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Shape transitions triggered by the extremes of charge, isospin and angular momentum

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The detailed investigation of new physical mechanisms which allows to extend the boundaries of particle-bound nuclear landscape beyond the traditional limits and lead to exotic nuclear shapes has been performed over recent years [1-5]. The increased role of the Coulomb interaction in the hyperheavy ($Z \geq 126$) nuclei leads to the situation when toroidal shapes become more energetically favored than ellipsoidal ones: this provides a substantial increase of nuclear landscape [2,3]. Toroidal nuclei are stable with respect to breathing deformation, but their stability with respect of sausage deformations is established so far only in the $Z \sim 134, N \sim 210$ region for fat toroidal nuclei [1,2]. However, the analysis of toroidal shell structure indicates their potential stability for other combinations of protons and neutrons both for thin and fat toroidal nuclei [3]. In the cases when toroidal shapes become unstable, the ground states are represented by spherical shapes characterized by a substantial depletion of the density in the center of nucleus ("bubble" nuclei). This takes place in the ($Z \sim 138, N \sim 230$), ($Z \sim 154, N \sim 308$) and ($Z \sim 186, N \sim 406$) islands of stability of spherical hyperheavy nuclei [1,3].

Rotational excitations provide an alternative mechanism of the extension of nuclear landscape beyond the limits defined at spin zero [4,5]. Both in hyperheavy and rotating nuclei, the collective coordinates play an important role in extending nuclear landscape. In hyperheavy nuclei, they (deformations) drive the nuclear systems from ellipsoidal-like to toroidal shapes. In rotating nuclei, the increase of collective coordinate (rotational frequency) triggers the transition of nucleonic configurations from particle-unbound to particle-bound. Strong Coriolis interaction acting on high-N intruder orbitals is responsible for this transformation. This new physical mechanism has two important consequences. First, it leads to a substantial extension of the nuclear landscape beyond the spin zero proton and neutron drip lines. Second, exotic shapes such as giant proton halos in rotating proton-rich nuclei [5] and super-, hyper- and megadeformed shapes in rotating neutron-rich nuclei [4] are formed at high spin. Their formation is triggered by the occupation of high-N intruder orbitals.

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