Impact of nuclear structure on production of superheavy nuclei

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The calculations performed with the modified two-center shell model reveal quite strong shell effects at $Z = 120 - 126$ and $N = 184$ [1]. So, our microscopic-macroscopic treatment qualitatively leads to the results close to those in the self-consistent mean-field treatments. If our prediction of the structure of heaviest nuclei is correct, than one can expect the production of evaporation residues $Z = 120$ in the reactions ^{50}Ti+^{249}Cf and ^{54}Cr+^{248}Cm with the cross sections 23 and 10 fb, respectively. The $Z = 120$ nuclei with $N = 175 - 179$ are expected to have Q_α about 12.1–11.2 MeV and lifetimes 1.7 ms–0.16 s in accordance with our predictions. These Q_α are in fair agreement with predictions of Liran et al. and about 2 MeV smaller than in other microscopic-macroscopic approaches. The experimental measurement of Q_α for at least one isotope of $Z = 120$ nucleus would help us to set proper shell model for the superheavies with $Z > 118$.

The nuclear level densities were calculated for the nuclei of α-decay chains containing $^{296,298,300}120$. The minima of the level density parameter clearly indicate the strong shell effect at $Z = 120$.

Based on the calculated one-quasiproton spectra and energies for a decays, one can explain [2] why the α-decay chain of $^{291}117$ or $^{287}115$ is terminated by spontaneous fission of ^{267}Db. It is shown that, in the α-decay chain of $^{293}117$, the α decay of ^{281}Rg is hindered by the structure effects and because of this, the ^{281}Rg nucleus undergoes spontaneous fission instead of a decay. In addition, the number of isomeric states in the heaviest odd-Z nuclei is predicted. For the ^{282}Rg nucleus, we expect $T_\alpha \approx 25$ s and $T_{sf} \approx 110$ s, i.e., about ten times larger than for neighboring even-odd nuclei ^{283}Cn and ^{281}Ds. Thus, ^{282}Rg undergoes α decay.

Although the values of T_α found in the α-decay chains of ^{287}Fl and ^{293}Lv are quite large, one cannot completely exclude the α decays from the one-quasiparticle isomeric states in ^{287}Fl, ^{283}Cn, and ^{281}Ds [3]. For example, it is shown that the α decay of the ^{281}Ds nucleus occurs only from the ground state which can be populated with small probability in the α-decay chains of the ^{289}Fl element. The minimum of Q_α in ^{286}Fl indicates the neutron shell at $N = 172$.

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[3] A.N. Kuzmina, G.G. Adamian, and N.V. Antonenko, Phys. Rev. C 85, 027308 (2012).