The study of nuclear structure properties of neutron-rich even-even $^{200-216}$Hg isotopes

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Introduction

The experimental and theoretical studies of exotic nuclei having a large number of neutron or protons are the most operational areas of research. The most prominent part in the enhancement of our understanding of nuclear physics away from the β-stability line goes to the radioactive ion beam (RIB) facilities and sensitive detection technologies. In the pursuit of a better understanding of the atomic nuclear structure, physicists observed a variety of nuclear shapes and structural phenomena. The study of nuclear shape evolution in an atomic nucleus is one of the fundamental quests in nuclear physics. As the number of nucleons increases after the shell closure, the additional nucleons create the polarizing effect that raises the deformation. These studies aim to address all these properties, which are: potential energy curves, binding energy per nucleon, charge radius, and neutron skin thickness.

Theoretical Framework

Self-consistent mean-field (SCMF) models provide a very successful tool to study and analyze a variety of nuclear structure properties throughout the entire nuclear chart. The Lagrangian of density-dependent point-coupling models contains isoscalar-scalar, isoscalar-vector, and isovector-vector four-fermion contact interactions in the isospace-space and is as follows.

$$\begin{aligned}\mathcal{L} &= \overline{\psi}(i\gamma.\partial - m)\psi - \frac{1}{2}\alpha_S(\rho)(\overline{\psi}\psi)(\overline{\psi}\psi) \\ &-\frac{1}{2}\alpha_V(\rho)(\overline{\psi}\gamma^\mu\psi)(\overline{\psi}\gamma_\mu\psi) \\ &-\frac{1}{2}\alpha_{TV}(\rho)(\overline{\psi}\vec{\tau}\gamma^\mu\psi)(\overline{\psi}\vec{\tau}\gamma_\mu\psi) \\ &-\frac{1}{2}\delta_S(\partial_\nu\overline{\psi}\psi)(\partial^\nu\overline{\psi}\psi) - e\overline{\psi}\gamma.\mathbf{A}\frac{1-\tau_3}{2}\psi, \end{aligned} \quad (1)$$

The Energy Density Functional of the point-coupling models is as follows.

$$\begin{aligned}\mathcal{E}_{RMF}[\psi,\overline{\psi},A_\mu] &= \int d^3r\mathcal{H}(r) \\ = \sum_{i=1}^{A}\int d^3r\psi_i^\dagger(\boldsymbol{\alpha}\mathbf{p}+\beta m)\psi_i - \tfrac{1}{2}(\boldsymbol{\nabla}A)^2 \\ +\tfrac{1}{2}e\int d^3r j_p^\mu A_\mu + \tfrac{1}{2}\int d^3r\big[\alpha_S\rho_s^2 + \alpha_V j_\mu j^\mu \\ +\alpha_{TV}\overrightarrow{j}_\mu\overrightarrow{j}^\mu + \delta_S\rho_s\Box\rho_s\big]. \end{aligned} \quad (2)$$

Results and Discussions

In this section, we have provided the potential energy curves for even-even neutron-rich Mercurry isotopes. The comparative analysis between the experimental and theoretical studies is also present in this section.

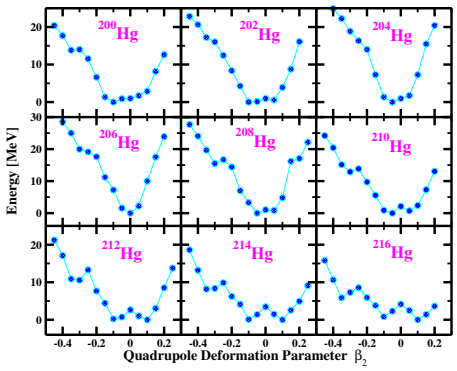

FIG. 1: The potential energy curves as a function of quadrupole deformation parameter β_2 for even-even $^{200-216}$Hg.

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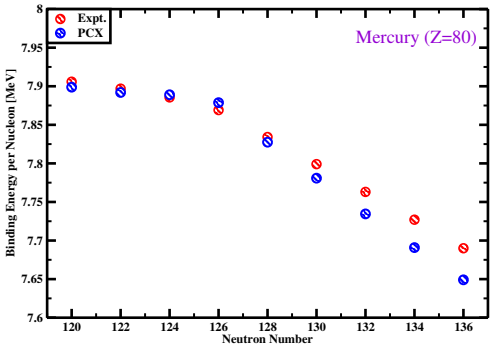

FIG. 2: The experimental[1] and theoretical binding energy per nucleon as a function of neutron number for even-even $^{200-216}$Hg.

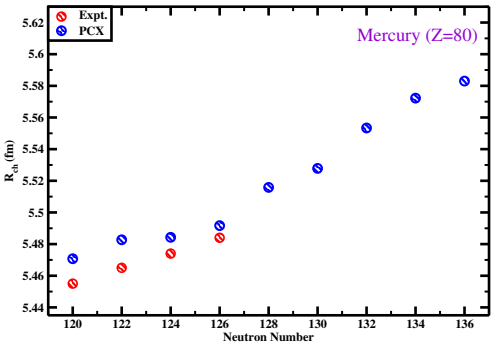

FIG. 3: The experimental[2] and theoretical charge radius as a function of neutron number for even-even $^{200-216}$Hg.

Conclusion

In this paper, we have briefly investigated the shape evolution and ground-state properties of neutron-rich even-even $^{200-216}$Hg isotopes using RHB Model. The program we used solves the nuclear RHB problem by using the harmonic oscillator basis. We have employed the DD-PCX parameterization for our theoretical calculations. The central focus of our research is to study the shape transition and trend of ground-state quadrupole deformation β_2 of neutron-rich even-even $^{200-216}$Hg isotopes. We have presented the shape transition and used final values of the quadrupole deformation parameter β_2 to find the ground

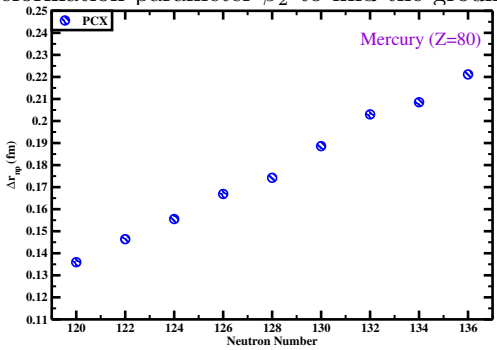

FIG. 4: The neutron skin thickness as a function of neutron number for even-even $^{200-216}$Hg.

state properties. The investigated ground-state properties are potential energy curves, binding energy per nucleon, charge radius, and neutron skin thickness. We have explained these ground-state properties and provided a comparative analysis with the available experimental[1,2] data. Theoretical estimations showed a adequate similarity with available experimental[1,2] data. After using the DD-PCX parameterization on ^{210}Hg ^{212}Hg ^{214}Hg, and ^{216}Hg, we have observed the shape coexistence of prolate-oblate shape.

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References

[1] https://www.nndc.bnl.gov/
[2] Xia, X. W., et al. Atomic Data and Nuclear Data Tables **121** (2018): 1-215.