**Abstract of master Amelia Kosior-Romanowska's PhD thesis titled *Theoretical description of even-even superheavy nuclei using the Hartree-Fock-Bogoliubov method with the Skyrme energy density functional***

This thesis presents results on the study of superheavy atomic nuclei, which was carried out using the self-consistent Hartree-Fock-Bogolubov (HFB) mean-field model, with a nuclear Skyrme density functional. A total of 68 even-even superheavy atomic nuclei were studied, including flerovium isotopes ($Z$=114) with a neutron number of $N$=154-196, $Z$=120 isotopes with $N$=160-196, a chain of $N$=184 isotones with a proton number of $Z$=106-126, and neutron-deficient $Z$=118, 120, 122, and 124 isotopes.

In nuclear stability studies, the change in the binding energy of a nucleus, as a function of its deformation, described by the expectation value of the quadrupole moment operator $Q_{20}$, is analyzed. For this purpose, microscopic models use additional costraints imposed on $Q_{20}$, which describes ellipsoidal nuclear shapes: prolate type ($Q_{20} > 0$), spherical nuclei ($Q_{20} = 0$) and oblate type ($Q_{20} < 0$). For the prolate deformation, with increasing quadrupole moment $Q_{20}$ the nucleus elongates, taking on a "cigar" shape. In this deformation region, there are two paths leading to fission: a symmetric one, where the nucleus splits into two equal fragments, and an asymmetric one, leading to the nucleus splitting into two fragments with different masses. In the case of oblate deformation, as the absolute value $|Q_{20}|$ increases, the nucleus assumes the shape of a flattened ellipsoid, passing into a bilaterally concave disk. At the critical value of $Q_{20} << 0$, a sudden change in the nucleus topology from spherical – simply connected (genus = 0) to toroidal (genus = 1) is observed. Using the self-consistent mean-field HFB model with the nuclear Skyrme density functional, it was observed that for most superheavy atomic nuclei ($Z$=106 to 122), their total energy $E^{tot}$ for toroidal shapes plotted as a function of $Q_{20}$ does not form local minima. This means that the toroidal solutions are not stable and the nucleus "returns" to its ground state when the constraint is released for a given value of the quadrupole moment $Q_{20}$. However, using Skyrme-HF cranking calculations (neglecting the pairing interaction), in which an additional constraint is imposed on the non-zero angular momentum along the symmetry axis of the nucleus *Oz* ($I_z \neq 0$), it is noted that the toroidal solutions stabilize, i.e., local minima in the $E^{tot}$ vs. $Q_{20}$ plot are formed, which is a necessary condition for the formation of metastable toroidal high-spin isomeric (THSI) states.

This thesis presents the properties of even-even superheavy atomic nuclei obtained using the self-consistent mean-field model with the nuclear Skyrme density functional SkM* (in the particle-hole channel) and a density-dependent delta-pairing interaction (in the particle-particle channel). Even isotopes of flerovium ($Z$=114) and $Z$=120 were compared: their ground states, barriers to fission, and instabilities associated with alpha particle emission. The properties of the even spherical $N$=184 isotones were also studied in this respect. An algebraic model of interacting bosons (IBM) was used to analyze in detail the evolution of nuclei shapes in the $Z$=114 and 120 isotope chains as a function of neutron number $N$. This allowed to identify nuclides corresponding to critical points in quantum phase transitions of nuclear equilibrium deformations. Furthermore, for the nuclei studied ($Z$=114 and $Z$=120 isotopes and $N$=184 isotones), the region of large oblate deformations was investigated, in which a change of the nuclear surface topology from spherical (simly connected) to toroidal is observed. Significantly, the possibility of a number of new metastable THSI states was demonstrated for a chain of even $Z$=120 isotopes and $N=184$ isotones. Results obtained for neutron-deficient even isotopes $Z$=118, 120, 122 and 124 are also presented, where recent theoretical predictions indicate the occurrence of superdeformed oblate (SDO) shapes in their ground states.

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