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ISOTOPIC DEPENDENCE OF ISOMER STATES IN HEAVY NUCLEI*

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The isotopic dependence of K-isomer states in heavy nuclei is treated.

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High-spin K-isomer states, which are usually assumed as two quasiparticle high-spin states, were observed in heavy nuclei ^{250,256}Fm, ^{252,254}No, ^{266}Hs, and ^{270}Ds [1]. The one-quasiparticle isomer states are also known among odd heaviest nuclei. In order to calculate the energies of isomer states, the two-center shell model [2] is used for finding the single-particle levels at the ground state of the nucleus. The shape parameterization used in this model effectively includes all even multipolarities. The dependence of the parameters of $\boldsymbol{ls}$ and l^2 terms on A and N–Z is modified for the correct description of the ground state spins of known odd actinides.

The contribution of an odd nucleon, occupying a single-particle state $|\mu>$ with energy e_μ, to the energy of a nucleus is described by the one-quasiparticle energy $\sqrt{(e_\mu - e_{\rm F})^2 + \Delta^2}$. Here, the Fermi energy $e_{\rm F}$ and the pairing-energy gap parameter Δ are calculated with the BCS approximation. The values of Δ obtained in our calculations differ from those in Refs. [3, 4] within 0.05–0.1 MeV.

The microscopical corrections, quadrupole parameters of deformation calculated with the two-center shell model are close to those obtained with the microscopic-macroscopic approaches in Refs. [3, 4]. The ground state of ^{248}Fm is found to be at $\beta_2 = 0.25$ and $\beta_4 = 0.027$. For comparison, in Ref. [4] $\beta_2 = 0.235$ and $\beta_4 = 0.049$ in this nucleus. While in ^{247,248,249}Fm

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the microscopic corrections in Ref. [4] are −3.52, −3.57, and −3.97 MeV, respectively, we get −3.85, −3.88, and −4.3 MeV. These values are also comparable with those in Ref. [3].

One can see in Fig. 1 that the discrepancy in energy of quasiparticle states with experimental values does not exceed 300 keV, that is quite satisfactory. The calculated quasiparticle spectra of ^{251,253,255}No are presented in Fig. 2. In ^{255}No we predict the long-living isomer state related to the configuration $9/2^-[734]$. In ^{251}No the isomer state assigned to the $1/2^+[631]$ configuration at ~ 0.105 MeV in Ref. [6] is higher in energy in our calculation.

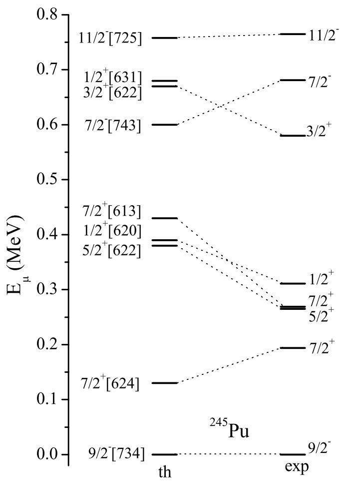

Fig. 1. The calculated (th) and experimental (exp) [5] energies of quasiparticle states in ^{245}Pu.

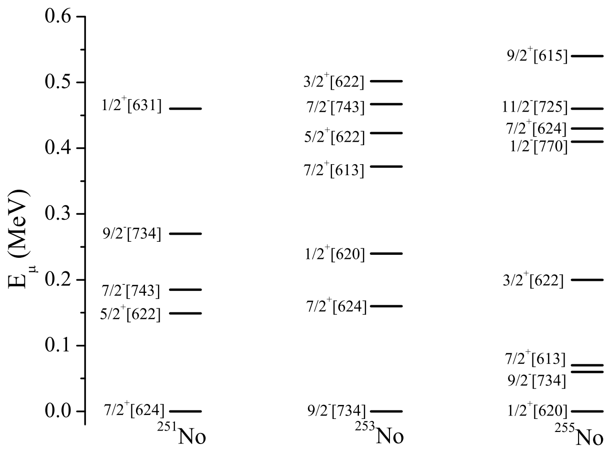

Fig. 2. The calculated energies of quasiparticle states in the indicated isotopes of No.

The calculated energies of two-quasiparticle states with $K \geq 4$ in several even isotopes of Fm are shown in Fig. 3. In the recent experiment [7] the state $8^-_\nu(9/2^-[734] \bigotimes 7/2^+[624])$ was observed in ^{250}Fm at 1.199 MeV that is close to our result. In ^{248,250}Fm the relatively low-lying isomer states with $K = 7^-_\nu$ and 8^-_ν are expected. In ^{242,244}Fm the K-isomer states with $K \geq 6$ are above 1.38 MeV that is larger than the energies of the K-isomer states in ^{252,254}No. In order to observe these states, one should produce the neutron-deficient Fm isotopes with the statistics similar to those for the nuclei ^{252,254}No.

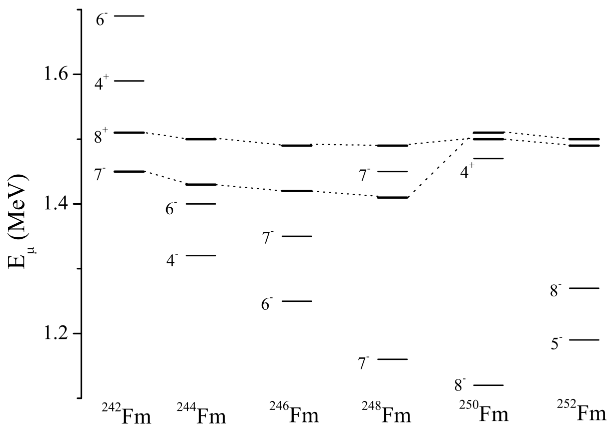

Fig. 3. The calculated energies of two-quasiparticle states in the indicated even isotopes of Fm. The states created by the break of proton and neutron pairs are indicated by thick and thin lines, respectively.

The calculated two-quasiparticle states with $K \geq 4$ in several even isotopes of No are presented in Fig. 4. While in ^{250,252}No the states related to the break of a neutron pair are well lower in energy than the states related to the break of a proton pair, in ^{244,246,254}No the lowest two-quasiparticle states are related to the break of a proton pair. This is in a good agreement with available experimental data [1]. Because of the subshell closure at $N = 152$, the energy of the lowest two-quasineutron isomer in ^{254}No is larger than in ^{252}No. In ^{250}No the two-quasineutron state 6^+ was attributed with the experimentally observed isomer state [8]. ^{256}No seems to be another good candidate to study the low-lying isomer states with $K = 8^-$.

Concluding, the used modified two-center shell model is suitable to describe structure properties of heaviest nuclei and to predict the isotopic trends of K-isomer states. Note that the calculated values of Q_α and, correspondingly, the estimated values of α-decay half-lives seem to be in a satisfactory agreement with the experimental data.

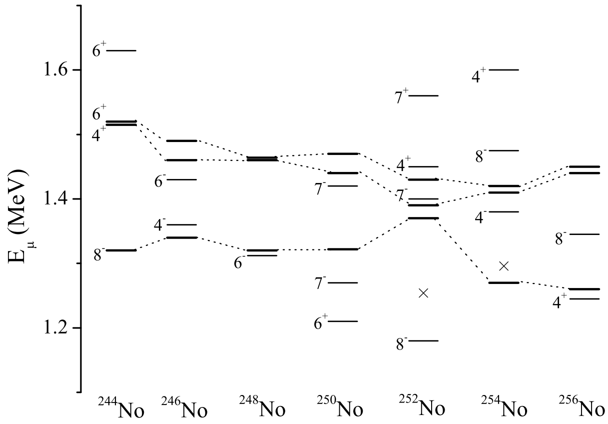

Fig. 4. The same as in Fig. 3, but for the indicated even isotopes of No. The crosses indicate the experimental results [1].

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