Deformation effects on Collective and Non-collective Rotations

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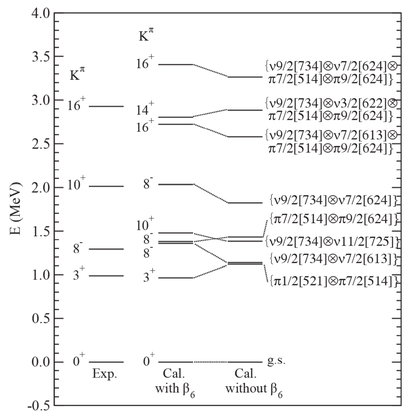
Introduction

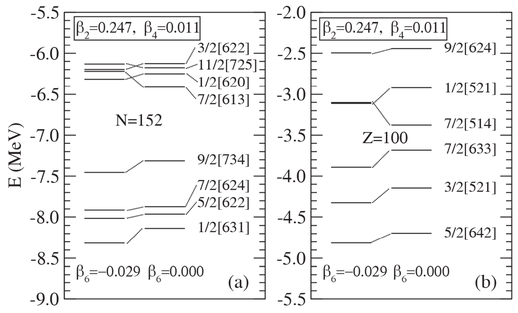
Using configuration-constrained potential-energy-surface (PES) and total-Routhian-surface (TRS) calculations, we have investigated the deformation effect on the structure of superheavy nuclei, showing significant effect from the high-order β_6 deformation [1, 2]. In $A \approx 190$ neutron-deficient nuclei, multi-quasiparticle (multi-qp) excitations extend the coexistence of prolate and oblate shapes [3]. The possible superdeformed (SD) multi-qp high-K states are systematically predicted in the $A \approx 190$ region [4]. These SD high-K states would be populated in future experiments.

Effects of high-order deformation on high-K isomers in superheavy nuclei

Using configuration-constrained PES calculations with the inclusion of β_6 deformation, we find remarkable effects of the high-order deformation on the high-K isomers in ^{254}No.

The inclusion of β_6 deformation significantly improves the description of the very heavy high-K isomers.

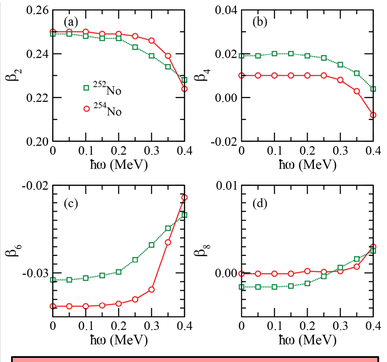




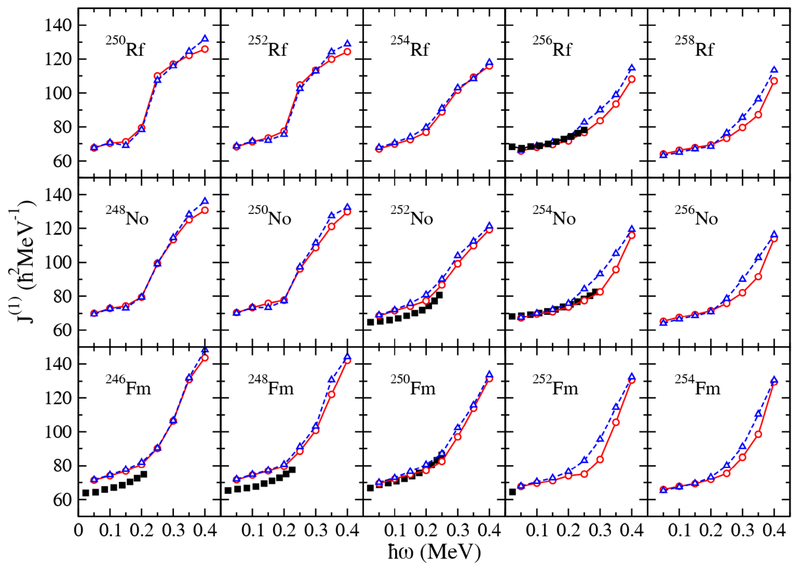
The high-order β_6 deformation leads to enhanced deformed shell gaps at $N = 152$ and $Z = 100$.

Understanding the different rotational behaviors of ^{252}No and ^{254}No

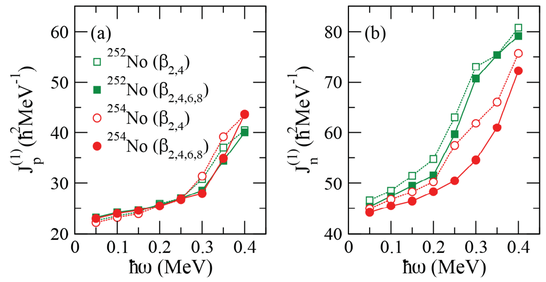
TRS calculations with the inclusion of high-order deformations reproduce well the observed fast alignment in ^{252}No and slow alignment in ^{254}No. The different rotational behaviors of ^{252}No and ^{254}No can be understood in terms of β_6 deformation that delays the alignment of the $\nu j_{15/2}$ orbits when the neutron Fermi is within or above the $N = 152$ closed shell. Our investigations reveal the importance of high-order deformation in describing the rotational spectra of rapidly rotating transfermium nuclei.



Calculated β_2 (a), β_4 (b), β_6 (c), and β_8 (d) deformations vs rotational frequency for $^{252, 254}$No.



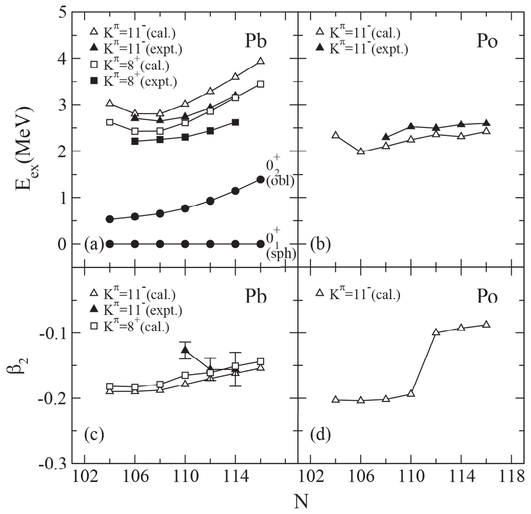
Calculated moments of inertia (MOI) for Fm, No, and Rf isotopes with (open circles) and without (open triangles) high-order deformations $\beta_{6,8}$. Filled squares (black) indicate experimental data.



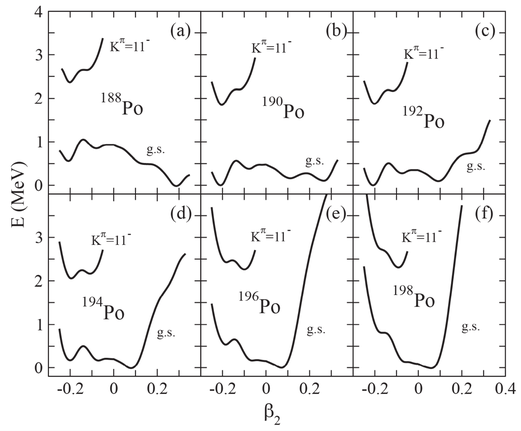
Proton (a) and neutron (b) components of the calculated MOI for $^{252, 254}$No. The comparison indicates that the slow alignment of ^{254}No mainly originates from the influence of β_6 deformation on the neutron MOI.

Multi-qp excitation: Extending shape co-existence in $A \approx 190$ neutron-deficient nuclei

Multi-qp high-K states in neutron-deficient Hg, Pb, and Po isotopes have been investigated by means of configuration-constrained PES calculations. An abundance of high-K states is predicted with both prolate and oblate shapes, which opens up new possibilities for the study of the shape coexistence phenomenon in $A \approx 190$ region.



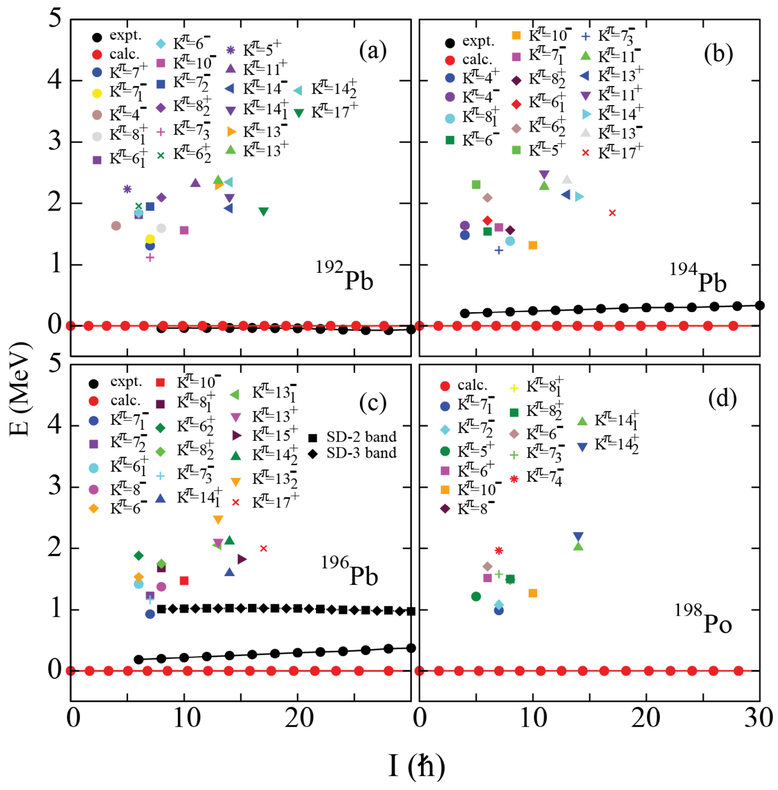
Excitation energies [(a) and (b)] and the corresponding β_2 deformations [(c) and (d)] for $K^\pi = 11^-$ and $K^\pi = 8^+$ oblate states in Pb and Po isotopes. In (a), the dots give the experimental energies for the 0_1^+ (spherical) and 0_2^+ (oblate) states.



Potential energy curves against β_2 deformation for ground state and two-quasiproton $K^\pi = 11^-$ state in neutron-deficient even-even Po isotopes.

SD multi-qp high- K states and possible isomers in Pb and Po isotopes

We have performed configuration-constrained PES calculations for multi-qp high-K states based on SD minima in $^{192, 194, 196}$Pb and ^{198}Po. The calculations predict that ^{196}Pb and ^{198}Po would be favorable candidates for the observation of low-lying SD high-K states. These SD high-K states would be populated in future experiments and be used as probes of K mixing in regions of high-level density.



Excitation energies relative to the calculated yrast SD band. A variety of multi-qp states are shown for ^{192}Pb (a), ^{194}Pb (b), ^{196}Pb (c), and ^{198}Po (d).

References

[1] H. L. Liu, F. R. Xu, P. M. Walker, and C. A. Bertulani, Phys. Rev. C **83**, 011303(R) (2011).
[2] H. L. Liu, F. R. Xu, and P. M. Walker, Phys. Rev. C **86**, 011301(R) (2012).
[3] Yue Shi, F. R. Xu, H. L. Liu, and P. M. Walker, Phys. Rev. C **82**, 044314 (2010).
[4] Yue Shi, F. R. Xu, P. M. Walker, and G. D. Dracoulis, Phys. Rev. C **85**, 064304 (2012).