours). Since the instanton method (in the form we use it) does not take into account pairing force, further calculations for chosen odd systems are performed within the "hybrid" model, in which only the contribution to the action coming from unpaired nucleon is estimated using the instantons. This study allows to test some hypotheses concerning the problem of configuration conservation during the fission process. As we show, keeping the configuration of decaying metastable state fixed greatly affects the fission barriers and resulting lifetimes.

Conclusions from our studies are presented in the final part of the thesis.