Decay Properties of superheavy nuclei $^{298,299}_{120}$X

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Introduction

The search for superheavy nuclei with $Z > 112$ has been vigorosly pursued during the last decade both theoretically and experimentally. Theoretically, the interest is kindled by the fact that the doubly magic superheavy nucleus would be $Z = 114$ according to macroscopic-microscopic theory. But when experimentally it was formed, it failed to give the expected long life. At this point, Hartree-Fock-Bogoliubov (HFB) and relativistic mean field (RMF) theories predicted that the next proton magicity after 82 could be 120, 124 or 126. Hence, experimental efforts turned towards reaching $Z = 120$. However, the neutron magicity after 126 is predicted to be 184 by all the above three theories. Hence increasing the neutron number towards 184 is being attempted to gain greater stability. In this direction, the major thrust came from the work of Oganessian et al. [1] who were able to succeed in producing superheavy nuclei with $Z = 113 - 118$ whose alpha decay chains and lifetimes were detected and presented.

Our work in this regard is able to calculate the lifetimes of the above decay chains theoretically using our SK Model [2], which has the particular advantage of incorporating shapes and deformations also. Further, our theoretical efforts [3] have demonstrated clearly that the doubly magic nucleus after $Z = 82$ and $N = 126$ should be the nucleus with $Z = 126$ and $N = 184$. Our calculations also demonstrated that after $Z = 112$ nuclear deformation shrinks less than $\beta = 0.1$ wherein the regime of gamma softness, prolate oblate co-existence and triaxiality take over. This fact prolongs the effort of reaching the doubly magic nucleus but yielded nuclei with $Z = 113 - 118$.

Hence, at the present juncture the production of nucleus with $Z = 120$ has gained momentum and efforts to produce it using U, Pu, Cm targets and Ni, Fe and Cr projectiles respectively, have been very recently tried by Oganessian et al. [4] and Kozulin et al. [5]. While the latter proved that the third combination is not suitable, the former two trials have failed to yield the decay chains. However, Oganessian et al. have presented the anticipated decay chains of $^{298,299}_{120}$X [4].

Aim of this work

The aim of this work is to obtain the alpha decay lifetimes of $^{298,299}_{120}$X by using the SK model and to compare the results obtained with those of the expected decay schemes of Oganessian et al. [4]. In this connection, it is to be noted that the decay chains for all the nuclei $Z = 113 - 118$ have been closely reproduced by our work [2].

Results

The decay properties of $^{298,299}_{120}$X obtained by our work are shown in the Table I and compared with those of Oganessian et al. The striking feature of the comparison is that our results have yielded alpha decay lifetimes of the nucleus $Z = 120$ in microseconds. This is not only consistent with the results of Oganessian et al. but also brings out the important fact that $Z = 120$ cannot be the next magic number after $Z = 82$. It is earnestly hoped that further experiments in the near future can also bring out that $Z = 126$ is the expected long lived superheavy nucleus as our calculations have already indicated [3].

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TABLE I: Lifetimes of alpha decays from superheavy nuclei $^{298}_{120}$X and $^{299}_{120}$X

A_p	Z_p	Q (MeV)	β_{2p}	β_{4p}	β_{2d}	$T_{calculated}$	T_{expt}
298	120	12.40	-0.079	-0.013	-0.087	65.45 μs	30 μs
294	118	11.65	0.087	-0.012	0.072	3.2 ms	0.89 ms
290	116	10.84	0.072	-0.031	-0.096	20.65 ms	7.1 ms
286	114	10.19	-0.096	0.035	0.089	0.718 s	0.13 s
299	120	12.30	-0.035	-0.008	-0.087	106.4 μs	50 μs
295	118	11.55	-0.087	-0.020	0.072	5.73 ms	1 ms
291	116	10.74	0.072	-0.038	-0.078	71.14 ms	18 ms
287	114	10.02	-0.078	0.034	0.089	1.957 s	0.48 s
283	112	9.54	0.089	-0.012	0.127	10.85 s	3.8 s
279	110	9.70	0.127	-0.033	0.183	0.4172 s	0.20 s
275	108	9.30	0.183	-0.077	0.212	0.4524 s	0.19 s
271	106	8.54	0.212	-0.082	0.221	256.9 s	1.9 min

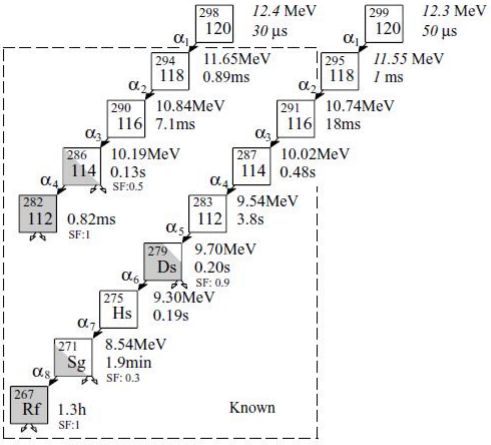

FIG. 1: Expected decay chains for ^{298,299}120 [4]

References

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