SK Model and decay properties of $^{299}_{119}$X

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Introduction

One of the important steps in detecting the formation of superheavy nuclei is to analyze accurately the lifetimes of alpha decay chains. This is usually done by comparing the measured alpha lifetimes with those obtained by the empirical Viola-Seaborg relation [1]. This relation connects the lifetime with the Q-value. Recently, Zagrebaev et. al [2] has brought out the possibility of forming the superheavy nucleus $^{299}_{119}$X and studied its decay properties namely alpha, beta and spontaneous fission.

They used the formula [1]

$$log_{10}T_\alpha(s) = \frac{aZ+b}{\sqrt{Q_\alpha(MeV)}} + cZ + d + h_{log} \quad (1)$$

with the parameters a=1.66175, b=-8.5166, c=-0.20228, d=-33.9069.

The value of h_{log} is taken as

$$h_{log} = \begin{cases} 0, & \text{Z and N are even,} \\ 0.772, & \text{Z is odd and N is even,} \\ 1.066, & \text{Z is even and N is odd,} \\ 1.114, & \text{Z and N are odd} \end{cases} \quad (2)$$

to incorporate odd-even effects.

We feel that this could be done by evaluating alpha decay lifetimes by rigorous theories, which may throw more light on the physics of the superheavy nuclei. With this intention, we use here [3] a unified fission model developed by Shanmugam and Kamalaharan (SK) which was first used for cluster radioactivity and then extended to alpha decay studies. This SK model uses a cubic potential in the pre-scission region connected by Coulomb plus Yukawa plus exponential potential in the post-scission region. Apart from using such a realistic potential this model has many more virtues. They are the inclusion of the zero point vibration energy, usage of correct barrier heights including centrifugal contribution and no adjustable parameters. The advantage of this model is further enhanced by its versatility in incorporating the deformation of the decaying parent and the daughter and also their shapes and spins which turn out to be very important now because of the hindrance they can cause, aiding to longevity and stability of superheavy nuclei. One other advantage of this model is that it can naturally be applied to the complicated study of the terminating spontaneous fission events.

Aim of this work

In this work, using SK Model we try to study the alpha decay properties of the yet to be formed nucleus $^{299}_{119}$X, the formation of which has been proposed by Zagrebaev et. al [2]. The decay properties of other known odd and even superheavy nuclei have already been analyzed with this model [3].

Results and Conclusions

We show below the alpha decay lifetimes of the $^{299}_{119}$X chain obtained by us along with those obtained by Zagrebaev et. al using Viola-Seaborg formula. From the table, it is clear that the deformations and shapes of the parent and daughter nuclei, which are very important are also taken into account. In addition, their spins are included in considering the centrifugal part of the barrier. In our calculations, we use Moller and Nix table [4] for the deformations and spins of the parent and daughter nuclei.

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TABLE I: Lifetimes of alpha decays from superheavy nucleus $^{299}_{119}$X

A_p	Z_p	Q (MeV)	β_{2p}	β_{4p}	β_{2d}	L($\hbar$)	$T_{calculated}$	$T_{reference[2]}$
299	119	12.8	-0.018	-0.008	-0.07	1	8.38μs	48μs
295	117	11.58	-0.07	-0.013	-0.061	1	1.84 ms	7 ms
291	115	9.66	-0.061	0.001	0.062	1	96.16s	220 s
287	113	8.82	0.062	-0.031	0.099	3	2.85 hrs	6.2 hrs
283	111	8.1	0.099	-0.036	0.108	1	3.34 days	20 days

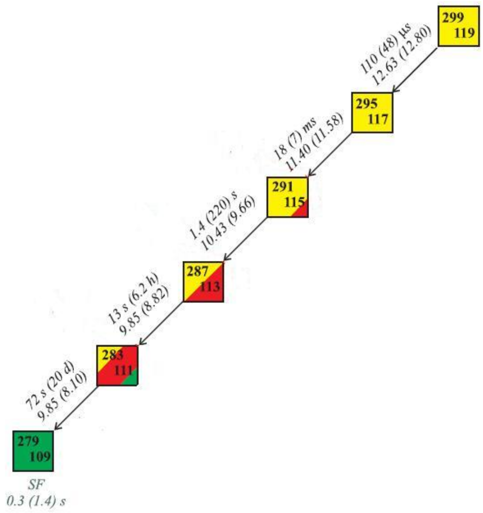

FIG. 1: Expected decay chain for $^{299}_{119}$X [2]

To conclude, we have studied the alpha decay properties of superheavy nuclei Z=113-118 using SK Model earlier. Our calculations were extended to Z=120 last year, which showed its lifetime to be in microseconds bringing out the important fact that Z=120 cannot be the next magic number after Z=82. The missing link nucleus Z=119 which is proposed by Zagrebaev et. al and yet to be formed is considered in this work, which should throw more light on reaching the expected doubly magic superheavy nucleus.

References

[1] V.E.Viola and G.T.Seaborg, J. Inorg. Nucl. Chem. **28**, 741 (1966).

[2] V.I.Zagrebaev, A.V.Karpov and Walter Greiner, Phys. Rev.C **85**, 0140608 (2012).

[3] G.Shanmugam, S.Sudhakar and S.Niranjani, Phys. Rev. C **72**, 034310, (2005) and references therein.

[4] P.Moller, J.R.Nix and K.L.Kratz At. Data Nucl. Data Tables **66**, 131 (1997).