CALCULATIONS OF THE OCTOPOLE DEFORMATION OF RADIUM AND THORIUM ISOTOPES IN THE HARTREE-FOCK-BOGOLYUBOV APPROXIMATION WITH SKYRME FORCES

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In the Hartree-Fock-Bogolyubov (HFB) approximation, assuming the axial symmetry of nuclei with Skyrme forces (SkM* and SLy4), we calculated the properties of Ra and Th isotopes with A = 218 – 230 (Fig. 1-4). These isotopes are currently intensively studied for the presence of octupole deformation in them. In addition, HFB calculations of the properties of Ra and Th isotopes were carried out in the vicinity of the neutron drip line with A = 280 – 290 (Fig. 5). We used the computer code HFBTHO v2.00d [1] in our calculations. Pairing of nucleons in nuclei is described by density-dependent zero-range pairing forces with different sets of pairing force constants [1-3]. In the calculations, we used the constrained conditions on the parameters of the quadrupole β_2 and octupole β_3 deformations of nuclei and refining calculations without the constrained conditions in the vicinity of the minimum of the dependence of the total nuclear energy E (β_2, β_3) on β_2 and β_3. It is shown that for the considered isotopes Ra and Th, the value of β_3 nuclei strongly depends on the choice of the parameters of the nucleon pairing force. The preferred values of the constants of the pairing forces of neutrons and protons for the considered isotopes Ra and Th were selected from a comparison of the calculated values of the proton and neutron energy gaps with their values calculated from the even-odd differences in the masses of neighboring nuclei. The increase in the pairing strength leads to a decrease or complete disappearance of β_2 and β_3 in the considered isotopes Ra and Th.

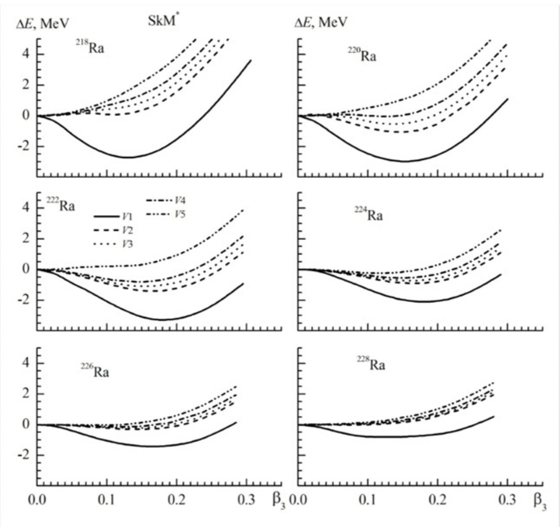

Fig.1. Differences in the energies of radium isotopes as a function of the octupole deformation parameter β_3, obtained in HFB calculations with Skyrme SkM * interaction with different sets of pairing force parameters.

$$\upsilon(\mathbf{r}_1,\mathbf{r}_2) = V_\tau \left\{ 1 - \frac{1}{2}\left[\frac{\rho(\mathbf{R})}{\rho_0} \right] \right\} \delta(\mathbf{r}_1 - \mathbf{r}_2)$$

$$\Delta E = E(\beta_2,\beta_3) - E(\beta_2^{'},\beta_3^{'}=0)$$

Sets of pairing force constants	V_n, MeV fm^3	V_p, MeV fm^3
SkM*		
V1	-233.22	-233.22
V2	-265.25	-340.0625
V3	**-271.88**	**-348.56**
V4	-278.51	-357.06
V5	-291.775	-374.0687
SLy4		
V6	-286	-286
V7	**-310**	**-360**
V8	-325.5	-378

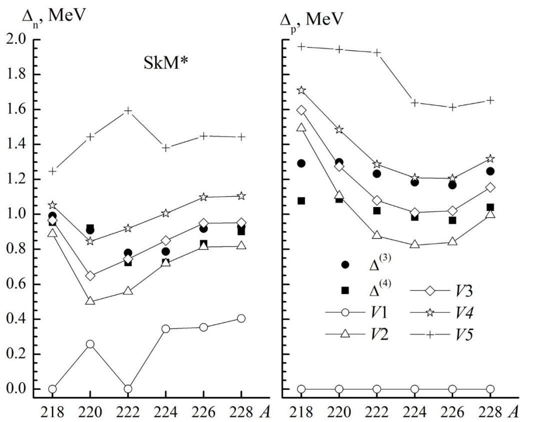

Fig.2. Comparison of neutron and proton energy gaps of radium isotopes calculated with Skyrme interaction SkM * for different sets of pairing force parameters with the values of energy gaps calculated from even-odd mass differences of neighboring nuclei.

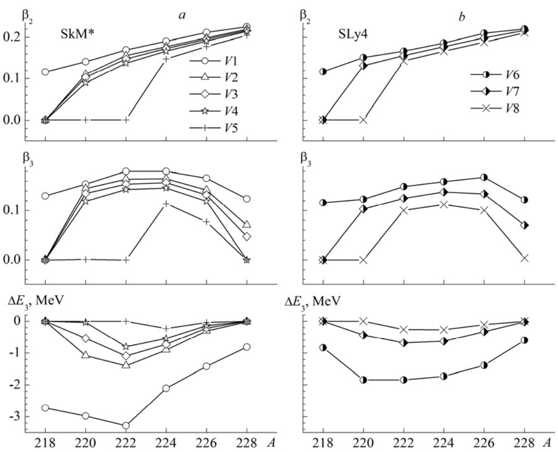

Fig.3. The deformation parameters β_2 and β_3 of radium isotopes, as well as their octupole energies, calculated with the Skyrme interaction SkM*(a) and SLy4 (b) for different sets of pairing force parameters. $\Delta E_3 = E(\beta_2,\beta_3) - E(\beta_2^{'},\beta_3^{'}=0)$.

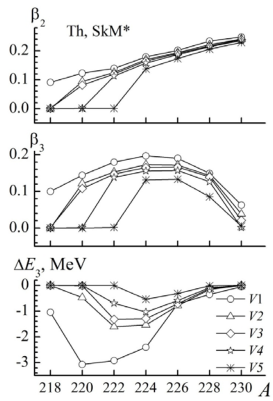

Fig.4. The deformation parameters β_2 and β_3 of thorium isotopes, as well as their octupole energies, calculated with the Skyrme interaction SkM* for different sets of pairing force parameters

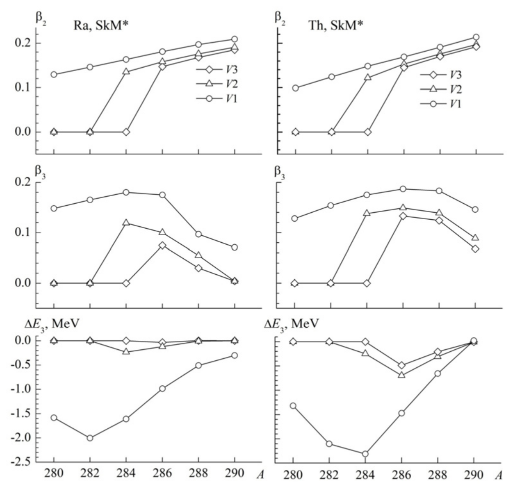

Fig.5. The deformation parameters β_2 and β_3 of radium and thorium isotopes, as well as their octupole energies, calculated with the Skyrme interaction SkM* for different sets of pairing force parameters in the vicinity of the neutron drip line.

Conclusion

It is shown that for the considered isotopes of radium and thorium, the octupole deformation of nuclei strongly depends on the choice of the parameters of the nucleon pairing force. The preferred values of the constants of the pairing forces of neutrons and protons for the considered radium isotopes are selected from the comparison of the calculated values of the proton and neutron energy gaps with their values calculated from the even-odd differences in the masses of neighboring nuclei. Overestimated values of the pairing force constants lead to a decrease or complete disappearance of the quadrupole and octupole deformation in the considered isotopes of radium and thorium.

References

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