Alpha decay chains of ^{302}122 using relativistic mean field model

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Introduction

In last few decades, several theoretical and experimental studies has been done regarding the island of stability and decay chains of superheavy elements. The neutron rich isotopes of elements with Z = 112, 114, 116 and 118 have been synthesized using both cold- and hot- fusion reactions [1, 2]. Recently different theoretical studies for α-decay properties of superheavy elements have been carried out using various models such as performed cluster model (PCM), dynamical cluster-decay model (DCM), Coulomb and proximity potential model (CPPM), generalised liquid drop model (GLDM) and cluster model etc.

In this contribution, our calculations are carried out in the frame work of relativistic mean field (RMF) theory using NL3* parameter set and compared with the Finite Range Droplet Model (FRDM) [3] estimates and experimental data [4]. We have studied the systematics of α-decay half lives of superheavy nuclei Z = 122 in the range A = 272-332 using two different techniques of alpha decay.

Theoretical formalism

The successful application of RMF formalism for finite nuclei as well as infinite nuclear matter are well documented in Refs. [5–7]. The α-decay half life is determined in the present study by using two empirical formulae given by (i) Viola and Seaberg [8] (ii) B. Alex Brown [9]. These formulae are mainly formulated for the super-heavy mass region. The formulae for α-decay half-life are defined as:

$\log T_\alpha^{1/2}$ (v) $= (aZ+b)Q_\alpha^{-1/2} + (cZ+d) + h_{log}$

and

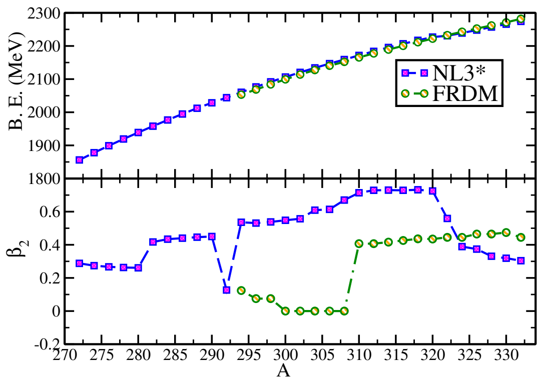

FIG. 1: Binding energy and quadrupole deformation parameters for the isotopic chain of Z=122 with N = 150−190 using RMF(NL3*) force parameter along with FRDM predictions [3].

$\log T_\alpha^{1/2}$ (b) $= (9.54 Z_d^{0.6}/\sqrt{Q_\alpha}) - 51.37$.
The details can be found from the reference [8, 9]. Where the α-decay energy (Q_α) values are estimated by using the relation $Q_\alpha(Z,N) = B.E.(N,Z) - B.E.(N-2, Z-2) - B.E.(2,2)$. The binding energies of the parent and the daughter nuclei are being estimated from RMF model using NL3* force.

Results and Discussions

The results from the RMF formalism using NL3* parameter set for the binding energy (B.E.) and quadruple deformation parameter (β_2) of super-heavy nuclei Z = 122 with N = 150-190 are shown in Fig. 1. The FRDM [3] results are also given for comparison. From the figure, one can see an overall good agreement between our results and FRDM predictions for all the isotopes of Z = 122. However,

TABLE I: α - decay chain of $^{302}122$. Here Q_α is in MeV and $log(T_\alpha^{1/2})$ is in second.

Parent	Q_α			$log(T_\alpha^{1/2})$(v)			$log(T_\alpha^{1/2})$(b)		
	NL3*	FRDM [3]	Expt. [4]	NL3*	FRDM	Expt.	NL3*	FRDM	Expt.
$^{302}Z_{122}$	12.62	14.05		-3.92	-6.77		-3.89	-6.37	
$^{298}Z_{120}$	10.75	13.35		0.05	-5.93		-0.435	-5.67	
$^{294}Og_{118}$	10.31	12.28	11.81	0.632	-4.24	-3.195	0.097	-4.20	-3.275
$^{290}Lv_{116}$	10.89	11.12	10.99	-1.55	-2.12	-1.79	-1.81	-2.32	-2.03
$^{286}Fl_{114}$	10.82	9.39	10.37	-1.965	2.08	-0.78	-2.17	1.44	-1.114
$^{282}Cn_{112}$	11.64	9.42	10.11	-4.51	1.30	-0.71	-4.44	0.79	-1.02
$^{278}Ds_{110}$	9.26	10.41	10.37	1.113	-2.13	-2.04	0.66	-2.29	-2.198
$^{274}Hs_{108}$	9.22	9.46	9.57	0.53	-0.18	-0.49	0.185	-0.46	-0.755
$^{270}Sg_{106}$	8.59	8.16	8.99	1.86	3.33	0.56	1.46	2.82	0.258
$^{266}Rf_{104}$	6.53	6.73	7.55	9.33	8.38	4.85	8.48	7.61	4.315
$^{262}No_{102}$	5.83	6.59	7.25	12.14	8.18	5.25	11.25	7.53	4.78

a slight variation is observed in case of (β_2). The estimated values of Q_α and alpha decay half life ($T_\alpha^{1/2}$) from NL3* is given in Table 1, with the FRDM [3] and available experimental data [4]. The table shows an underestimation of our results than that of FRDM and experimental values for almost all the nuclei except Flerovium (Fl) and Copernicium (Cn). As the alpha decay energy differs a little, hence the decay half life too differs a bit. We are getting more close values of Q_α and $\log_{10} T_\alpha^{1/2}$(v) for the nucleus Livermorium (Lv) and Seaborgium (Sg). The results for Q_α of above two nuclei are 10.89 and 8.59 MeV, whereas experimental data are 10.99 and 8.99 MeV respectively. Again for $log(T_\alpha^{1/2})$ our result are -1.55 and 1.86 s whereas experimental data are -1.79 and 0.56 s respectively. From the table it can be noticed that the α-decay half life estimated from Viola and Seaberg [8] is closer to the data than that of the results form Brown [9].

Conclusion

We have estimated the ground state properties of the isotopic chain with Z = 122, for N = 150 -190 using NL3* parameter set and compared our results with FRDM and the available experimental data. Then the α-decay energy (Q_α) and decay half life ($T_\alpha^{1/2}$) are calculated by using the relations given under formalisms. We found the results quantified from Viola et al. is more closer to the data in comparison to the estimation from B. Alex Brown.

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