α-decay series of $^{298}124$ isotope with CEDF

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Introduction

Recently, the study of superheavy nuclei (SHN) i.e, Z≥100 become the centre of attraction for both theorists and experimentalists. In the nuclaer chart, these nuclei are located at the extremes of nuclear landscape. The fusion of heavy nuclei just over the fission barrier is the key procedure for synthesizing SHN [1]. The region of SHN is hopefully stretched up to Z=120 by the experimental techniques at Dubna superheavy element factory. Still, the predicted centre of Island of stability inferred by theoretical model [2] are not senthesized by experimental facilities.

It is evinced during the experimental synthesization of SHN that α-emission is main mode of decay in SHN which terminates through spontaneous fission (SF) [3]. The stability of SHN is decided by comparing the study of α-decay and SF. Recently, it has been shown that theoretical prediction of known nuclei can be extended by using state of the art of functionals of Covariant Energy Density Functionals (CEDFs). We have used CEDFs with parameters namely DD-ME2 [4] and DD-PC1 [5] for calculating ground state (GS) and decay properties of $^{298}124$.

Results and Discussion

Here we are presenting results for α-chain of $^{298}124$ being N=174 as a neutron shell closure found in our structural calculation. The most reliable semi-empirical method for calculating decay half-lives in the superheavy region by Poenaru *et.al.*, as UNIV2, and SemFIS2 [6].The comparison of results are made through available non-relativistic FRDM and experimental findings. The semi-empirical formula given by Xu *et.al* [7] has been utilized for calculating spontaneous fission half-lives. Table I represents the numerical results for quadrupole deformation (β_2), released energy (Q_α) due to α emission, and α-decay half-lives. The FRDM results for the first daughter nucleus ($^{294}122$) are same as that of relativistic parameters. The $^{290}120$ is found to be exactly spherical by both the relativistic force parameters which suggest spherical magicity of Z=120 while FRDM predicts slightly oblate shape ($\beta_2 = -0.12$) for the same nucleus. Similarly, the β_2 differ by ~ 0.1 in magnitude obtained by FRDM with relativistic interaction for, the next two isotopes i.e, $^{286}118$, and $^{282}116$. All the isotopes after the $^{282}116$ have same value of β_2 for FRDM and relativistic interaction i.e, prolate in shape ($\beta_2 \sim 0.25$). The calculated Q_α from the relativistic approach and FRDM are nearly to each other and have maximum deviation of $\sim 1.0 - 1.5MeV$. The measured SF half-lives for two beginning nuclei in the decay chain is too high, even greater than the life time of Universe. So, we can conclude that spontaneos fission is impossible for these two nuclei. As we move down through the chain, the SF half-lives are decreasing up to ^{266}Hs and farthur increase for the ownward chain. The α-decay half-lives obtained by SemFIS2 is slghtly greater than half-lives through UNIV2. The very lesser vaue for α-decay half -lives than SF half-lives at the beginning suggest that α-decay is most dominant mode for decay. The experimental results are available for the last six daugter nuclei in the chain and superscripted as star in the table. The experimental decay half-lives are more nearer to α-decay half-lives than SF half-lives in ^{270}Ds and ^{266}Hs which strongly supports for α emission as main mode of decay for these two nuclei. For ^{262}Sg, the calculated

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TABLE I: The predicted quadrupole deformation parameter (β_2), Q_α (MeV) and α-decay half-lives [$logT^{\alpha}_{1/2}$] for α-decay series of $^{298}124$ nucleus, with DD-ME2, DD-PC1 forces. The results are compared with the FRDM and experimental results wherever available.

					[$logT^{\alpha}_{1/2}$]						[$logT^{\alpha}_{1/2}$]	
Nuclei	Form	β_2	Q_α (MeV)	$logT^{SF}_{1/2}$	SemFIS2	UNIV2	Nuclei	β_2	Q_α (MeV)	$logT^{SF}_{1/2}$	SemFIS2	Univ2
$^{298}124$	DD-ME2	-0.17	13.96	31.22	-5.64	-6.30	^{270}Ds	0.24	10.65	-1.98	-2.55	-3.07
	DD-PC1	-0.17	13.86		-5.45	-6.12		0.24	10.80		-2.91	-3.42
	FRDM							0.22	10.32		-1.70	-2.25
	Expt.								11.12		-4.00*	
$^{294}122$	DD-ME2	-0.13	13.96	22.38	-6.16	-6.76	^{266}Hs	0.26	10.30	-2.06	-2.32	-2.80
	DD-PC1	-0.15	13.31		-4.94	-5.60		0.26	10.37		-2.49	-2.97
	FRDM	-0.15	14.63		-7.30	-7.86		0.23	9.69		-0.65	-1.18
	Expt.								10.35		-2.64*	
$^{290}120$	DD-ME2	0.00	12.07	15.05	-2.88	-3.59	^{262}Sg	0.27	9.11	-1.24	0.34	-0.16
	DD-PC1	0.00	13.70		-6.18	-6.75		0.27	9.59		-1.07	-1.54
	FRDM	-0.12	13.78		-6.32	-6.89		0.22	9.61		-1.11	-1.58
	Expt.								9.60		-2.16*	
^{286}Og	DD-ME2	0.17	13.58	9.15	-6.48	-7.01	^{258}Rf	0.28	8.41	0.42	1.85	1.37
	DD-PC1	0.17	13.87		-6.98	-7.50		0.28	8.74		0.76	0.30
	FRDM	0.08	13.05		-5.48	-6.05		0.24	9.33		-1.01	-1.43
	Expt.								9.19		-2.83*	
^{282}Lv	DD-ME2	0.19	12.88	4.58	-5.69	-6.23	^{254}No	0.29	7.75	2.83	3.44	3.00
	DD-PC1	0.18	13.13		-6.17	-6.68		0.24	7.98		2.59	2.16
	FRDM	0.06	11.67		-3.14	-3.77		0.24	7.97		2.63	2.20
	Expt.								8.23		1.71*	
^{278}Fl	DD-ME2	0.20	12.66	1.26	-5.80	-6.29	^{250}Fm	0.28	7.69	5.92	2.83	2.46
	DD-PC1	0.20	12.88		-6.21	-6.70		0.29	7.73		2.71	2.34
	FRDM	0.19	12.65		-5.77	-6.27		0.24	7.19		4.83	4.43
	Expt.								7.56		1.48*	
^{274}Cn	DD-ME2	0.23	10.94	-0.90	-2.63	-3.19						
	DD-PC1	0.23	11.24		-3.35	-3.89						
	FRDM	0.22	11.39		-3.69	-4.22						
	Expt.											

α-decay half-lives from DD-PC1 and FRDM are very close to SF half-lives but sligh differ from experimental half-lives which leads to the conclusion there is equal probability of SF and α-decay. The FRDM results of α-decay half-lives for ^{252}Rf is more closer to experimental half-life than relativistic parameter and Xu. The experimental half-lives for the last two nuclei are less than α-decay half-lives from all the approaches and SF half-lives giving idea of other mode of decay which is different from these two studied here (α and SF).

From the above results, we can't report for exact number of α decay before SF. The SF comes into picture at ^{266}Hs and ^{262}Sg but, α decay become again dominant after ^{262}Sg. The experimental results also supports for α-decay at the end of the chain.

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