

Evolution of the neutron shell gap for $N \geq 150$ with increasing Z from 89 to 100

A. D. Efimov^{1,2*}, I. V. Koval¹, H. M. Devaraja³, I. N. Izosimov³

¹Admiral Makarov State University of Maritime and Inland Shipping, Saint-Petersburg, Russia

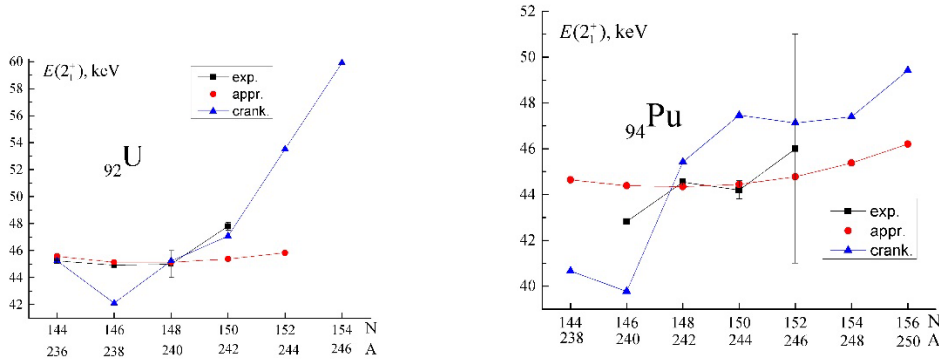
²Physical-Technical Institute, Russian Academy of Sciences, Saint-Petersburg, Russia

³Joint Institute for Nuclear Research, Dubna, Russia

*e-mail: efimov98@mail.ru

Understanding shell-gap evolution in neutron-rich nuclei is crucial for exploring the still-unknown r-process pathway and the formation of the heaviest elements. Nuclei around the deformed $N = 152$ gap in the actinium to fermium region ($Z = 89-100$) offer key insights into shell evolution and the predicted island of stability for superheavy nuclei. In this work, theoretical calculations are compared with the limited available experimental data and extended toward the unknown region to guide future experiments aimed at synthesizing these nuclei. Standard fusion methods, which have been successful in producing nuclei in this region, have reached their experimental limits, and multinucleon transfer (MNT) reactions are considered a promising alternative [1]. However, the simultaneous production of many isotopes makes their separation and identification challenging, highlighting the importance of reliable prior predictions of nuclear properties.

A pronounced shell gap is observed in neutron-rich actinide nuclei and is particularly strong in ^{246}Pu ($N = 152$), as reported in Ref. [2]. With increasing proton number, especially in Cm, Cf, and Fm isotopes, the gap shifts toward higher neutron numbers ($N \geq 154$), while in uranium isotopes it appears already at $N \geq 150$ and, according to our calculations, becomes even more pronounced at $N = 152$. The calculations were performed within the self-consistent nuclear mean-field framework using the Hartree-Fock-Bogoliubov (HFB) method and the cranking model with the UDF1m energy density functional (see Refs. [3]). In addition to the experimental energies and the results of calculations using the CHFB+LN method, the figures also show energies obtained from approximations based on deformation energies [4]. These energies were derived using the Gogny forces. Recent estimates indicate that the Gogny interaction does not reproduce the shell gap in the region around $N = 152$. However, outside this region, the approximation based on the analysis of the energies of actinides and superheavy nuclei is successful. This is clearly demonstrated in the figures for U and Pu isotopes, where the energies are given in keV.



References

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