Competition between $\alpha-$ decay and spontaneous fission modes for the $\alpha-$ decay chain isotopes of $^{306}122$

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Introduction

Now a days, search for new elements in superheavy region is an emerging field of study. The production capability and analysis of nuclei with extreme value of proton number (Z) i.e, superheavy nuclei (SHN) are confirmed by the experimental progress and current theoretical studies. The advance detection technology and radioactive ion beam (RIB) facilities have been utilized for synthesizing SHN by using cold, warm, and hot fusion reaction. The successful attempts for production of SHN up to Z=110-112 have been done at GSI using cold fusion reaction [1]. The SHN with Z=114-118 have been synthesized successfully at Dubna using hot fusion [2].

It is well known that SHN are very short lived and decay mainly through α emission Therefore, a wealthy information are inferred by the observation of α-decay: half-lives, released energy, and shell effects. It is observed from decay of SHN that it generally terminate through spontaneous fission after several decay of α particle. Thus, it is advantageous to examine the decay properties in superheavy region which helps to investigate the possibility of existence and degree of stability of nuclei in this region.
In this paper, we have studied the decay properties of $^{306}122$ and its decay chain nuclei. The ground state (GS) properties of the decay chain of $^{306}122$ have been studied within the self-consistent relativistic mean field model with density dependent parameters DD-ME2 [3] and DD-PC1 [4]

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Results

We have studied the ground state structural and decay properties of Z=122 SHN. Here we are presenting the numerical results of $^{306}122$ being N=184 as neutron magic number. The reliable calculation for α decay in superheavy region can be achieved by semi-empirical relationship proposed by Poenaru et.al., as UNIV2 [5], and SemFIS [5]. We have used semi-empirical relationship given by Xu.et.al., [6] for calculating spontaneous fission (SF) half-lives of nuclei against α decay. The numerical results for decay chain of $^{306}122$ are given in the table. The table contains information about ground state properties like quadrupole deformation (β_2), decay energies (Q_α) and the corresponding α-decay half-lives. Non relativistic FRDM is used for the sake of comparison. At the beginning of the decay chain, FRDM predicts Q_α energy larger than that of relativistic force parameter except for DD-PC1 at $^{306}122$ but situation become reversed at $^{290}114$ and onward except at ^{274}Hs and ^{270}Sg. The exactly spherical shape is predicted at $^{302}122$ and $^{298}120$ by all the interaction used here. There is lack of consensus between result of β_2 at $^{306}122$, $^{294}116$, and $^{290}114$. As we move down through the α-chain after $^{290}114$, the shape of daughter nucleus move to prolate region. By comparing α-decay half-lives ($T^{\alpha}_{1/2}$) and spontaneous fission half-lives ($T^{SF}_{1/2}$), one can decide for number of α-decay in the decay chain. The decay half-lives calculated with SemFIS2 are slightly larger than half-lives obtained with UNIV2. A very short $T^{\alpha}_{1/2}$ in comparison to $T^{SF}_{1/2}$ is calculated at the beginning of the chain suggest that α-decay would be the most probable decay mode at the beginning. At $^{294}116$ and $^{290}114$ the results of decay half-lives from rel-

TABLE I: The predicted quadrupole deformation parameter (β_2), Q_α and α-decay half-lives [$logT^{\alpha}_{1/2}$] for α-decay series of $^{306}122$ nucleus, with DD-ME2, DD-PC1 forces, compared with the the corresponding micro-macroscopic FRDM 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
$^{306}122$	DD-ME2	0.00	13.40	17.40	-5.39	-5.95	^{282}Ds	0.14	8.16	-7.94	4.12	3.86
	DD-PC1	-0.16	15.19		-8.45	-8.9		0.15	8.93		1.72	1.48
	FRDM	0.00	14.91		-8.02	-8.48		0.18	7.76		5.98	5.70
$^{302}120$	DD-ME2	0.00	11.62	9.91	-2.19	-2.80	^{278}Hs	0.16	7.92	-8.19	4.46	4.32
	DD-PC1	-0.03	13.39		-5.91	-6.40		0.20	8.46		2.52	2.39
	FRDM	-0.03	13.71		-6.51	-6.97		0.20	8.52		2.30	2.17
^{298}Og	DD-ME2	0.00	10.46	3.84	0.71	0.10	^{274}Sg	0.18	7.69	-7.54	4.51	4.49
	DD-PC1	0.04	12.12		-3.93	-4.41		0.21	7.73		4.34	4.32
	FRDM	-0.06	12.50		-4.74	-5.20		0.21	8.31		2.24	2.22
^{294}Lv	DD-ME2	-0.23	9.60	-0.89	1.92	1.37	^{270}Rf	0.25	7.67	-6.05	3.69	3.79
	DD-PC1	-0.09	9.96		0.82	0.30		0.23	8.17		1.88	1.97
	FRDM	0.00	10.96		-1.88	-2.33		0.23	7.29		5.22	5.33
^{290}Fl	DD-ME2	-0.21	11.10	-4.37	-4.17	-4.50	^{266}No	0.29	6.89	-3.81	6.03	6.28
	DD-PC1	0.11	10.61		-1.66	-2.04		0.23	7.22		4.60	4.84
	FRDM	-0.10	8.50		4.84	4.33		0.23	6.31		8.77	9.05
^{286}Cn	DD-ME2	0.15	8.81	-6.70	3.19	2.83	^{262}Fm	0.25	4.88	-0.89	16.41	16.97
	DD-PC1	0.14	9.57		0.51	0.19		0.24	5.16		14.49	15.01
	FRDM	0.12	8.47		4.11	3.74						

ativistic and FRDM are not in good agreement. The FRDM suggests that α-decay is more probable $^{294}116$ while relativistic model (DD-ME2) supports for spontaneous fission. The condition at $^{290}114$ is different that relativistic calculation giving the idea of equal probability for both decay mode while FRDM determine the SF decay as the most probable decay mode. From the table, it is clear that SF decay is the most dominate from $^{286}112$ and onward because of very short SF decay half-lives in comparison to α-decay half-lives for all parameter used here. Results using relativistic parameter are more or less in agreement with FRDM after the daughter nucleus $^{286}112$.

conclusion

We have examined the properties for α-chain of $^{306}122$. The present study shows that RMF results are more or less same as FRDM except at some points which have been discussed above. The calculation shows that the daughter nucleus become stable against α emission after $^{282}112$ and preferably decay through SF. The calculation will help to design the detector to detect the nuclei in this region. Detector must have high resolution power to detect such SHN with very short half-lives.

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