Shape co-existence in Pt isotopes

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Introduction

The Hartree-Fock-Bogoliubov (HFB) theory is a self-consistent mean field model unifying the Hartree-Fock (HF) theory and the Bardeen-Cooper-Schrieffer (BCS) theory. Recently a lot of work is directed towards investigating shape co-existence in Pt isotopes experimentally [1][2]. Different theoretical models are also employed to study the structural properties of the Pt isotopes [3][4]. In this work, we used the code HFBTHO v2.00d [5] that solves the Skyrme HFB equations to study the nuclear structure properties of Pt isotopes.

Theoretical Framework

The HFB equation can be written in matrix form as

$$\begin{pmatrix} e+\Gamma-\lambda & \Delta \\ -\Delta^* & -(e+\Gamma)^*+\lambda \end{pmatrix} \begin{pmatrix} U \\ V \end{pmatrix} = E \begin{pmatrix} U \\ V \end{pmatrix} \quad (1)$$

where e is the kinetic energy operator, Γ the mean field potential, Δ the pairing field and λ is the Fermi energy. E gives the quasiparticle energy while U and V are the coefficients that transform the single-particle states into quasi-particle states.

The quadrupole deformation β_2 of the nucleus is a general measure of its shape about the axially symmetric axis. In spherical coordinates the multipole moment $\hat{Q}_l$ of order l is given as

$$\hat{Q}_l(r,\theta,\varphi) = r^l \sqrt{\frac{2l+1}{4\pi}} P_l(\cos\theta) \quad (2)$$

where P_l is the Legendre polynomial of order l. We have the relations $r^2 = \rho^2 + z^2$ and $r\cos\theta = z$ connecting spherical and cylindrical coordinate systems. The quadrupole deformation β_2 then has the form [6]

$$\beta_2 = \sqrt{\frac{\pi}{5}} \frac{\langle \hat{Q}_2 \rangle}{\langle r^2 \rangle} \quad (3)$$

where $\hat{Q}_2$ is the quadrupole moment and $\langle r^2 \rangle$ is the root mean square radius.

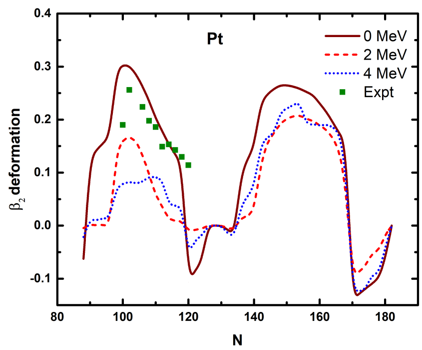

FIG. 1: Quadrupole deformation β_2 for the even-even isotopic chain $^{166-260}$Pt.

Results

Fig. 1 depicts the quadrupole deformations calculated at different temperatures 0 MeV, 2 MeV and 4 MeV along with the available experimental data [7] for the ground state configuration of Pt isotopes. The experimental results show fair agreement with the calculated deformation values. An interesting observation is that the nuclear shape tends to move from oblate to prolate at the boundary of magic nuclei with $N = 126$ [8]. We also observe the nuclei tending towards a more spherical shape as the temperature increases.

Fig. 2 gives the potential energy curves as a function of the deformation parameter

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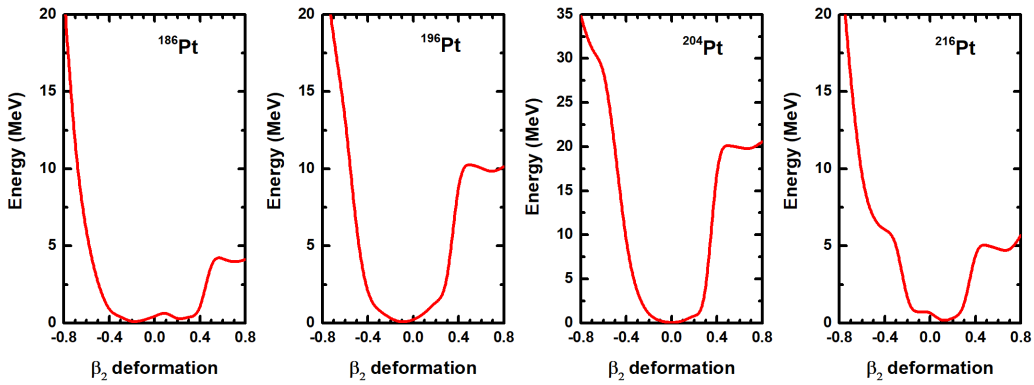

FIG. 2: The potential energy curves for isotopes ^{186}Pt, ^{196}Pt, ^{204}Pt and ^{216}Pt as a function of the deformation parameter β_2.

β_2 calculated using Skyrme parametrization SLY4. Owing to its magic number configuration of 126 neutrons ^{204}Pt has a perfect spherical structure. ^{196}Pt and ^{216}Pt isotopes have their energy minima at deformations -0.1 and 0.1 resulting in oblate and prolate shapes respectively. We observe very flat minima or a secondary minima in some nuclei suggesting chances of shape co-existence. This is seen in ^{186}Pt where we have two minima, one corresponds to the prolate shape and another with an oblate shape.

Conclusion

We have calculated nuclear structure properties of the Pt isotopic chain in the self-consistent framework of the Skyrme-Hartree-Fock-Bogoliubov theory. Potential energy calculations suggest shape co-existence in certain isotopes of Pt.

Acknowledgments

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