Structure of ^{287,288}115 superheavy nuclei

S. Mahapatro[1],* B. K. Sahu[2], M. Bhuyan[3,4], and S. K. Patra[4]
[1] *Dept. of Physics, Spintronic Technology and Advance Research, Bhubaneswar-752050, India.*
[2] *Dept. of Physics, Manikeswari College, Sundargarh-770024, India.*
[3] *School of Physics, Sambalpur University, Jyotivihar, Burla-768019, India. and*
[4] *Institute of Physics, Sachivalaya Marg, Bhubaneswar-751005, India.*

I. INTRODUCTION

Our aim is to study the properties of already synthesized element Z =115 which contribute to the fundamental knowledge of nuclear potentials and the resulting nuclear structure. The elements upto Z=118 have been synthesized till today with half-lives varying from a few minutes to milli-seconds. The fusion-evaporation reaction of ^{243}Am + ^{48}Ca, leads to the formation of ^{291}115 nuclei. According to the predictions [1], the 3n- and 4n- evaporation channels results the odd-odd isotope ^{288}115 (N = 173) and odd-A isotope ^{287}115 (N = 172). Here our basic motivation is to study the α-decay properties of these synthesized isotopes.

II. METHOD OF CALCULATION AND DISCUSSION

We have used microscopic self-consistent RMF calculation to investigate the nuclear structure[2, 3]. Here we study the bulk properties like the binding energies(BE), quadrupole deformation parameter β_2, charge radii (r_{ch}), pairing energies E_{pair} for the synthesized superheavy element (SHE) Z=115, within the formalism of relativistic mean field theory (RMF). A systematic comparison between the binding energies of RMF result and finite range droplet model (FRDM) results is made. We notice from table-I that, the microscopic RMF (NL3) binding energy overestimated than that of FRDM at N=156-167, after that the difference in binding energy decreases towards the higher mass region (around A=287). The ground state quadrupole deformation parameter β_2 for RMF compared with FRDM results. It is clear that FRDM results differ from RMF(NL3) results for some mass regions. For example, the prolate structure has been found for all the isotopes within RMF. There is a shape change from prolate to oblate [A = 286 (N=171) to A = 288 (N=173)] in FRDM. The rms radius increases with increase of the neutron number. Though the proton number Z=115 is constant for the isotopic series, the charge radius value also increases with neutron number. Both the rms radius and charge radius jump to a lower value at A=282 (with N=167). The two neutron separation energy S_{2n} (N,Z) = BE (N,Z) - BE (N-2,Z) is mentioned in Table I. S_{2n} values decrease gradually with increase of the neutron number, except for the noticeable kinks at A = 282 (N=167) in RMF and there is no such behaviour in FRDM. The Q_α energy is obtained from the relation [4], $Q_\alpha(N,Z)$ = $BE(N,Z)$ - $BE(N-2,Z-2)$ - $BE(2,2)$. Here, $BE(N,Z)$ is the binding energy of the parent nucleus with neutron number N and proton number Z, $BE(2,2)$ is the binding energy of the α - particle (^{4}He), i.e., 28.296 MeV, and $BE(N-2,Z-2)$ is the binding energy of the daughter nucleus after the emission of an α -particle. We have also calculated half-life time $T^{\alpha}_{1/2}$ by using the phenomenological formula, $log_{10}T^{ph}_{\alpha}(Z,N) = aZ[Q_\alpha(Z,N) - \overline{E_i}]^{-1/2} + bZ + c$, with Z as the atomic number of parent nucleus. Where the parameters are a = 1.5372, b = -0.1607, c = -36.573. It is shown in fig.1. The details of calculation of isotopes ^{288}115 and ^{287}115 are given in Ref [5].

*Electronic address: narayan@iopb.res.in

TABLE I: The RMF (NL3) results for binding energy BE, two-neutron separation energy S_{2n}, pairing energy E_{pair}, the binding energy difference $\triangle E$ between the ground- and first-excited state solutions, and the quadrupole deformation parameter β_2, compared with the corresponding Finite Range Droplet Model (FRDM) result. The energy is in MeV.

	RMF (NL3) Result					FRDM Result		
Nucleus	BE	S_{2n}	E_{pair}	ΔE	β_2	BE	S_{2n}	β_2
272	1944.3	16.7	17.3	6.51	0.255	1932.8		0.182
274	1961.0	16.6	16.9	6.20	0.244	1950.3	17.5	0.192
276	1977.2	16.3	16.3	5.87	0.232	1967.4	17.1	0.202
278	1992.8	15.6	15.8	5.30	0.218	1983.9	16.5	0.202
280	2008.0	15.1	15.4	4.77	0.196	2000.3	16.4	0.053
282	2022.8	14.7	14.7	4.15	0.182	2015.8	15.5	0.053
284	2036.7	13.9	14.3	3.18	0.173	2030.8	15.0	0.062
286	2049.8	13.1	14.0	2.06	0.165	2045.2	14.4	0.071
288	2062.5	12.7	13.7	1.23	0.152	2059.1	13.8	-0.087
290	2074.5	11.9	13.6	0.15	0.103	2072.6	13.5	-0.079
292	2086.5	11.9	13.5	0.02	0.060	2085.7	13.1	-0.061

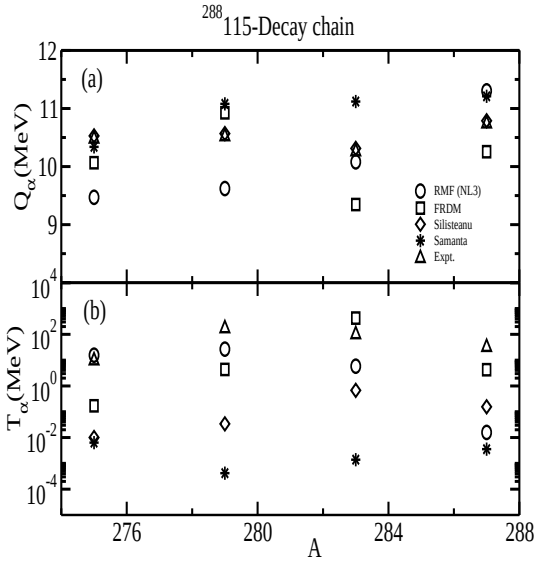

FIG. 1: (a)The Q_α-energy for α-decay series of ^{288}115 nucleus (b) The $T^{\alpha}_{1/2}$-half-life time for α-decay series of ^{288}115 nucleus.

III. SUMMARY AND CONCLUSION

In summary, we have calculated the binding energy, rms charge and matter radii, quadrupole deformation parameter of the isotope of ^{287}115 and ^{288}115 and also investigated two-neutrons separation energy and energy difference between ground and first excited state for studying the shape co-existence. We observe that the most stable isotope is ^{282}115. From fig.1, We notice that the value of Q_α and T_α are in good agreement with the available experimental data[1], and with the prediction of Refs.[6] and [7]. We have seen that the RMF theory provides a reasonably good description for whole isotopic chain.

References

[1] Yu. Ts. Oganessian *et al..*, *Phys. Rev.C* **69** (2004) 054607. Yu. Ts. Oganessian *et al.*, *Phys. Rev. C rapid communications* **69** (2004) 021601(R).

[2] B. D. Serot and J. D. Walecka,*Adv. Nucl. Phys.* **16** (1986) 1.

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

[4] S. K. Patra and C. R. Praharaj, *J. Phys. G* **23** (1997) 939.

[5] B. K. Sahu,M. Bhuyan,S. Mahapatro and S. K. Patra,Int. J. Mod. Phys. E (in press)(2011).

[6] I. Silisteanu,A. I. Budaca, A. O. Silisteanu, *Rom. J. Phys.*, Vol. **55**, (2010) Nos. 9-10, P. 1088-1110, Bucharest.

[7] P. Roy. Chowdhury and C. Samanta and D. N. Basu , *arxiv: 0802. 4161v2 [nucl-th]* (2008).