Decay properties of Z = 122 isotopic chain

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Nowadays, to unveil the unexplored superheavy region of nuclear landscape especially Z > 118 is one of the prime aim of various experimental facilities around the world viz. GSI, RIKEN and JINR. An experiment has attempted to synthesis the isotopes of Z = 120 using the reaction ^{244}Pu (^{58}Fe, xn)$^{302-x}$120 [1]. In superheavy region Z = 112-118 new isotopes investigated at the DGFRS separator using the reaction of ^{48}Ca with ^{238}U - ^{249}Cf target [2]. Using the systematic behavior of parameters of α-nucleus double-folding potentials α-decay properties have been studied of the unknown nucleus ^{296}118 [3]. Decay properties of the isotopes of Z = 126 (within 288 $\leq$ A $\leq$ 339), Z = 124 (within 284 $\leq$ A $\leq$ 339) and Z = 122 (within 280 $\leq$ A $\leq$ 339) have been investigated by Santosh *et al.* [4]. To synthesize Z = 122 element different type of most probable projectile-target (Cr+Cf, Fe+Cm, Se+Ra, and As+Ac) combinations have been used and found alpha decay mode of $^{307-314}$122 isotopes [5]. Encouraging from the above mentioned theoretical and experimental studies, we have chosen Z=122 isotopic chain to investigate decay properties by applying relativistic mean-field plus state dependent BCS (RMF+BCS) approach [6].

To study the decay properties (α-decay, β-decay and spontaneous fission (SF)) of even and odd isotopes of superheavy nuclei Z=122 within the range of N =162-230, we perform calculation using RMF+BCS approach and compare our results with Macroscopic-Microscopic approach with triaxially deformed Nilson Strutinsky method (NSM) [7]. We compute Q_α, Q_β, $log_{10}T_\alpha$ and $log_{10}T_{SF}$ for the Z = 122 isotopic chain and found that $^{292-308}$122 isotopes having long α-decay chain. Here to calculate α decay half lives ($\log_{10}T_\alpha$), we use modified Royer formula [8] and for spontaneous fission half-lives (T_{SF}), formula reported by C. Xu et al. [9]. In table I, these values are shown for one of the representative even-even and even-odd isotopes i.e. $^{292-293}$122 decay chains.

$$T_\beta^{1/2} = (540 \times 10^5) \frac{m_e^5}{\rho_{d.s.}(W_\beta^6 - m_e^6)} \qquad (1)$$

TABLE I: Decay chains of $^{292-293}$122 superheavy nuclei and their decay products (decay-chain) by comparing the α-decay half-lives (sec) and the corresponding SF half-lives (sec).

Nuclei	Q_α(MeV)		$\log T_\alpha(1/2)$		$\log T_{SF}(1/2)$	Decay Mode	
	RMF	Mac-Mic	RMF	Mac-Mic		RMF	Mac-Mic
^{292}122	13.52	15.99	-4.42	-8.53	20.72	α1	α1
^{288}120	12.36	15.51	-2.69	-8.30	13.42	α2	α2
^{284}118	13.46	14.97	-5.44	-7.99	7.54	α3	α1
^{280}116	12.96	12.64	-5.07	-4.44	3.01	α4	α2
^{276}114	12.45	10.34	-4.66	0.18	-0.29	α5	SF
^{272}112	12.05	12.07	-4.44	-4.47	-2.42	α6	α2
^{293}122	13.79	15.32	-4.30	-6.88	22.10	α1	α1
^{289}120	12.07	15.04	-1.45	-6.98	14.77	α2	α2
^{285}118	13.76	14.49	-5.40	-6.64	8.87	α3	α3
^{281}116	12.72	13.53	-4.05	-5.56	4.30	α4	α4
^{277}114	12.32	9.82	-3.86	2.15	0.99	α5	SF
^{273}112	11.83	11.38	-3.46	-2.48	-1.17	α6	α6

Further to search the possibility of β-decay, we use the empirical formula of Fiset and Nix [10] to estimate the β-decay half-lives. Here W_β = Q_β + m_e, is the total maximum energy of the emitted β-particle in which m_e is

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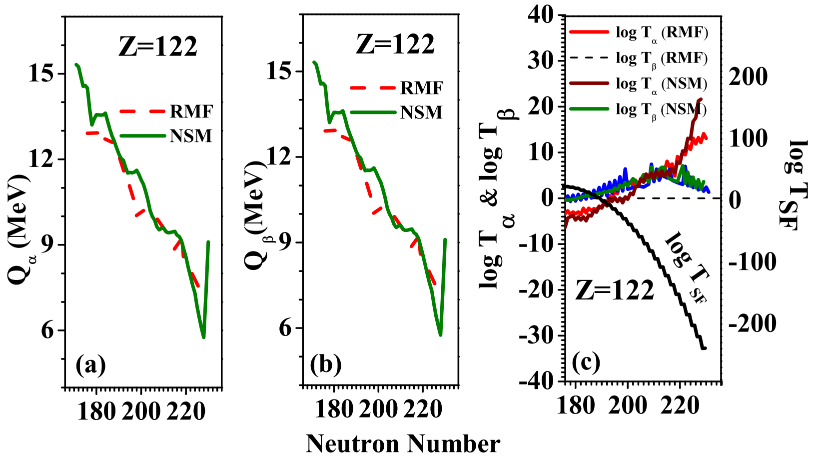

FIG. 1: (a) Q_α (b) Q_β and (c) $log_{10}T_\alpha$, $log_{10}T_\beta^{1/2}$ and T_{SF} as a function neutron number N

rest mass and Q_β = BE(Z + 1,A) - BE(Z,A). $\rho_{d.s.}$ is average density of states in the daughter nuclei and is equal to $e^{-A/290}\times$ number of states within 1 MeV of ground states. For our calculation, we use values of number of states as 2.73 and 8.6 for even and odd mass nuclei respectively [11].

After estimating Q-values and half lives of Z=122 isotopic chain, we plot these values in Fig.1. Fig.1(a) and (b) display Q_α values and Q_β values, respectively, calculated by both the theories. It is noteworthy here these values from both the theories are in reasonable agreement. Fig.1 (c) shows the α-decay half-life ($log_{10}T_\alpha$), β-decay half-life $log_{10}T_\beta^{1/2}$ and spontaneous fission half-life (T_{SF}) for Z = 122 as a function of neutron number N calculated by RMF and NSM theories. From Fig.1(c), it reveals that towards lower mass region α-decay half-life ($log_{10}T_\alpha$) is lower than β-decay half-life $log_{10}T_\beta^{1/2}$ and spontaneous fission half-life (T_{SF}), which shows that the α-decay is found to be favourable decay mode for A $\leq$ 314 with Z = 122. Beyond A > 314 values spontaneous fission half-life (T_{SF}) becomes lower and decay through spontaneous fission become more favourable. Therefore, we may conclude that chances of decay thorough β are negligible in this superheavy region and the nuclei with A $\leq$ 314 are most probable nuclei to be predicted in laboratory in near future.

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