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Nuclear shape evolution in the lead region: neutron-deficient bismuth and gold isotopes

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The shape and the size of a nucleus are among its most fundamental properties. Usually, isotopic dependence of nuclear radii is smooth, however the neutron-deficient isotopes in the lead region (near Z = 82) exhibit the richest manifestation of shape evolution and shape coexistence phenomena which lead to marked irregularities in the radii isotopic trends. The behavior of the ground and isomeric states shape differs noticeably for different Z in this region. While in Hg isotopic chain (Z = 80) jump-like odd-even shape staggering was observed at N = 101 - 105 [1], for Po nuclei (Z = 84) an early onset and gradual increase of deformation was found at N < 113 [2]. At the same time the neutron-deficient Tl and Pb nuclei (Z = 81, 82) remain essentially spherical, up to and beyond the neutron mid-shell at N = 104 [3].
Recently a successful investigations of bismuth and gold isotopes were performed at ISOLDE facility (CERN) using the in-source resonance-ionization spectroscopy technique. This highly efficient method provides information about isotope shift (IS) and hyperfine structure (hfs) of optical lines. Changes in nuclear mean-squared charge radius ($\delta\langle r^2\rangle$) and the nuclear electromagnetic moments can be deduced from the IS and hfs. These nuclear observables are sensitive to the radial distribution of the nuclear wavefunction, and thus to the shape evolution across the nuclear landscape.
In this work, we present the results of the IS and hfs measurements for neutron deficient Bi (Z = 83, N = 104-108) and Au isotopes (Z = 79, N = 97-104).
The most interesting findings are as follows:
1) The huge staggering in radii was observed for $^{188}Bi^g$ relative to $^{187,189}Bi^g$ at the same neutron number (N = 105) and with the same amplitude as in the famous Hg case [1]. Quadrupole moment of $^{188}Bi^g$ confirms the strong prolate deformation in this nucleus [4].
2) The isotopes $^{180,181,182}Au$ keep the strong deformation, observed earlier for the heavier gold isotopes $^{183-186}Au$, whilst the lightest isotopes $^{176,177,179}Au$ return to near-spherical shape which is inherent to Au isotopes with A>186.
3) Shape coexistence was found in ^{178}Au which have ground and isomeric states with different deformation.

1. B. Marsh et al., Nature Physics 14, 1163 (2018).
2. T. E. Cocolios et al., Phys. Rev. Lett. 106, 052503 (2011).
3. A. E. Barzakh, et al., Phys. Rev. C 88, 024315 (2013).
4. A. E. Barzakh, et al., Phys. Rev. Lett. 127, 192501 (2021).

The speaker is a student or young scientist

No

Section

1. Nuclear structure: theory and experiment

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