Relativistic mean field study of 'Island of Inversion' in neutron rich Z=37-40 nuclei

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Introduction

The shell model calculation is successful in nuclear structure theory. Although the application of this model in various region explains the data quite well, it fails to reproduce the binding energy for some of the neutron rich Ne, Na and Mg nuclei [1]. Patra et al. [2] performed the relativistic mean field (RMF) calculation with NL1 parameter set and could explain the reason of failure of shell model study for these nuclei. One of their explanation is the large deformation of these nuclei which are not taken in the shell model calculation. Recently predicted by mass formula [3] Z=17-23, 37-40, 60-64 three different regions of the periodic chart which shows extra stability. This prediction motivate us to study the properties of such nuclei. In the present report, we have done the calculation only for one region (Z=37-40) by using the axially deformed RMF formalism.

Theory

we have taken the relativistic mean field model Lagrangian [4] with NL3 parameter set [5]. This force parameter is successful both in β- stable and drip line nuclei. A set of coupled equation are obtained from the above defined Lagrangian are solved numerically in an axially deformed harmonic oscillator basis. The pairing correlation is taken care of by using BCS approach and center of mass correction is also included.

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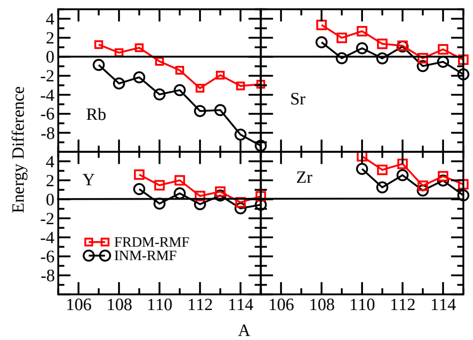

FIG. 1: We are taking energy difference for both cases square represent FRDM-RMF and circle represent INM-RMF .

Result and Discussion

In Fig. 1, we have shown the relative binding energy (BE) difference of RMF from infinite nuclear matter (INM) [3] and finite range droplet model (FRDM) [6] result. In Rb isotopes, increasing the neutron number the BE difference of INM and RMF increases as shown in first square of figure 1. It means both models are not consistent with larger neutron number. In other nuclei (Sr, Y, Zr) the BE difference decreases with neutron number. Similar trend is also observed for the BE difference of FRDM and RMF value (Z=37-40). Hence in these cases both models are consistent with the neutron number. In lower mass region these difference increases for Sr, Y, Zr nuclei. In Fig 2, we have plotted the root mean square charge, neutron, proton and matter radius for Rb, Sr, Y, Zr nuclei. In general, the radii increase monotonically with mass number. Finally in Fig 3, the quadruple deformation parameter β_2 for RMF and FRDM mod-

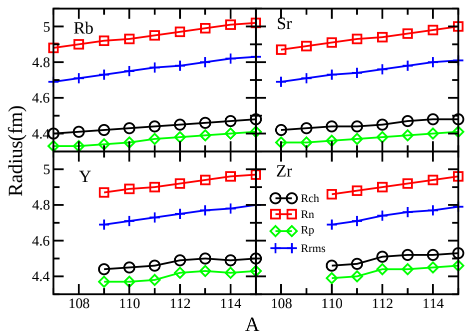

FIG. 2: We are taking charge radius (circle), neutron radius(square), proton radius(diamond), Root mean square radius(plus) respectively.

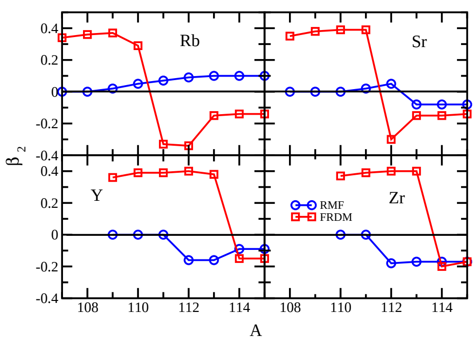

FIG. 3: Quadrupole deformation parameter in both case RMF(circle) and FRDM (square).

els is plotted as a function of mass number. It is to be noted that almost all part of the mass table, the quadrupole deformation parameter obtained from FRDM predictions agree well with the RMF calculations. However in the present case the value of β_2 differ considerably from each other. Both the deviation of binding energy and β_2 values suggest the speciality of these nuclei.

Conclusion

In summary, we calculated the binding energy, rms radii and quadrupole deformation parameter for some of the neutron drip line nuclei which are recently predicted to be special interest of their stability. Since the considered isotopes are experimentally unknown, we compared the results with various mass formula predictions. We found large differences both in binding energy and deformation indicating the special nature of these nuclei. The true properties can be revealed after the experimental observation. The result of other two region Z=17-23 and Z=60-64 will also be discussed at the time of presentation.

TABLE I: In this table we are putting calculated values for second region i.e. Z=37-40 nuclei.

nucl	BE (MeV)	Rch (fm)	Rn (fm)	Rp (fm)	Rrms (fm)	β_2
^{107}Rb	848.399	4.399	4.877	4.325	4.694	0.000
^{108}Rb	850.976	4.407	4.897	4.334	4.712	0.000
^{109}Rb	853.078	4.416	4.915	4.343	4.729	0.017
^{110}Rb	855.357	4.427	4.934	4.354	4.747	0.048
^{108}Sr	865.423	4.418	4.871	4.345	4.692	0.000
^{109}Sr	868.382	4.426	4.891	4.353	4.710	0.000
^{110}Sr	870.774	4.435	4.908	4.362	4.727	0.000
^{111}Sr	873.210	4.444	4.926	4.371	4.743	0.024
^{109}Y	881.486	4.439	4.865	4.366	4.693	0.000
^{110}Y	884.786	4.447	4.886	4.374	4.711	0.000
^{111}Y	887.606	4.455	4.903	4.382	4.727	0.000
^{112}Y	890.560	4.490	4.923	4.418	4.753	-0.160
^{110}Zr	896.646	4.460	4.860	4.388	4.694	0.000
^{111}Zr	900.391	4.467	4.880	4.395	4.711	0.000
^{112}Zr	903.845	4.507	4.899	4.435	4.739	-0.175
^{113}Zr	907.487	4.515	4.918	4.444	4.756	-0.172

References

[1] E.K.Warburton, J.A.Becker and B.A. Brown, *Phys. Rev. C* **41** (1990) 1147.

[2] S.K.Patra and C.R.Praharaj, *Phys.Letters.B* **273** (1991) 13-19.

[3] R.C.Nayak,L.Satapathy, *Atomic and Nuclear Data Tables* **98** (2012) 616-719.

[4] Y. K. Gambhir, P. Ring, and A. Thimet, Ann. Phys. (N.Y.)198, 132 (1990).

[5] G.A.Lalazissis, J.Konig and P.Ring, *Phys. Rev. C* **55** (1997) 1.

[6] P.Möller,J.R.Nix,W.D.Myers and W.J.Swiatecki, *Atomic and Nucl.Data Tables* **59** (1995) 185.