Search for shape coexistence in odd - Z rare earth proton emitters

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Introduction

New experimental advances in measuring decay by spontaneous proton emission [1] from proton rich ground or isomeric states can be used as a powerful tool to probe the structure of proton unbound Nilson orbitals and investigate nuclear deformations beyond proton drip line and require reliable theoretical predictions to interpret the upcoming experimental data and to provide valuable inputs to future experiments. Nuclear shapes are very sensitive to the structural effects and can change with isospin and from one nucleus to its neighbour and in some cases configurations corresponding to different shapes may coexist at similar energies which may arise from intruder excitations [2]. Search for such interesting phenomena of shape coexistence ar rapidly changing shapes in the less explore region of rare earth odd Z nuclei from Z = 5 to 75 are the focus of present work.

Brief description of work

Calculations [3] are performed within tl framework of triaxially deformed Nilsson p tential including shell corrections where tl classical collective properties of the liquid drc model are combined with the quantum corre tions due to shell effects via Strutinsky forma ism by incorporating higher order correctio with Hermite polynomials. Energy minin are searched for Nilsson deformation paran eters β and γ where we find various γ competing for E minima and sometimes lead to a situation where E minima is found to coexist for two γs with similar energies.

Results and Discussion

Our predictions of the first proton unbound nucleus with $S_P \leq 0$ defining the proton drip line for odd Z (= 53 to 75) and calculated values of 1p separation energy S_P and their ground state quadrupole deformations have shown excellent agreement with the available experimental data (See Ref. [3]). Here we present our results for nuclei ^{112,113,114,115}Cs and $^{103-105}$Sb on rapid shape transitions and search for shape coexistence. Fig. 1 shows energy minimization curves of neutron deficient nuclei ^{112,113,114,115}Cs.

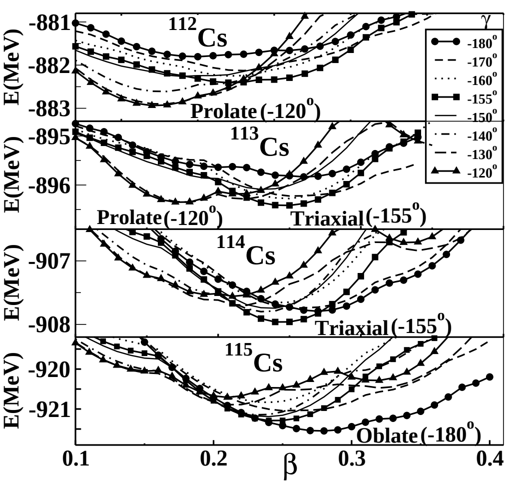

FIG. 1: Two energy minima in ^{113}Cs indicate shape coexistence shown in plots of energy minima with β and γ for nuclei ^{112,113,114,115}Cs. Rapid shape transitions are seen while moving from one nucleus to its neighbour

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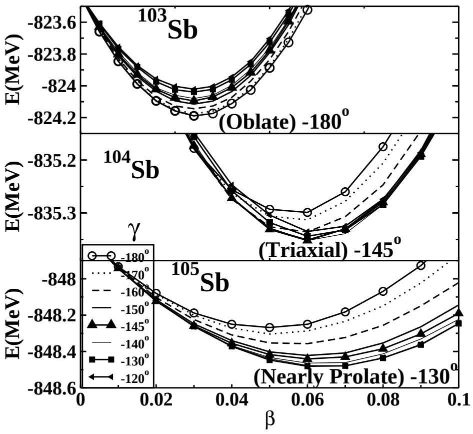

FIG. 2: Rapid shape transitions in $^{103-105}$Sb but absence of coexisting states although γs are seen competing very closely for energy minima

cated in experimental data [4]. Equillibrium deformation $\beta = 0.17$ in ^{112}Cs increases upto value $\beta = 0.28$ at ^{115}Cs with a shape change from prolate (^{112}Cs) to triaxial(^{113,114}Cs) to oblate(^{115}Cs). At ^{113}Cs, we notice another E minima at prolate shape apart from E minima at triaxial shape. During the smooth transition from prolate shape at ^{112}Cs to triaxial (γ= 155^o, β= 0.24) at ^{114}Cs, we observe shape coexistence at ^{113}Cs where both prolate (γ= -120^o, β = 0.17) and triaxial(γ= 155^o, β= 0.25) shapes are coexisting at similar energies and hence two energy minima are seen in ^{113}Cs. Further moving to higher N, the shape transition from triaxial to well deformed (β=0.28) oblate shape at ^{115}Cs takes place. Fig. 2 shows rapid shape transitions in $^{103-105}$Sb but absence of coexisting states although γs are seen competing very closely for energy minima. Due to small deformation, shapes are not well defined and energies corresponding to all γs are very close.

Conclusion

Rapid shape transitions and shape coexistence are searched in ground state proton emitters in rare earth region with odd Z = 51 to 75. This region is well deformed and γ soft and various γs compete closely for energy minima and sometimes lead to coexisting configurations at similar energies as seen in $^{112-115}$Cs but absent in $^{103-105}$Sb nuclei. Shape coexistence in ^{113}Cs with prolate and triaxial shapes coexisting with strong deformations is predicted.

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References

[1] C. Detraz and D. J. Vieira, Annu. Rev. Nucl. Part. Sci.**39**, 407 (1989).

[2] J. L. Wood, K. Heyde, W. Nazarewicz, M. Huyse and P. van Duppen, Phys. Rep. **215**, 101(1992).

[3] Mamta Aggarwal, Phys. Rev. **C 89**, 024325 (2014).

[4] T. Faestermann et al., Phys. lett.**B 137**, 23 (1984).