Superdeformed ground state in Z=120 nuclei and the α-decay Chain of the $^{292,304}120$ Isotopes

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1. Introduction

Recently considerable effort was devoted to superheavy nuclei because it is important in determining the structure properties in nuclear physics. The α-decay is one of the important decay modes of these SHEs, and properties of this decay give for identification of stability of the decaying nuclei. The amount of already collected information for α-decay is quite large and is still increasing. It is important then, both the interpretation of existing data and for predictions for new experiments, to realize with what accuracy one can presently describe both observables of this process: α-decay energy Q_α and α-decay half life T_α. The very possibility of an extremely heavy Z nucleus motivated us to see the structure of such nuclei in an isotopic mass chain.

Therefore, on the basis of the relativistic mean-filed (RMF) and non-relativistic Skyrme Hartee-Fock (SHF) methods, we calculated the bulk properties of a Z = 120 nucleus in an isotopic chain of mass A = 280−324. This choice of mass range covers both the predicted neutron magic numbers N = 172 and 184 [1].

2. Method of Calculation and Discussion

In our calculation we have used both the non-relativistic Skyrme-Hartree-Fock SHF (SkI4 and SLy4) [2] and Relativistic Mean Field RMF (NL3) [3] force parameter sets. The constant gap BCS pairing approach is taken care for calculating the energy contribution from pairing interaction [4, 5].

TABLE I: The RMF(NL3), SHF (SkI4) and SHF (SLy4) results for BE, β_2, S_{2n} and $\triangle E$, compared with the corresponding FRDM results [6] for the isotopic chain of $^{280-292}120$. The energy is in MeV.

Nucleus	Formalism	BE	β_2	S_{2n}	ΔE
280	RMF (NL3)	1963.33	0.258	18.11	0.058
	SHF (SkI4)	1944.92	0.529	18.32	2.555
	SHF (SLy4)	1927.51	0.227	18.37	0.008
	FRDM				
282	RMF (NL3)	1981.08	-0.422	17.75	0.200
	SHF (SkI4)	1963.24	0.520	17.68	2.096
	SHF (SLy4)	1945.88	0.227	16.62	0.003
	FRDM				
284	RMF (NL3)	1998.42	-0.428	17.34	0.929
	SHF (SkI4)	1980.91	0.519	17.16	1.507
	SHF (SLy4)	1962.51	0.202	16.86	2.343
	FRDM				
286	RMF (NL3)	2015.48	0.567	17.16	0.340
	SHF (SkI4)	1998.08	0.521	16.76	0.947
	SHF (SLy4)	1979.37	0.537	16.86	0.165
	FRDM				
288	RMF (NL3)	2031.75	0.560	16.28	0.929
	SHF (SkI4)	2014.83	0.523	16.48	0.408
	SHF (SLy4)	1996.23	0.122	16.51	0.593
	FRDM	2023.03	-0.113		
290	RMF (NL3)	2047.50	0.551	15.75	0.301
	SHF (SkI4)	2031.31	0.119	16.37	0.135
	SHF (SLy4)	2012.74	0.115	15.98	1.310
	FRDM	2039.49			
292	RMF (NL3)	2064.11	0.540	16.61	0.730
	SHF (SkI4)	2047.68	0.113	15.53	0.591
	SHF (SLy4)	2028.71	0.107	15.38	1.966
	FRDM	2055.19	-0.130	15.70	

The ground state and first intrinsic excited state bulk properties like binding energy (BE), quadrupole deformation parameter (β_2), two neutron separation energies (S_{2n}), the bind-

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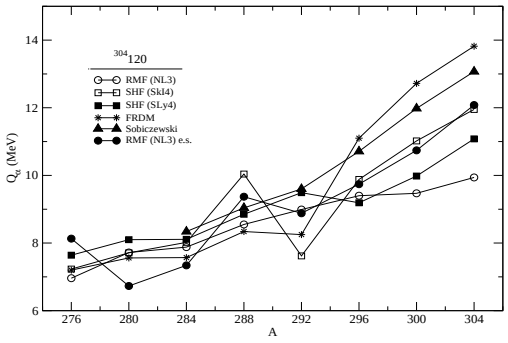

FIG. 1: The Q_α energy for the α-decay chain of the ^{304}120 nucleus.

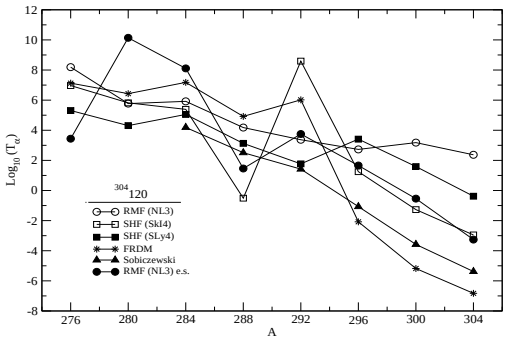

FIG. 2: The half-life time $T^{\alpha}_{1/2}$ (in seconds) for the α-decay chain of the ^{304}120 nucleus.

ing energy difference $\triangle E$ between the ground- and first-exited state solutions of superheavy nuclei with Z=120 and N=160-204 are investigated using both SHF and RMF formalisms [1]. As a representative case, here we have displayed few selective results compare with the corresponding Finite Range Droplet Model (FRDM) results [6]. From Table I, we found qualitatively similar predictions in both techniques. In RMF and SHF calculation most of the ground state structures are found to be highly deformed prolate, differing strongly with the FRDM calculation where most of the ground state structures are with spherical solutions.

Considering the possibility of magic neutron number, two different mode of α-decay chains ^{292}120 and ^{304}120 are also studied. Results for the α-decay energy (Q_α) and half-life ($T^{\alpha}_{1/2}$) for ^{304}120 nucleus, calculated in the SHF and RMF models are shown in Fig 1. and Fig 2. The detailed results for the α-decay series for two different nuclei (^{292}120 and ^{304}120) and their corresponding decay chain are in Ref. [1]. Our predicted values for Q_α and $T^{\alpha}_{1/2}$ agree nicely with the FRDM and other available theoretical results[7].

3. Summary and Conclusion

We found qualitatively similar predictions in both techniques, the ground state structures are found to be highly deformed prolate, differing strongly with the FRDM calculation where most of the ground state structures are spherical solutions. Some shell structure is also observed in the calculated quantities at N = 168, 172 for RMF and at N = 156, 160, 168 for SHF calculations for the various isotopes of the ^{292}120 nucleus.

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References

[1] Shakeb Ahmad, M. Bhuyan, and S. K. Patra, Phys. Rev. C 2011, (*communicated*).

[2] E. Chabanat, P. Bonche, P. Hansel, J. Meyer, and R. Schaeffer, Nucl. Phys. **A627**, 710 (1997).

[3] J. Boguta, A. R. Bodmer, Nucl. Phys. A **292**, 413 (1977).

[4] S. K. Patra, M. Bhuyan, M. S. Mehta, and Raj K. Gupta, Phys. Rev. C **80**, 034312 (2009).

[5] M. Bhuyan, S. K. Patra, and Raj K. Gupta, Phys. Rev. C **84**, 014318 (2011).

[6] P. Möller, *et al.*, At. Data and Nucl. Data Tables **59**, 185 (1995); P. Möller, *et al.*, At. Data and Nucl. Data Tables **66**, 131 (1997).

[7] I. Muntian, *et al.*, Acta Phys. Pol. B **32**, 691 (2001); I. Muntian, *et al.*, Acta Phys. Pol. B **34**, 2073 (2003); I. Muntian, *et al.*, Phys. At. Nucl. **66**, 1015 (2003).