Microscopic description of rotation: from ground states to the extremes of ultra-high spin

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It is well know fact that microscopic description of rotational properties of nuclei can be achieved within the cranking model based on density functional theory (DFT). However, the efforts within such frameworks were mostly directed towards the description of superdeformed rotational bands for absolute majority of which neither spin nor parity are known. As a consequence, a direct estimate of model errors in the reproduction of rotational properties (kinematic moments of inertia or single-particle alignments) depends on the assumptions about spins of these bands. Such error estimates should be straightforward for low-spin rotational bands. However, until now such bands have been studied only in a few cases in three different versions of DFT (Skyrme, Gogny and covariant DFT).

To fill this gap in our knowledge, the cranked relativistic Hartree-Bogoliubov (CRHB) theory has been applied for a systematic study of pairing and rotational properties of actinides and light superheavy nuclei. The investigation of the moments of inertia at low spin and the $\Delta^{(3)}$ indicators related to odd-even mass staggerings shows the need for an attenuation of the strength of the Gogny D1S force in pairing channel. The investigation of rotational properties of even-even and odd-mass nuclei at normal deformation, performed in the DFT framework in such a systematic way for the first time, reveals that in the majority of the cases the experimental data are well described. These include the evolution of the moments of inertia with spin, band crossings in the $A \geq 242$ nuclei and the impact of the particle in specific orbital on the moments of inertia in odd-mass nuclei. The analysis of the discrepancies between theory and experiment in the band crossing region of $A \leq 240$ nuclei suggests the stabilization of octupole deformation at high spin, not included in the present calculations. The evolution of pairing with deformation, which is important for the fission barriers, has been investigated via the analysis of the moments of inertia in the superdeformed minimum.

In addition, triaxial rotational bands in ^{158}Er at ultrahigh spins have been studied in the framework of relativistic and nonrelativistic nuclear DFT. Consistent results are obtained across the theoretical models. Theoretical analysis suggests that experimental band 1 in ^{158}Er extends up to $I \sim 74\hbar$ which is the highest spin ever observed.