Nuclear shape evolution of even-even isotopic chains of Sn, Te, and Xe using PCX interaction

Vikesh Kumar[1]* , *Shashi K Dhiman*[1]
[1]*Himachal Pradesh University, Summer Hill Shimla INDIA 171005*
* *Presenting author email: vickyrao955@gmail.com*

Abstract: The primary objective of this research is to analyze the shape evolution of even-even isotopic chains of Sn, Te, and Xe using covariant density functional theory. We have taken the whole even-even isotopic chains of Sn, Te, and Xe, to provide a comparative analysis using PCX interaction. The other properties we included are binding energy per nucleon, quadrupole deformation parameter β_2, one-neutron separation energy, two-neutron separation energy, shell closure parameter Dn(Z, N), differential variation dS2n(Z, N), proton rms-radii, neutron rms-radii, and neutron skin thickness. Theoretically calculated results are discussed and compared with available experimental data[1,2] and other theoretical models[3]. The shape coexistence for these isotopic chains of Sn, Te, and Xe is investigated and discussed in the results section. The adequate resemblance between our calculated results and experimental data provides the experimental background to our studies.

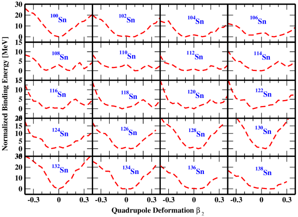
INTRODUCTION

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: shape evolution, shape coexistence, binding energy per nucleon, quadrupole deformation parameter β_2, one-neutron separation energy, two-neutron separation energy, shell closure parameter Dn(Z, N), differential variation dS2n(Z, N), proton rms-radii, neutron rms-radii, and neutron skin thickness. 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 reason for using Tin, Tellurium, and Xenon is because these are potential candidate at and above shell closure 50.

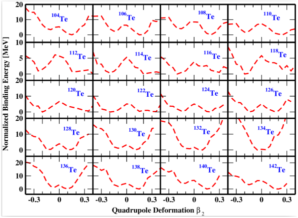
The Lagrangian of density-dependent point-coupling models contains isoscalar-scalar, isoscalar-vector, and isovector-vector four-fermion contact interactions in the isospace-space and is as follows.

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

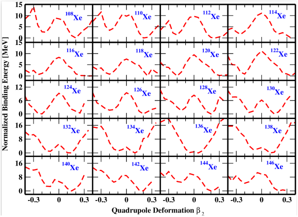
RESULTS



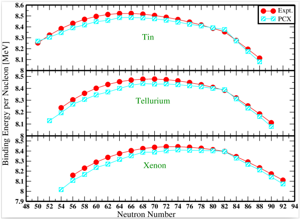
(a) PECs of Tin



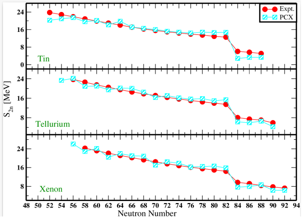
(b) PECs of Tellurium



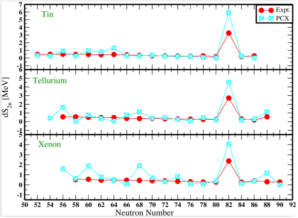
(c) PECs of Xenon



(d) BEPN in MeV



(a) S_{2n} in MeV



(b) dS_{2n} in MeV

CONCLUSIONS

In this paper, we have briefly investigated the shape evolution and ground-state properties of even-even Tin, Tellurium, and Xenon isotopes using the 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 even-even Tin, Tellurium, and Xenon isotopes. We have presented the shape transition and used final values of the quadrupole deformation parameter β_2 to find the ground state properties.

The investigated ground-state properties are the binding energy per nucleon, two-neutron separation energy and its differential variation. We couldn't add the figures for remaining properties due to limits of slides. We have explained these ground-state properties and provided a comparative analysis with the available experimental data[4]. Theoretical estimations showed a adequate similarity with available experimental data. After using the DD-PCX parameterization on ^{104}Sn, ^{106}Sn, ^{108}Sn, ^{110}Sn, ^{112}Sn, ^{104}Te, ^{106}Te, ^{108}Te, ^{110}Te, ^{112}Te, ^{114}Te, ^{116}Te, ^{118}Te, ^{120}Te, ^{122}Te, ^{124}Te, ^{126}Te, ^{128}Te, ^{130}Te, ^{136}Te, ^{138}Te, ^{140}Te, ^{142}Te, ^{108}Xe, ^{110}Xe, ^{112}Xe, ^{114}Xe, ^{116}Xe, ^{118}Xe, ^{120}Xe, ^{122}Xe, ^{124}Xe, ^{126}Xe, ^{128}Xe, ^{130}Xe, ^{132}Xe, ^{134}Xe, ^{138}Xe, ^{140}Xe, ^{142}Xe, ^{144}Xe, and ^{146}Xe we have observed the shape coexistence of prolate-oblate shape.

REFERENCES

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4 http://www.nndc.bnl.gov.