# Shape Coexistence and bubble structure in Iodine isotopes

Afaque Karim[1*] and Shakeb Ahmad[2†]
[1]*Department Of Physics, Aligarh Muslim University, Aligarh-202002,INDIA and*
[2]*Physics section, Women's College, Aligarh Muslim University, Aligarh-202002,INDIA*

## Introduction

Nuclear shape coexistence is one of the very peculiar phenomenon studied in various mass regions of the periodic table. Nuclei with two different shapes within a very narrow energy range, i.e shape coexistence is an important challenge for theoreticians as well as experimentalists. A reliable work both theoretical and experimental has been done for studying the coexistence of different shapes by different researchers [1, 2]. The other interesting investigation is bubble structure in atomic nuclei. The bubble structure is characterized by a depletion of central density in nuclei. In 1940s, Wilson [3] started the poineering work of bubble structure studies. Now a days, bubbles are studied in various light, medium, heavy and superheavy nuclei [2–4].

In the present work, isotopes of iodine (Z=53, N=122-133) has been chosen for studying shape coexistence and bubble structure as it has been the focal point for large number of experimental studies. We have studied the ground state as well as intrinsic excited state using covariant density functional theory(CDFT) [5] with different interactions (DD-ME1, DD-ME2, DD-PC1, NL3*). The theoretical formalism for CDFT are presented in Ref. [5]. We have also studied the other ground state properties like rms radii, charge radius, quadruple deformation, pairing energy which are not presented in this paper.

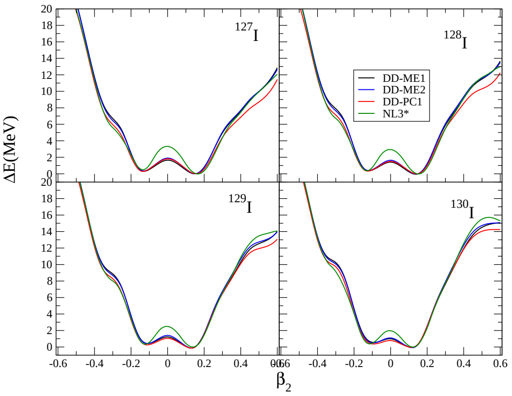


FIG. 2: PES of $^{127-130}$I

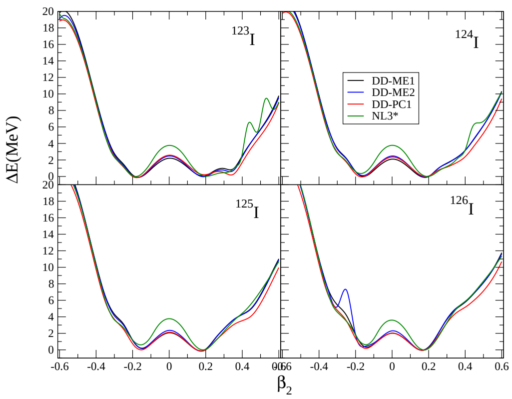


FIG. 1: PES of $^{123-126}$I.

## Result and Discussion

### A. Shape Coexistence

The constraint calculation to obatin potential energy surface(PES) is done for $^{123-133}$I nuclei. The PES of $^{123-133}$I nuclei presented here clearly demarcates the shape coexistence behaviour. From PES, it is clear that Iodine isotopes bear two different shapes (i.e. oblate and prolate) with slight variation in energy.Thus, one can infer that nucleus can oscillate from one state to another state by perturbing small energy. In addition to this, the difference of the

*Electronic address: `afaquekrm@gmail.com`
†Electronic address: `physics.sh@gmail.com`

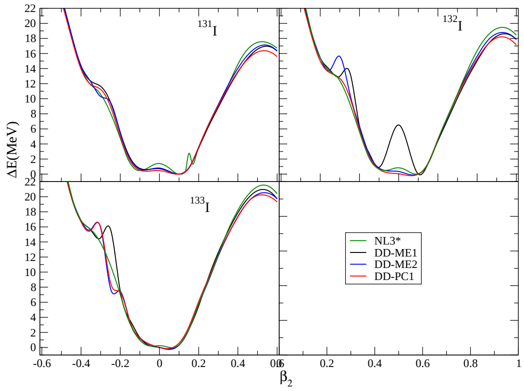


FIG. 3: PES of $^{131-133}$I

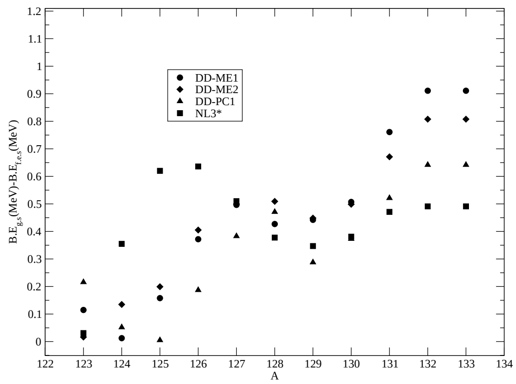


FIG. 4: B.E(g.s)-B.E(f.e.s) for $^{123-133}$I.

BE(g.s) and BE(f.e.s)(which is $\leq$ 1 MeV for all interactions) have been presented in Fig.4 which also supports the shape coexistence phenomenon in iodine isotopes.

### B. Bubble Structure

We have obtained the neutron, proton and total density of iodine isotopes using different interaction but presented only total density obtained using NL3* interaction. From Fig. 5, one can observe the depletion of central density which indicates the bubble structure in iodine isotopes. For quantitative understanding, we have also calculated Depletion Factor(D.F)(For expression See Ref. [2]) which is listed in Table 1. From the table 1, it is clear that nuclei posses bubble structure in their intrinsic states.

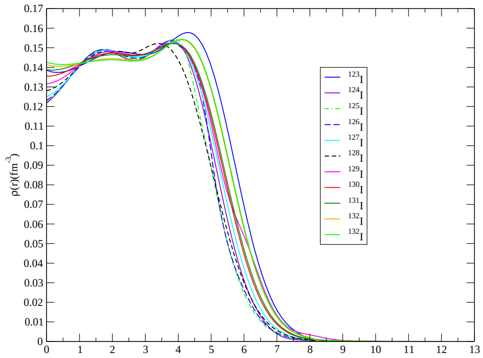


FIG. 5: Total density plot of $^{123-133}I$ using RMF(NL3*).

## Conclusion

The studies based on CDFT using different interactions predicts the shape coexistence and bubble structure in $^{123-133}$ I nuclei which is confirmed by different investigations.

TABLE I: Depletion factor(in %) for proton,neutron and total nucleon matter.

| Nuclei | $(D.F)^{proton}$ | $(D.F)^{neutron}$ | $(D.F)^{Total}$ |
|---|---|---|---|
| $^{123}$I | 17.77 | 9.06 | 12.18 |
| $^{124}$I | 24.04 | 10.56 | 20.80 |
| $^{125}$I | 24.35 | 12.90 | 20.86 |
| $^{126}$I | 24.65 | 15.60 | 19.38 |
| $^{127}$I | 24.60 | 13.86 | 18.25 |
| $^{128}$I | 24.13 | 8.92 | 15.84 |
| $^{129}$I | 23.17 | 7.04 | 13.64 |
| $^{130}$I | 21.84 | 5.21 | 10.95 |
| $^{131}$I | 20.82 | 4.19 | 8.80 |
| $^{132}$I | 19.03 | 3.44 | 8.31 |
| $^{133}$I | 18.62 | 2.52 | 7.62 |

## References


[1] F. Sarazin *et al.*, Phys. Rev. Lett. **84** (2000) 5062.

[2] S. K. Singh *et al.*, IJMPE **22** (2013) 1350001.

[3] H. A. Wilson, Phys. Rev. C**69** (1946) 538.

[4] M. Grasso *et al.*, Phys. Rev. C**79** (2009) 034318.

[5] T. Nikšić *et al.*, Comp. Phys. Comm. **185**, 1808 (2014).