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Isomer Spectroscopy of the Heaviest Elements

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The existence of superheavy elements implies that there are substantial shell effects, beyond the macroscopic liquid drop energy, which stabilize the nucleus against fission. The specific "magic"proton and neutron numbers, representing major spherical shell gaps, are a matter of considerable debate. Shell gaps can also occur when the nucleus distorts to non-spherical shapes leading to enhanced stability at particular deformations. It is well established that nuclei near Z=100, N=152 (252Fm) have well-deformed prolate shapes. Orbitals that originate from above the predicted shell gaps can intrude close to the Fermi surface of these deformed nuclei. There are also many high-K orbitals, which lie close to both the proton and neutron Fermi surfaces. This favors the occurrence of high-K multi-quasiparticle isomeric states at low excitation energy. By identifying such high-K states, and studying their decay to states with lower-K, we can learn about the single-particle structure, pairing correlations, and excitation modes in the heaviest nuclei.

Experiments were carried out at the 88-Inch Cyclotron of the Lawrence Berkeley National Laboratory and used the Berkeley Gas-filled Separator (BGS). High-K isomeric states have been identified in 255Lr (Z=103) and 256Rf (Z=104), representing the highest odd-Z and even-Z nuclei to be studied in this manner, to date. Detailed gamma-ray and electron decay spectroscopy has been performed. Three isomeric states have been discovered in 256Rf and their decay properties are strikingly different from the high-K states seen in the lighter N=152 isotones. A three quasi-particle isomer has been identified in 255Lr and its decay populates lower-lying rotational structures. The behaviors of these rotational bands provide new information on single-particle assignments and pairing properties. The implications of all the recent experimental studies (including these new LBNL results) on the structure of transfermium nuclei will be discussed.

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