The search of Triaxility in Z=120 isotopes.

Afaque Karim[1],* Tasleem Ahmad Siddiqui[1,2],† and Shakeb Ahmad[1,3‡]
[1]*Department of Physics, AMU, Aligarh - 202002, India*
[2]*Department of Basic Sciences, Secab I.E.T, Bijapur - 586101, India and*
[3]*Physics Section, Women's College, AMU, Aligarh - 202002, India*

Introduction

The possibilities of synthesizing superheavy elements in laboratory is very challenging for the nuclear experimentalists [1].The theoretical predictions of nuclear structure properties play important role in the synthesis of these superheavy elements. Mainly, the superheavy nuclei (SHN) are produced by fusion of heavy nuclei just over the barrier [2]. The SHN with Z=113-118 are synthesized successfully by the experimentalists at Dubna and at the same time they attempted for Z=120 using hot fusion reaction [3] (and references therein). Generally, the synthesized SHN are mostly observed via α-cascade decay [3]. Thus theoretically,the α-decay energies (Q_α) and α-decay half-lives for SHN with Z$\geq$100 are calculated systematically by Wang et al. [4] using 20 mass models and 18 semi-empirical mass formulae respectively. The SemFIS2 formula [5] is found to be best one in above study to predict the α-decay half-lives.

To resolve the problem of flatness in the axially symmetric potential energy surface (pes), in the present study, we have included the role of triaxiality in terms of β_2 and γ for Z=120 isotopes to get a better microscopic structure. A detailed and systematic axial and triaxial study is carried out within the Relativistic Hartree Bogoliubov (RHB) framework with density dependent DD-ME2 effective interaction [6]. The obtained results are compared with available macro-microscopic Finite Range Droplet Model (FRDM12), WS4 model and experimental findings [6] (and references therein). We have used three different semi-empirical relations namely SemFIS2 [5], Im-Sahu [7], and UNIV2 [5] to calculate the α decay half-lives. A comparison of Spontaneous fission (SF) half-lives obtained through formula given by Xu. et. al. [8], with α decay half-lives is done to account the number of α decay before the spontaneous fission starts. We along with the ground state properties, have calculated the neutron/proton single particle energy levels within the triaxial basis, to better understand the neutron or proton shell closer, and level density around the Fermi level.

TABLE I: The calculated Binding Energy, deformation parameter (β_2 and γ) of the ground state of decay series of ^{300}120 nucleus.

Nuclei	β_2	γ	$B.E_{ax}$	$B.E_{Tx}$	$B.E_{Expt}$	$B.E_{FRDM}$
$^{300}120$	0.00	0.00	2112.10	2107.63	-	2113.73
^{296}Os	0.05	0.00	2095.49	2091.07	-	2099.12
^{292}Lv	0.05	10.00	2078.02	2073.70	2076.41	2083.10
^{288}Fl	0.15	0.00	2061.46	2056.94	2060.35	2065.62
^{284}Cn	0.15	10.00	2043.08	2038.71	2041.96	2046.49
^{280}Ds	0.15	5.00	2023.96	2019.58	2023.28	2027.16
^{276}Hs	0.20	0.00	2004.42	1999.95	2004.86	2007.68

Results and Discussion

The ground state properties like Binding energy and deformation for the decay chain corresponding to axial and triaxial symmetry are tabulated in Table I and are compared with available experimental and FRDM12 results. Due to space limitation, we are pre-

*Electronic address: afaquekrm@gmail.com
†Electronic address: tasleemahmad038@gmail.com
‡Electronic address: physics.sh@gmail.com

TABLE II: Q_α, Spontaneous half-life and half-lives of α decay series of $^{300}120$ nucleus.

	Decay Series of $^{300}120$					
				$logT^{\alpha}_{1/2}$		
	Nuclei	Q_α	$logT_{1/2}$(SF)	Imsahu	SemFIS2	UNIV2
Axial	$^{300}120$	11.68	12.55	-2.50	-2.18	-2.89
	^{296}Os	10.82	6.51	-1.02	-0.68	-1.37
	^{292}Lv	11.73	1.81	-3.72	-3.54	-4.07
	^{288}Fl	9.91	-1.65	0.17	0.44	-0.12
	^{284}Cn	8.97	-3.94	2.34	2.62	2.09
	^{280}Ds	9.175	-5.16	1.02	1.18	0.78
Triaxial	$^{300}120$	11.74	12.55	-2.64	-2.32	-3.03
	^{296}Os	10.92	6.51	-1.28	-0.94	-1.63
	^{292}Lv	11.54	1.81	-3.30	-3.10	-3.65
	^{288}Fl	10.06	-1.65	-0.25	0.01	-0.55
	^{284}Cn	9.16	-3.94	1.72	1.98	1.47
	^{280}Ds	8.67	-5.16	2.64	2.84	2.41
FRDM	$^{300}120$	13.69	12.55	-6.45	-6.34	-6.89
	^{296}Os	12.28	6.51	-4.32	-4.16	-4.70
	^{292}Lv	10.82	1.81	-1.60	-1.34	-1.93
	^{288}Fl	9.17	-1.65	2.39	2.74	2.11
	^{284}Cn	8.97	-3.94	2.35	2.63	2.10
	^{280}Ds	8.82	-5.16	2.15	2.34	1.92
WS4	$^{300}120$	13.29	12.55	-5.76	-5.61	-6.19
	^{296}Os	11.72	6.51	-3.15	-2.91	-3.52
	^{292}Lv	11.10	1.81	-2.29	-2.05	-2.62
	^{288}Fl	9.62	-1.65	1.01	1.31	0.72
	^{284}Cn	9.52	-3.94	0.65	0.87	0.38
	^{280}Ds	9.41	-5.16	0.29	0.44	0.05
Expt.	$^{300}120$	-	-	-	-	-
	^{296}Os	-	-	-	-	-
	^{292}Lv	10.80	-	-1.74*	-	-
	^{288}Fl	10.08	-	-0.10*	-	-
	^{284}Cn	-	-	-	-	-
	^{280}Ds	-	-	-	-	

senting here few numerical results for Z=120, N=180 nuclei. In the final presentation we will present the detailed study of Z=120 with N=172, 174, 184 also.

From the Table I, it is observed that the decay chain $^{300}120$ contains three triaxialy deformed isotopes i.e, ^{292}Lv, ^{284}Cn, and ^{280}Ds which have ground state minima at $(0.05, 10^0)$, $(0.15, 10^0)$, and $(0.15, 5^0)$ respectively. Further, in comparison with the FRDM12 and available experimental results [6](and references therein), it is found that the ground state energies corresponding to axial symmetry are more closer to it. In addition to this, α - decay energies (Q_α) and the corresponding α - decay half-lives, spontaneous fission half-lives $T_{1/2}$ (SF) are calculated and tabulated in Table II.

From Table II, we can see that, the nuclei $^{300}120$ survives the spontaneous fission up to 3α-decay for both the axial and triaxial symmetry. FRDM and WS4 model also predict the same. Only two isotopes ^{292}Lv and ^{288}Fl have experimental values for Q_α and half-lives. From the TableII, it can be seen that FRDM calculation nearly coincide with experimental result for ^{292}Lv and experimental result for ^{288}Fl nearly overlaps with triaxial calculation. The semi-empirical relation ImSahu gives closest α-decay half-lives to experimental half-lives for these two ^{292}Lv, ^{288}Fl with FRDM and triaxial approach respectively.

In the present study,the investigation suggests the strong model and its parameter dependence for most of the predicted results. Our predicted results agrees fairly well with the experimental data of the $^{300}120$ nucleus. Based on the comparison between the calculated α-decay half-lives and the spontaneous fission half-lives, we have presented the numbers of α-decay for $^{300}120$ nucleus. In general, we found that ImSahu formula is best suited to accurately predict the α-decay half lives for the superheavy nucleus $^{300}120$.

References

[1] S.A. Giuliani *et.al.*, Rev. Mod. Phys. 91 (2019) 011001.
[2] S. Hofmann, G. Mnzenberg, Rev. Mod. Phys. **72** (2000) 733.
[3] Yu.Ts. Oganessian *et.al.*, Phys. Rev. C **79** (2009) 024603.
[4] Y.Z. Wang, S.J. Wang, Z.Y. Hou, J.Z. Gu, Phys. Rev. C **92** (2015) 064301.
[5] D.N. Poenaru, R.A. Gherghescu, N. Carjan, Euro Phys. Lett. **77** (2007) 62001.
[6] A. Karim and S. Ahmad, Chinese Journal of Physics **59** (2019) 606.
[7] S. Zhang *et.al.*, Phys. Rev. C **95** (2017) 014311.
[8] C. Xu, Z. Ren, Y. Guo, Phys. Rev. C **78** (2008) 044329