

References

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3 - 11 Shape Coexistence in Neutron-Deficient Nuclei with $Z \sim 82$, $N \sim 104$ *

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Neutron-deficient nuclei around mid-shell at $N \sim 104$ in the lead region provide many cases of shape coexistence and shape isomers^[1,2]. In order to study shape coexistence in this region, prompt and delayed γ -ray spectroscopy of the ¹⁸⁷Pb, ¹⁸³Hg, ¹⁸⁸Bi and ¹⁸⁸Po nuclei produced by the fusion-evaporation reaction ⁵⁰Cr + ¹⁴²Nd \rightarrow ¹⁹²Po* has been performed at the Argonne Gas-Filled Analyzer. The recoil-decay tagging (RDT) technique was used to provide an unambiguous γ -ray assignment to a specific nuclide.

In ¹⁸⁷Pb, a new 5.15(15)- μ s isomeric state at 308 keV above the spherical $3/2^-$ ground state is identified. As shown in the left panel of Fig. 1, a strongly-coupled rotational band (Band 1 in Fig. 1) is observed on top of this isomer, which is nearly identical to the one built on the prolate $7/2^-$ [514] Nilsson state in the isotope ¹⁸⁵Hg. Based on this similarity, the new isomer in ¹⁸⁷Pb was proposed to be prolate with $J^\pi = (7/2^-)$ and classified as a shape isomer. The retarded character of the 308-keV $(7/2^-) \rightarrow 3/2^-$ gs transition with a deduced $B(E2) = 5.6(2) \times 10^{-4}$ W.u. can be well explained by the significant shape difference between the prolate initial and spherical final configurations. The combined results of the present work and the previous α -decay and laser spectroscopy studies exhibit the evidence for the triple spherical-oblate-prolate shape coexistence at low energy in the negative-parity configurations of ¹⁸⁷Pb, which is well reproduced by the potential-energy surface (PES) calculations as presented in the right panel in Fig. 1. For detailed discussion and result, please refer to the published paper^[3].

In ¹⁸³Hg, the decay of the nearly spherical $13/2^+$ isomeric state was first observed following the α decay of the $13/2^+$ isomer in ¹⁸⁷Pb. By the α - γ correlation measurement, the half-life of this isomer was measured to be $T_{1/2} = 290(30)$ μ s. As displayed in the decay scheme in Fig. 2, this isomer was proposed to deexcite by an unobserved low-energy M2 transition to the known $9/2^-$ member of a strongly prolate-deformed $7/2^-$ [514] band,

followed by a 105-keV M1 transition to the bandhead. A lower limit of $B(M2) \geq 0.018$ W.u. was deduced for the unobserved transition. The presumed retardation can be explained by the notable shape change between the initial nearly-spherical and the final strongly-deformed states, see the published paper^[4] for more details.

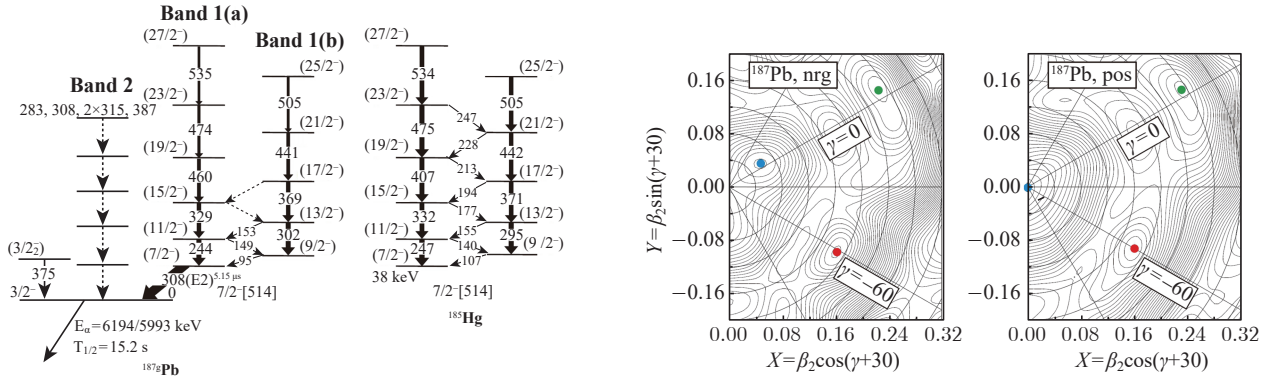


Fig. 1 (color online) Proposed level scheme for ^{187}Pb and partial level scheme of ^{185}Hg (left panel). Calculated PESs for positive and negative configurations in ^{187}Pb (right panel). In the PESs, spherical, prolate and oblate minima are indicated by the blue, green and red circles, respectively.

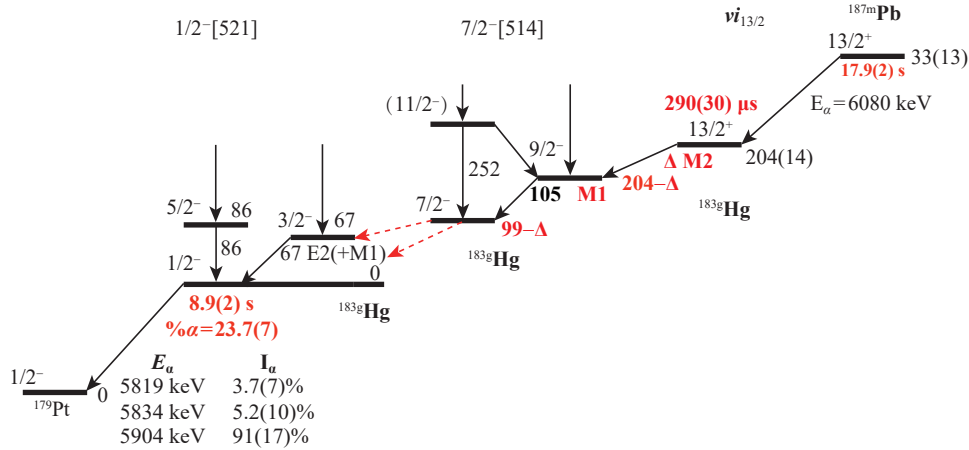


Fig. 2 (color online) Partial α -decay schemes of $^{187\text{m}}\text{Pb}$ and $^{183\text{g}}\text{Hg}$, and of γ decays of low-lying states in $^{183\text{g}}\text{Hg}$. The new data from this study are shown in red and the possible decay paths of the $7/2^-$ level are shown by the red dashed lines.

In this study, a new $0.25(5)$ - μs isomeric state and a prompt 319-366-462-keV γ cascade were identified above (10^-) $^{188\text{m}}\text{Bi}$, and a number of γ rays were also observed on top of $1^{(+)}$ $^{188\text{g}}\text{Bi}$, see the left panel in Fig. 3. Based on the systematics with the neighbouring isotopes $^{187,189}\text{Bi}$, this cascade could be a candidate for a prolate rotational band in ^{188}Bi . The first excited 2^+ state in ^{188}Po was identified, its excitation energy of 242(2) keV continues the nearly constant trend for the first 2^+ states in $^{190,192,194}\text{Po}$, as shown in the right panel in Fig. 3. The new results obtained in the present work provide new information to shape coexistence on bismuth and polonium isotopes near the neutron midshell at $N = 104$, all corresponding details are seen in the published paper^[5].

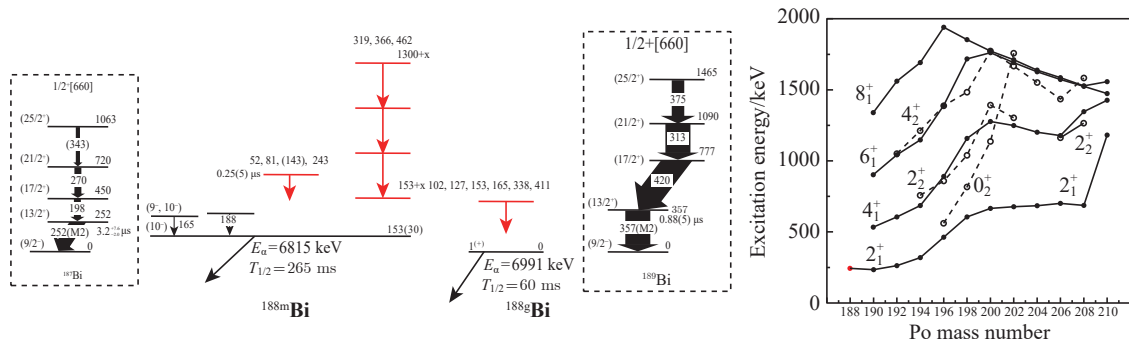


Fig. 3 (color online) Proposed level scheme for $^{188\text{m,g}}\text{Bi}$ (left panel) and systematics of selected positive-parity near-yrast states for even-even polonium isotopes (right panel). The new energy levels and transitions from this study are marked in red.

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3 - 12 A Gas-filled Recoil Separator, SHANS2, at the China Accelerator Facility for Superheavy Elements*

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Over the past years, experimentalists have launched an expedition to explore the predicted, centered near the double-magic $Z = 114$, $N = 184$ nucleus. With their remarkable efforts, elements from hydrogen up to element 118 at present. The discovery of the superheavy elements offers the possibilities to study properties of nuclei under extremely strong Coulomb fields and to explore the limits of existence of nuclei. The fusion evaporation reactions induced by low-energy heavy ions are employed for synthesis and study of superheavy isotopes, and the gas-filled recoil separator technique is always used to effectively separate the produced evaporation residues from projectile-like and target-like products.

Due to the extremely low production cross-section of superheavy nuclei with current above mentioned methods, it is urgent to build an accelerator for high-intensity heavy ions and to develop corresponding efficient separation and collection techniques. In 2019, a research project named CAFE2 (China Accelerator Facility for Superheavy Elements) was launched at IMP-CAS (Institute of Modern Physics, Chinese Academy of Sciences), with the purpose of constructing a dedicated experimental facility for the synthesis and study of superheavy nuclei. A gas-filled recoil separator, SHANS2 (Spectrometer for Heavy Atoms and Nuclear Structure-2), with five magnets arranged in a Q_v -D- Q_h - Q_v -D configuration was constructed at the end of beam line. Its structure shown in the left panel of Fig. 1 can be roughly divided into five parts: a differential pumping system, a rotating target system, a magnet system, a detection system, and a data acquisition system. The total optical length (from the target point to the focal plane) is 5.97 m and the detailed design is available in the published paper^[1].

In this work^[1], several test experiments were conducted to evaluate the performance of SHANS2. The momentum dispersion, which influences background suppression and resolving power, was determined to be $21.1(5) \text{ mm}/\% (B \cdot \rho)$, which is in good agreement with the designed one ($21.7 \text{ mm per } 1\% \text{ of } (B \cdot \rho)$)^[2]. Through the data analysis of the $^{169}\text{Tm}(^{40}\text{Ar}, 4n)^{205}\text{Fr}$ reaction, the optimal pressure of the operating gas filled in the device was about 100 Pa