Structural Properties Of Superheavy Isotopes Z=122 with CDFT Approach.

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Introduction

After the prediction of existence of long-lived superheavy nuclei, the next magic number for protons (Z=82, N=126) in superheavy mass regions become very intresting issue. Devoted experimental facilities like Dubna Superheavy Element Factory can hopefullty stretch the region up to Z=120. Still we cannot reach the predicted centers of the island of stability of SHEs as infered by microscopic + macroscopic (MM) approaches or by covariant and Skyrme Density Functional Theories (DFTs), respectevely. It is found that physics of SHEs is more reliable in the DFT frame work than MM approaches. An accurate description for investigating the nuclear structure phenomena, ground state properties, and collective excitation of nuclei provided by self-consistent mean-field model based on Relativistic mean field theory (RMF) [1] over the long range of nuclear chart.
These conditions make it necessary to reanalyze the structure of superheavy nuclei using both the new set of energy density functionals. We can compare the analyses of results obtained with several state-of-the-art functionals to estimate the spread of theoretical predictions for extended region of SHEs beyond the currently known. The present work have been done using framework of covariant density functional theory (CDFT)[2]. We have obtained the ground state and bulk properties such as binding energy, neutron sepration energy, quadrupole deformation, potential energy surface. Since there is no experimental observations made yet for such a large Z region, therefore we have compared our results with Finite Range Droplet Model(FRDM).
We have used meson exchange (DD-ME) and point-coupling model (DD-PC) for carrying the present work. These two models differs in traetment of interaction range, the mesons, and density dependence. Each of the corresponding model have thier own parameter set. formalism have discussed elaborately in Secs.II-IV of Ref.[3] and Sec. II of Ref.[4].

Results and Discussion

In this section we are presenting the binding energy (B.E), quadrupole deformation (β_2), two neutron separation energy (S_{2n}), and Potential Energy Surface curve (PES) of isotopic chain of Z=122. Table 1 shows the β_2, B.E, and S_{2n} of isotopic chain of $Z = 122$ with interactions DD-ME2, DD-PC1. We have covered the range N=170 to 190 which include two magic numbers (172, 184).The nuclei from N=170 to 178 are oblate in shape. At N=170 and 172, the shape is comperatively less oblate or nearly spherical. Both the interaction predicts exactly spherical shape at N=182 to 86 which confirms the magicity at N=184. We have compared our results with FRDM and both results are very close to each other. There is downfall in S_{2n} at 184 which supports magicity of this number.
Fig.1, and 2 represents Potential Energy surface curve for DD-ME2 and DD-PC1 respectevely. The dashed line shows the actual ground state that we have chosen. It is clarly seen from PES curve that outer barrier height is lower than inner barrier height, therefore we have neglected prolate superdeformed minimum which is even lower than spherical or oblate minima. Most of the nuclei shows the shape coexistence, but both the shapes fall on oblate region.

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TABLE I: Quadrupole Deformation (β_{20}), B.E, S_{2n} of series $^{292-310}122$

Neutrons(N)	DD-ME2			DD-PC1			FRDM		
	β_2	B.E	S_{2n}	β_2	B.E	S_{2n}	β_2	B.E	S_{2n}
170	-0.13	2037.2332	15.133	-0.13	2034.3752	-14.015	-	-	-
172	-0.13	2054.2664	17.033	-0.15	2051.3207	-16.945	-0.15	2053.16	-
174	-0.16	2070.2931	16.026	-0.17	2067.8869	-16.566	-0.13	2068.99	15.83
176	-0.15	2084.7468	14.453	-0.20	2082.6463	14.759	-0.096	2084.26	15.27
178	-0.23	2099.5158	14.769	-0.23	2097.9594	15.313	0.009	2099.64	15.38
180	0.00	2112.7453	13.229	0.00	2108.8735	10.914	0.418	2113.98	14.34
182	0.00	2126.618	13.872	0.00	2122.2049	13.331	0.00	2126.87	12.89
184	0.00	2139.9862	13.368	0.00	2134.7692	12.564	0.00	2139.43	12.56
186	0.00	2151.0421	11.055	0.00	2146.6872	11.918	0.001	2150.84	11.41
188	-0.19	2162.8441	11.802	-0.19	2162.3844	15.697	0.003	2162.05	11.21

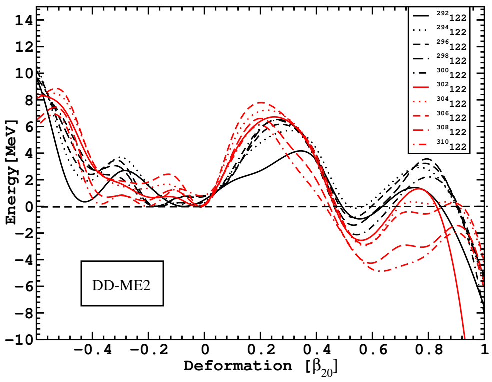

FIG. 1: The Potential Energy Surface curve of isotopic series of Z=122 for DD-ME2 interaction.

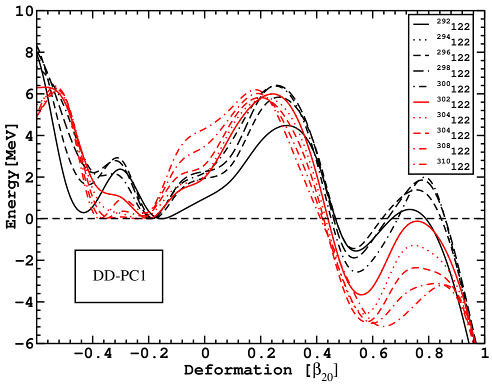

FIG. 2: The The Potential Energy Surface curve of isotopic series of Z=122 for DD-PC1 interaction.

Conclusion

The ground state of isotopes under consideration either oblate or spherical in shape. There exist a prolate superdeformed minima in all the nuclei which reflect in the PES curve. Calculated values for quadrupole deformation, B.E, and S_{2n} more or less close to FRDM results. We have predicted a nearly spherical shape at N=172 while at N=184, the shape is completely shperical. Shape coexistence found in isotopes near to magic number (N=172, 184) which is clearly seen in the PES curve. Both the shapes lying on the oblate region. Two neutron separation energy decreases 2.313 MeV at N=184 which suggest the extra stability of this neutron number.

References

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