Model predictions of nuclear structure and production cross sections of new superheavy nuclei

G.G. Adamian

Studies of production cross sections and structural properties of superheavy nuclei (SHN) rely strongly on the predictions of the shell effects for which the single-particle dynamics is the driving force. Thus, a good account for the central and spin-orbit single-particle potentials is mandatory to strengthen the predictive power of the conventional microscopic-macroscopic (MM) models, where the potentials are purely empirical. Because the self-consistent mean-field approaches can well describe the structural peculiarities, a meaningful extension is to incorporate into the MM method the single-particle potentials derived self-consistently by nonrelativistic or relativistic mean-field theories. Following this strategy and integrating elements of the established nonrelativistic Giessen nuclear energy density functional approach into the MM model, we calculated the ground-state shell corrections, the mass excesses, Q_α values, and one-quasiparticle states in the SHN with the charge numbers $Z = 112-126$. The possible α-decay chains of nuclei $^{295}119$ and $^{295,297}120$ were analyzed and compared with the available experimental data. The termination of the α-decay chains by spontaneous fission was investigated. We found that the self-consistent approach provides deeper single-particle potentials that those used in the phenomenological consideration and endorses the stronger shell effects at $Z = 120$ rather than those at $Z = 114$. The island of stability of SHN was found to be rather flat and looks like one of "coral reef" origin due to interplay between the proton and neutron shell closures. The next and next-to-next double magic numbers after ^{208}Pb were predicted. The production cross sections are calculated for SHN with $112 \leq Z \leq 120$ in the actinide-based complete fusion reactions with projectiles ^{48}Ca and ^{50}Ti and compared with those calculated in the conventional phenomenological MM approach. Our calculations provide us with some hope for the success of the experiments on the production of $Z = 119$ and 120 nuclei.