# Isotopic Shift In Even-Even Barium Isotopes

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## Introduction

Isotopic shift of atomic spectra is one of the important field of study and has wide applications in systematic study of nuclear ground state spin, electro- magnetic moments and charge radii. The investigations of long isotopic sequences, including a short life of nuclei far from stability are subjected to this field of study [1]. This behavior has been reported in various rare earth regions [2]. The anomalous shifts and kinks has been reported in different nuclei to explain the isotopic shift in nuclear isotopes [3, 4].

We have studied neutron-rich Barium(Ba) isotopes as these lies, at an interesting section of the nucleic chart close to the well known transitional region from spherical to deformed of rare earth isotopes. The systematic constrained calculation with axial-symmetry assumption is done in the self-consistent mean field model with separable pairing and BCS pairing approach. The model parameter used are the density-dependent DD-ME1, DD-ME2, and DD-PC1(density-dependent point-coupling), and the nonlinear meson-nucleon interaction (NL3*). A systematic comparison is made with calculated values and experimental observations, Infinite Nuclear Matter(INM) model , Macro-microscopic Finite Range Droplet Model(FRDM) as well as with the self-consistent Hartree-Fock-Bogoliubov(HFB) calculations based on the SkP, SkM* and SLy4 functionals and the HFB theory extended by the generator coordinate method and mapped onto a five-dimensional collective quadrupole Hamiltonian with the Gogny D1S interaction (CHFB+5DCH).

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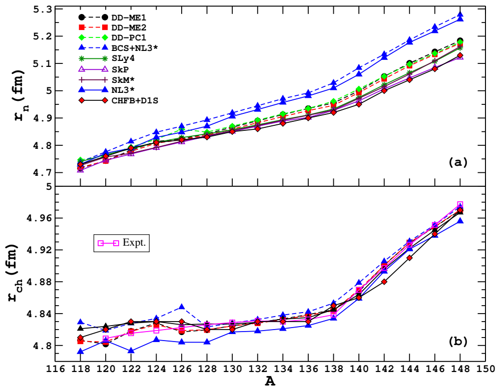


FIG. 1: Nuclear radii for even-even $^{118-148}$Ba nuclei obtained using different relativistic interactions. The other results are presented for comparision available wherever.

## Results and Discussion

We have discussed the correlation between a nuclear shape and its matter distribution. Here, we present the root-mean-square radii ($r_{rms}$) and rms charge radius ($r_{ch}$).We have also discussed the isotopic shift in terms of the observable $\langle \Delta {r^2}_c \rangle^{N,82}$ and its differential $\langle \Delta {r^2}_c \rangle^{N-2,N}$ . In Fig. 1, we present nuclear radii evaluated using different interactions. Fig. 1(a) show neutron radii and Fig. 1(b) show charge radii for all the isotopic chains. Neutron radii for Ba isotopes show an increasing trend with the neutron number for all isotopic chains. One can observe a clear kink about magic number N=82. This is the indication of shell effects in nuclei. The similar behavior is observed in Fig. 1(b). One can additionally notice a fluctuation in the proton rich side of the Ba isotopes which can be due to the variation in deformations.

We have also studied the isotopic shifts in Ba isotopes presented in Fig.2. Isotopic shifts provide information about the size and angu-

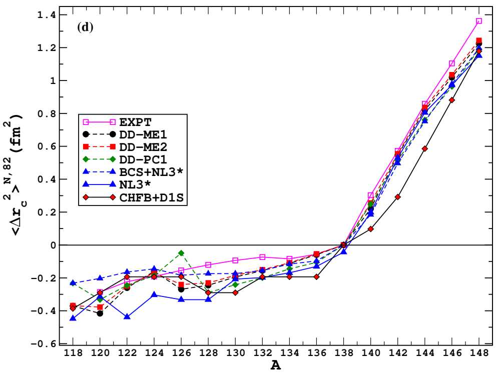


FIG. 2: The isotopic shift for even-even Ba isotopes.

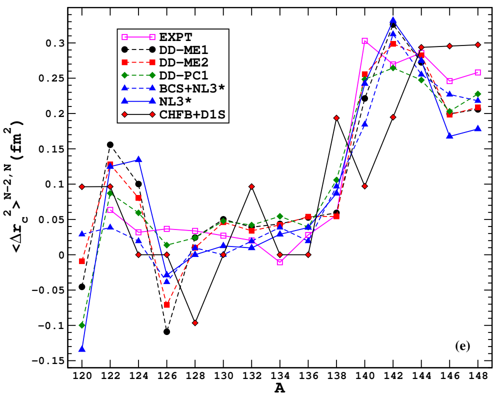


FIG. 3: Differential isotopic shift for even-even Ba isotopes.

lar shape of atomic nuclei. The shift is attributed to field effects of valence nucleons. The RMF charge radii have been used to obtain isotopic shifts $\langle\Delta {r^2}_c\rangle^{N,82}$ for all isotopic chains with N=82 as reference as it is neutron magic and closed-shell position. This has been done with a view to facilitate comparison of our predictions. Isotopic shifts for Ba chains for all interactions show a value nearly same with higher neutron rich side. The overall agreement with the experimental data [5] towards neutron-rich side is very good for all the isotopes. In Fig. 2, the appearance of a prominent kink at A=138(N=82) due to shell effect for Ba isotopes is well reproduced. This also confirms the transitional behaviour of nuclei. The nuclei on either side of A=138(N=82) are deformed. Thus, it supports the shape transition from deformed shape to spherical to deformed. Apart from this, at $^{118-136}$Ba nuclei, though one gets the negative value in the isotopic shift yet one can find a decrease in value at $^{120,126}$Ba (in case of DD-ME1,DD-ME2), $^{120,128}$Ba (in case of DD-PC1), and $^{126}$Ba (in case of NL3*) with respect to their neighbouring nuclei. This implies that these barium nuclei has smallest rms charge distribution than their neighbouring nuclei. This disagreement with the experimental data may be attributed to the triaxial deformation. To get a better understanding, we have studied differential changes of mean square charge radii, presented in Fig.3. A strong peak can be easily seen at A=142 in barium isotopic chains in case of all relativistic interaction presented here except, experimental results which show it at A=140. These peakings correspond to sudden increase of static deformation in Ba isotopes. This is clearly due to variation in deformation values which are not presented here.In this study, discrepancy in towards the proton- rich side of the Ba isotopes can be attributed to complex and slightly different evolution of shapes and magnitudes of deformation while adding or subtracting the valence neutrons to closed shell nuclei (N=82). One has to consider triaxial-symmetry to get a better picture.

## References

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