Indian Journal of Pure & Applied Physics
Vol. 58, May 2020, pp. 397-403

Alpha-decay chains of Z=122 superheavy nuclei using cubic plus proximity potential with improved transfer matrix method

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Received 4 May 2020

The alpha decay chain properties of Z = 122 isotope in the mass range 298≤ A ≤ 350, even-even nuclei, are studied using a fission-like model with an effective combination of the cubic plus proximity potential in the pre and post-scission regions, wherein the decay rates are calculated using improved transfer matrix method, and the results are in good agreement with other phenomenological formulae such as Universal decay law, Viola-Seaborg, Royer, etc. The nuclear ground-state masses are taken from WS4 mass model. The next minimum in the half-life curves of the decay chain obtained at N=186,178 & 164 suggest the shell closure at N=184, 176 & 162 which coincides well with the predictions of two-centre shell model approach. This study also unveils that the isotopes $^{298-300,\ 302,\ 304-306,\ 308-310,\ 312,314}122$ show 7α, 5α, 4α, 3α, 2α and 1α decay chain, respectively. All the other isotopes from A = 316 to 350 may undergo spontaneous fission since the obtained SF half -lives are comparatively less. The predictions in the present study may have an impact in the experimental synthesis and detection of the new isotopes in near future.

Keywords: Transfer matrix method, Superheavy nuclei, Alpha decay, Spontaneous fission, Magic numbers, and Decay chain

1 Introduction

The quest to find the island of stability in superheavy region is one of the important research areas of modern nuclear physics; which has been widely investigated by various theoretical approaches and experimental efforts[1]. The nuclear structure and decay properties can help to pinpoint these islands of stability locations[1-3]. Theoretical predictions using different formalism suggests proton magic number in superheavy region to be Z=114, 120, 126, 132, 138 and neutron magic number to be N=172, 184, 198/202, 228, 238[4-10]. Through experimental studies, if increase in nuclear stability could be seen in around these proposed magic numbers, the nuclear stability locations could be confirmed[3]. Our periodic table is growing with discovery of every new elements, the heaviest element known so far is Z = 118. Elements up to uranium 92 can be found in nature, the majority of these elements consists the light and medium-heavy nuclei, and with those of Z > 83 are heavy nuclei. A superheavy element, in general, is referred to elements with an atomic number greater than 104. All the transuranium elements discovered so far are from one of the four laboratories: Lawrence Berkeley National Laboratory in the United States (elements 93 to 101, 106, & joint credit for elements 103 to 105), the Joint Institute for Nuclear Research in Russia (elements 102 and element 114 to 118, & joint credit for element 103 to 105), the GSI Helmholtz Centre for Heavy Ion Research in Germany (elements 107 to 112), and RIKEN in Japan (element 113)[1,2]., the elements present in our periodic table and their isotopes exhibit diverse neutron-proton ratio, binding energy, size, and stability.

Radioactive decay is an important phenomenon associated with the nucleus, in which a nucleus undergoes transition via decay modes which can be alpha decay, beta decay, gamma decay, neutron emission, proton emission, spontaneous fission, and cluster decay. Light and medium-heavy nuclei decays majorly via beta decay, electron capture, and proton emission[11]. Heavy and superheavy nuclei decay transform via beta decay, alpha decay, and spontaneous fission, but beta decay for the superheavy nuclei is slow as it proceeds via a weak interaction and is less favored compared to spontaneous fission and alpha decay[3]. Cluster radioactivity is a rare process where nuclei decay and

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emit a fragment which is heavier than the alpha particle but lighter than the fission fragment. The possible existence of such phenomena was established in the theoretical work of Sandulescu, Poenaru, and Greiner in 1980[12]. Shortly in 1984, Rose and Jones experimentally observed this radioactivity, where ^{223}Ra emitted ^{14}C cluster[13]. In last three decades, many other clusters have been observed which include ^{20}O, ^{23}F, $^{24-26}$Ne, $^{28-30}$Mg, and ^{32}Si, where the parent mainly was either a actinide series nuclei or some heavier nuclei near to actinides (like Fr and Ra)[14,15]. But cluster decay observation from SH nuclei is yet to be observed experimentally. Recently, the concept of cluster radioactivity has been changed to accommodate the emission of particles with the charge number $Z_c > 28$ from the parent nuclei with $Z_p = Z_c + Z_d > 110$ and the daughter nuclei are 208 Pb or the neighboring ones[16]. Poenaru and Gherghescu theoretically investigated the^{92,94}Sr cluster radioactivity of ^{300,302}120 and predict a branching ratio relative to α decay being −0.10 and 0.49,, respectively, which suggests that such cluster decay modes have good chances to be observed in competition with alpha decay[17]. An interesting latest experiment was performed at the velocity filter SHIP (GSI Darmstadt) trying to produce the ^{299}120 isotope in a fusion reaction involving ^{248}Cm (^{54}Cr, 3n)[18]. Hence with the synthesis of ^{300,302}120 isotopes, large clusters like ^{92,94}Sr can be expected to be observed in the decay in superheavy region.

In this work, we perform systematic study on the decay properties of Z=122 isotopes which is likely to be synthesized in the near future, and in turn will give the experimentalist a chance to observe the decays associated with these particular isotope. The superheavy isotopes synthesized decay rapidly and are identified by their alpha decay chains, where a series of alpha particles are emitted which ends with a spontaneous fission. We employ our recently developed Cubic plus proximity potential model with improved transfer matrix method[19]to study the emission of alpha chain from isotopes of $Z = 122$ for spherical nuclei. Each isotope has a unique alpha chain signature associated with it; we aim to theoretically predict the features of alpha chain from superheavy nuclei having $298 \leq A \leq 350$ with $Z= 122$.

2 Theoretical Framework

The parent nucleus that undergoes decay is treated to be fission like process where the daughter and parent nucleus is formed. The interaction between daughter nuclei and alpha particle is majorly influenced by the nuclear potential and Coulomb potential with some contribution from centrifugal potential. In the post scission region when $r > r_t$ the total interaction potential turns out to be:

$$V_{ext}(r,\theta\emptyset) = V_n(r,\theta\emptyset) + V_c(r,\theta\emptyset) + V_l(r,\theta\emptyset) \quad \dots (1)$$

Taking into consideration for a spherical daughter and fragment nuclei, the total interaction potential in the post scission region is:

$$V_{ext}(r) = v_n(r) + \frac{z_1 z_2 e^2}{r} + \frac{l(l+1)\hbar^2}{2\mu r^2} \quad \dots (2)$$

To define the nuclear interaction between the daughter and fragment a proximity-77 potential is considered[20]:

$$V_n(r) = 4\pi\gamma b \frac{C_1 C_2}{C_1 + C_2}\phi(\epsilon) \quad \dots (3)$$

where $\phi(\epsilon)$ is the universal function which depends upon $\epsilon = (r - C_1 - C_2)/b$and γ represents the nuclear surface tension which differs from one nucleus to other.

$$\gamma = \gamma_0 \left[1 - k\frac{(N-Z)^2}{A^2}\right] \quad \dots (4)$$

$$C_i = R_i - \frac{b^2}{R_i} \quad \dots (5)$$

$C_i$is the central radii, with width b ≈1fm. The values of γ, $\phi(\epsilon)$ and $R_i$is taken from Prox-77 formalism[20], here k=1.7826 and $\gamma_0 = 0.9517$.

$$R_i = 1.28\, A_i^{\frac{1}{3}} - 0.76 + 0.8\, A_i^{\frac{-1}{3}} \quad \dots (6)$$

$$\phi(\epsilon) = -4.41\, exp\left(-\frac{\epsilon}{0.7176}\right) \quad \epsilon > 1.9475 \quad \dots (7)$$

$$\phi(\epsilon) = -1.7817 + 0.9270\epsilon + 0.0169\,\epsilon^2 - 0.05148\,\epsilon^3 \quad for \quad 0 \leq \epsilon \leq 1.9475 \quad \dots (8)$$

For the pre-scission region when $r < r_t$ the potential employed is in form of cubic polynomial 21 and is ensured conservation of energy,

$$V_{ov}(r) = (-E_v + Q) + [V(r_t) + E_v - Q] \times \left[s_1\left(\frac{r-r_i}{r_t-r_i}\right)^2 - s_2\left(\frac{r-r_i}{r_t-r_i}\right)^3\right] \quad \dots (9)$$

where s_1 and s_2 are obtained by matching pre and post scission region. E_v is the vibrational energy obtained by using:

$$E_v = Q\left(0.056 + 0.039\, exp\left[\frac{4 - A_2}{2.5}\right]\right) \quad \dots (10)$$

and r_i is the distance between the centre of mass of daughter and fragment within the parent nucleus:

$$r_i = \frac{3}{4}\left[\left(\frac{h_1^2}{R_0+h_1}\right) + \left(\frac{h_2^2}{R_0+h_2}\right)\right] \quad \dots (11)$$

Here h_1 and h_2 are the heights obtained by using a planar sectioncut into two unequal portions between the daughter and fragment[21]. To define the mass in the pre scission region where $r < r_t$ and effective mass is much appropriate than reduce mass since the fragment would not have attained its separate entity[22]. The effective mass μ_{eff} is:

$$\mu_{eff} = \mu + \frac{17}{15}\,\mu exp\left[-\frac{128}{51}\left(\frac{r - r_i}{R_0}\right)\right] * 16\, f(r, r_t), \quad \dots (12)$$

Where

$$f(r, r_t) = \left[\frac{r_t - r}{r_t - r_i}\right]^4 \quad \dots (13)$$

At $= r_t \mu_{eff} = \mu$. The effective mass is a decreasing function. To evaluate the tunneling probability an improved transfer matrix method is been used instead of traditional WKB approximation. Here the potential barrier is split into several small regions and the potential barrier is calculated in each of these regions with WKB at boundary and plane waves elsewhere[23]. The potential V(r) is:

$$V(r) = V_j = V\left[\frac{r_{j-1} + r_j}{2}\right] \quad \dots (14)$$

The wavefunction ψ_j when the potential is almost constant and behaves like a plane wave with the energy Q is:

$$\psi_j(r) = A_j exp(ik_j r) + B_j exp(-ik_j r), \quad \dots (15)$$

where $k_j = \frac{1}{\hbar}\sqrt{2\mu(Q - V)}$.At the boundaries the first order WKB wavefunction in pre and post scission region is

$$\psi_0^{wkb}(r) = \frac{A_0}{\sqrt{\hbar\, k(r)}} e^{i\int^r k(r')dr'} + \frac{B_0}{\sqrt{\hbar\, k(r)}} e^{-i\int^r k(r')dr'}, \quad \dots (16)$$

$$\psi_{N+1}^{wkb}(r) = \frac{A_{N+1}}{\sqrt{\hbar\, k(r)}} e^{i\int^r k(r')dr'} + \frac{B_{N+1}}{\sqrt{\hbar\, k(r)}} e^{-i\int^r k(r')dr'} \quad \dots (17)$$

Applying the condition that the wave function and its derivative should be continuous at r_0 and r_N:

$$\begin{bmatrix} A_1 \\ B_1 \end{bmatrix} = M_0 \begin{bmatrix} A_0 \\ B_0 \end{bmatrix}, \quad \dots (18)$$

$$\begin{bmatrix} A_{N+1} \\ B_{N+1} \end{bmatrix} = M_N \begin{bmatrix} A_N \\ B_N \end{bmatrix} \quad \dots (19)$$

The matrix inside the barrier is taken to be:

$$\begin{bmatrix} A_j \\ B_j \end{bmatrix} = \prod_{y=0}^{j-1} M_y \begin{bmatrix} A_0 \\ B_0 \end{bmatrix} \quad \dots (20)$$

Here M_0, M_y and M_N are the 2×2 matrices that can used to find the wavefunction anywhere inside or at the post barrier region:

$$M_0 = \frac{1}{2\sqrt{\hbar\, k_0}}\begin{bmatrix} (1 + S_0^+)e^{-ik_1 r_0} & (1 - S_0^-)e^{-ik_1 r_0} \\ (1 - S_0^+)e^{ik_1 r_0} & (1 + S_0^-)e^{ik_1 r_0} \end{bmatrix}, \quad \dots (21)$$

$$M_y = \frac{1}{2}\begin{bmatrix} (1 + S_y)e^{-i(k_{y+1} - k_y)r_y} & (1 - S_y)e^{-i(k_{y+1} + k_y)r_y} \\ (1 - S_y)e^{i(k_{y+1} + k_y)r_y} & (1 + S_y)e^{i(k_{y+1} - k_y)r_y} \end{bmatrix}, \quad \dots (22)$$

$$M_N = C_N \begin{bmatrix} (iS_N^+ + G_N)e^{ik_N r_N} & (iS_N^- + G_N)e^{-ik_N r_N} \\ (iS_N^- - G_N)e^{ik_N r_N} & (iS_N^+ - G_N)e^{-ik_N r_N} \end{bmatrix}, \quad \dots (23)$$

where

$$S_0^{\pm} = \frac{k_0}{k_1} \pm \frac{ik_0'}{k_0 k_1}, \quad \dots (24)$$

$$S_y = \frac{k_y}{k_{y+1}} for \quad y = 1,2,\dots N-1, \quad \dots (25)$$

$$S_N^{\pm} = k_{N+1} \pm k_N, \; G_N = \frac{k_{N+1}'}{2k_{N+1}}, \quad \dots (26)$$

with

$$k_0' = -\frac{\mu V'(x_0)}{k_0 \hbar^2},$$

$$k_{N+1} = -\frac{\mu\, V'(r_N)}{k_{N+1}\, \hbar^2},$$

$$C_N = \frac{\sqrt{\hbar}}{2\, i\, \sqrt{k_{N+1}}} \quad \dots (27)$$

By fixing $A_0 = 1$ and $B_0 = 0$ for $j = N + 1$ the transmission amplitude is given by[16]:

$$A_{N+1} = \frac{k_1}{k_N}\frac{\det(M_0)\det(M_N)}{M_{22}} \quad \dots (28)$$

$$M = \begin{bmatrix} M_{11} & M_{12} \\ M_{21} & M_{22} \end{bmatrix} = \prod_{y=0}^{N} M_y \quad \dots (29)$$

The tunneling probability is given by, $P = |A_{N+1}|^2$. The decay constant is, $\lambda = P\nu$ where assault frequency is, $\nu = \frac{1}{2R}\sqrt{2Q/\mu}$. The half-life of nuclei which decay through particle or cluster emission is calculated using:

$$T_{\frac{1}{2}} = \frac{ln2}{\lambda} \quad \dots (30)$$

3 Results and Discussion

We describe the empirical formulae to find alpha decay and spontaneous fission half-lives. The Universal decay law (UDL)[24] given by:

$$log_{10}T_{\frac{1}{2}} = a\,X' + b\,\rho' + c, \quad \dots (31)$$

is used for alpha decay and cluster decay half-life calculations, where:

$$X' = Z_1Z_2\left(\frac{\mu}{Q}\right)^{\frac{1}{2}}, \qquad \rho' = \left(\mu\, Z_1Z_2\left(A_1^{\frac{1}{3}} + A_2^{\frac{1}{3}}\right)\right)^{\frac{1}{2}} \quad \dots (32)$$

Qi *et al.*,[24,25] have obtained the values of coefficients a, b and c by fitting this relation to experimental data and found thata= 0.4314, $b = -0.4087$ and $c = -25.7725$.

Viola-Seaborg relation[26] is one of the widely used relations for calculating the alpha decay half-lives. It is given by:

$$log_{10}T_{\frac{1}{2}} = (aZ + b)Q^{-\frac{1}{2}} + cZ + d + h_{log} \quad \dots (33)$$

The coefficients a, b, c, d and $h_{\log}$are taken fromDong and Ren[27]. Accordingly we use $a = 1.64062$,$b = -8.54399$, $c = -0.19430$ & $d = -33.9054$.

The Royer [28] also gave a formula for calculating the alpha decay half-lives. Such as:

$$log_{10}T_{1/2} = a + bA^{1/6}\sqrt{Z} + c\,\frac{Z}{\sqrt{Q}}, \quad \dots (34)$$

where $a = -25.31$, $b = 1.1629$ & $c = 1.5837$ are the coefficients taken by fitting the experimental data for even-even nuclei with RMS deviation being 0.42.

Spontaneous fission half life is calculated using[29]:

$$log_{10}T_{1/2} = exp\left[2\pi\left(c_0 + c_1\,A + c_2Z^2 + c_3Z^4 + c_4(N - Z)^2 - \left(0.13323\,Z^2A^{-\frac{1}{3}} - 11.64\right)\right)\right], \quad \dots (35)$$

where $c_0 = -195.09227$,$c_1 = 3.10156$,$c_2 = -0.04386$, $c_3 = 1.4030\ 10^{-6}$&$c_4 = -0.03199$.

Decay half-life calculations are sensitive to choice of Q-value, and there exist different mass models to evaluate the Q-value. The decay half-life in general changes by several order for 1 MeV difference in Q-value. Hence for present calculations we choose the binding energy from WS-4 model and evaluate the Q-value of decay process. To start with, we calculate the alpha decay half-lives of some superheavy nuclei and compare with the experimental data. The results presented in Table 1 indicate the alpha decay half-life evaluated with present formalism is in good agreement with the experimental values. We extend this formalism to study the decay chain properties of Z=122 isotope.

In decay chain, the first step is alpha decay originating from Z=122 isotope and daughter nuclei created in this step acts a parent for second step of decay chain. This series of alpha emission is due to alpha decay half-life being several orders less than spontaneous fission that is alpha decay is the dominant decay mode. In the subsequent steps when

Table 1 – Comparison of theoretically calculated alpha decay half life of some superheavy nuclei with the corresponding experimental values[30].

Parent nuclei	Q (MeV) Experiment	WS-4	Alpha decay *log*T$_{1/2}$ Experiment	Present model
^{294}Og	11.820	12.202	-3.161	-4.512
^{293}Lv	10.710	10.797	-1.244	-1.672
^{292}Lv	10.780	11.130	-1.886	-2.135
^{291}Lv	10.890	11.124	-1.721	-2.348
^{290}Lv	11.000	11.088	-2.081	-2.454
^{290}Mc	10.410	10.287	-0.187	-0.495
^{289}Mc	10.490	10.299	-0.481	-0.517
^{288}Mc	10.630	10.401	-0.785	-0.979
^{287}Mc	10.760	10.505	-1.432	-1.089
^{284}Nh	10.120	10.119	-0.041	-0.034
^{283}Nh	10.380	10.412	-1.125	-0.731

spontaneous fission becomes dominant decay mode, the decay chain ends. The alpha decay half-life and spontaneous fission half-life obtained for each subsequent step of decay chain originating from different isotopes is represented in Figs 1 and 2. The crossing of SF curve with alpha decay curve indicates closure of alpha chain, and from this the chain length can be found. In Table 2, the alpha decay half-life

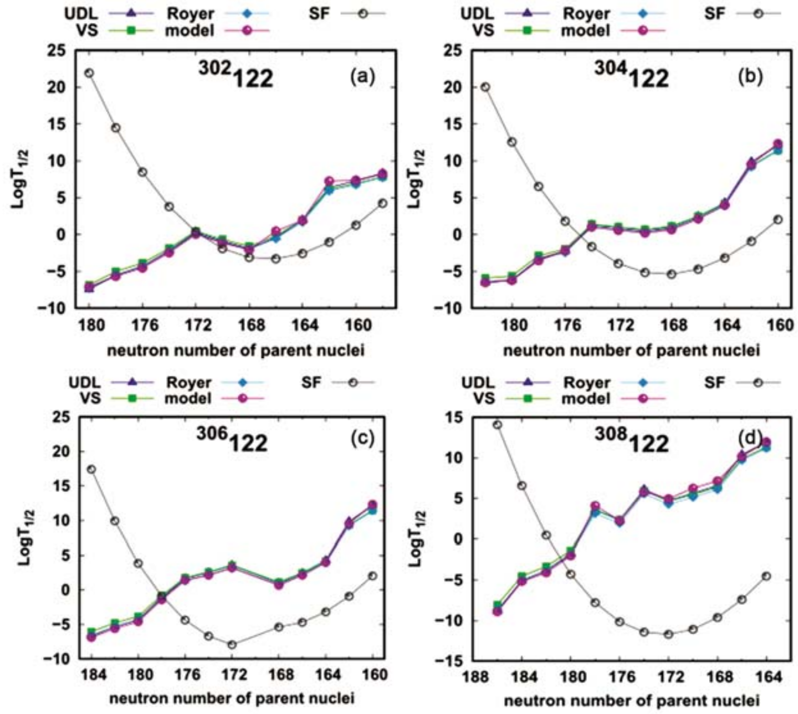

Fig. 1 – Alpha decay and spontaneous fission half-lives for decay chains originating from Z=122 isotopes.

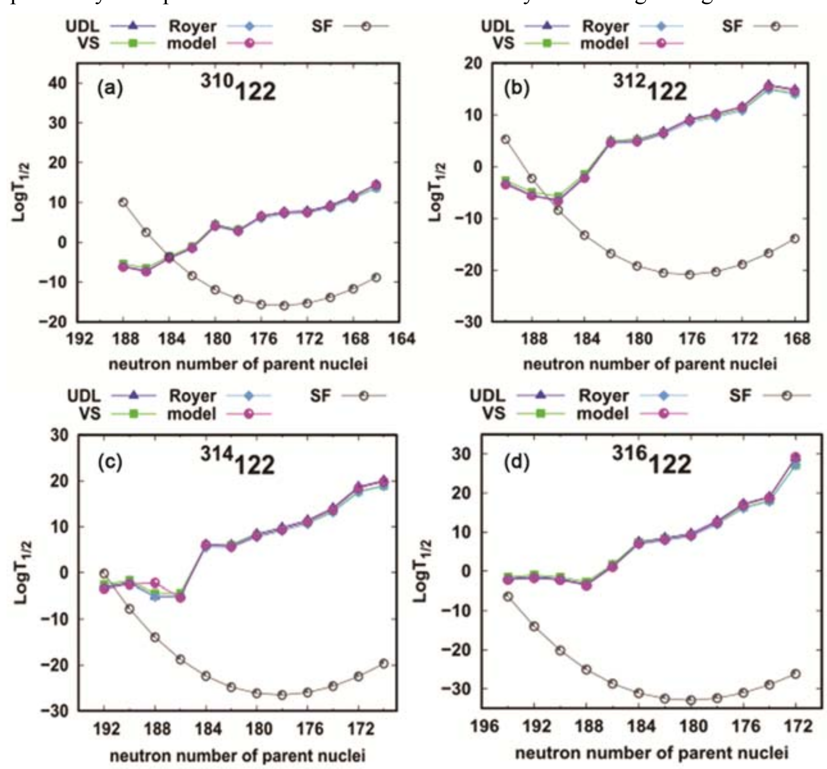

Fig. 2 – Alpha decay and spontaneous fission half-lives for decay chains originating from Z=122 isotopes.

calculated from this model is compared with empirical formulas, and it is found that the model calculation is close to the values from different reliable empirical formula and matches well with UDL values. Further the modes of decay are given in the last column of the table.

The isotopes of Z=122 exhibit decay chains of varying lengths. The decay chains from isotopes $^{298\text{-}300,\ 302,\ 304\text{-}306,\ 308\text{-}310,\ 312,314}122$ is expected to show 7α, 5α, 4α, 3α, 2α and 1α decay, respectively. For decay chains originating from isotopes with A = 298 to 316, the length of chain is seen to decrease with increase in mass number. All the other isotopes from A = 316 to 350 may undergo spontaneous fission since the obtained SF half -lives are comparatively less. The

Table 2 – Alpha decay half-lives obtained from the model calculation is compared with empirical formulae. The spontaneous fission half-life, and possible decay modes associated with the isotopes are also given.

Parent Nuclei	Q-Value (MeV)	Alpha decay $log_{10}T_{1/2}$				SF $log_{10}T_{\frac{1}{2}}$	Decay Mode
		Model	UDL	Royer	VS		
$^{298}122$	14.7075	-7.9557	-8.2394	-7.6465	-8.0399	23.5852	α
$^{294}120$	13.2460	-5.8002	-5.9340	-5.4753	-5.8532	16.2047	α
$^{290}118$	12.6049	-5.0047	-5.1357	-4.7113	-5.0840	10.2483	α
$^{286}116$	11.3164	-2.5677	-2.6827	-2.4106	-2.7551	5.6268	α
$^{282}114$	11.3817	-3.1524	-3.4930	-3.1498	-3.4996	2.2529	α
$^{300}122$	14.2260	-7.3318	-7.3716	-6.8081	-7.2301	23.1121	α
$^{296}120$	13.3474	-4.9372	-6.1774	-5.6721	-6.0893	15.7046	α
$^{292}118$	12.2446	-4.6066	-4.3499	-3.9499	-4.3510	9.7209	α
$^{288}116$	11.2943	-2.9564	-2.6580	-2.3578	-2.7390	5.0722	α
$^{284}114$	10.5769	-1.6716	-1.4007	-1.1739	-1.5350	1.6708	α
$^{280}112$	10.8669	-2.8941	-2.8586	-2.5180	-2.8896	-0.5693	α
$^{276}110$	10.8887	-3.8287	-3.5775	-3.1772	-3.5482	-1.7328	α
$^{272}108$	9.5314	0.7737	-0.4493	-0.2651	-0.5767	-1.9031	SF
$^{278}112$	11.7833	-4.8373	-5.0943	-4.6265	-4.9903	0.0404	α
$^{274}110$	10.8721	-3.2913	-3.5025	-3.1374	-3.4701	-1.0954	α
$^{270}108$	9.0297	1.5517	1.1945	1.2319	0.9820	-1.2378	SF
$^{302}122$	14.2409	-7.0626	-7.4320	-6.8346	-7.2937	21.9250	α
$^{298}120$	13.0112	-5.6464	-5.4987	-5.0104	-5.4573	14.4905	α
$^{294}118$	12.2026	-4.5167	-4.2842	-3.8590	-4.2961	8.4797	α
$^{290}116$	11.0888	-2.4550	-2.1538	-1.8590	-2.2712	3.8037	α
$^{286}112$	9.9739	0.0552	0.3248	0.4605	0.0838	0.3750	α
$^{282}110$	10.1446	-1.1714	-0.8903	-0.6585	-1.0412	-1.8927	SF
$^{304}122$	13.7424	-6.4920	-6.4839	-5.9219	-6.4084	20.0243	α
$^{300}120$	13.3229	-6.1920	-6.1904	-5.6249	-6.1152	12.5628	α
$^{296}118$	11.7561	-3.5338	-3.2451	-2.8623	-3.3247	6.5249	α
$^{292}116$	11.1308	-2.1354	-2.2963	-1.9621	-2.4125	1.8216	α
$^{288}114$	9.6497	1.0657	1.3056	1.4021	1.0008	-1.6345	SF
$^{306}120$	12.8940	-5.5930	-5.3078	-4.7737	-5.2913	9.9216	α
$^{302}118$	12.1867	-4.5959	-4.3104	-3.8245	-4.3347	3.8567	α
$^{298}116$	10.6687	-1.4170	-1.0729	-0.7945	-1.2671	-0.8738	α
$^{294}114$	9.5244	1.4350	1.6795	1.7790	1.3459	-4.3573	SF
$^{308}122$	14.94453	-8.9093	-8.8257	-8.0444	-8.6249	14.0826	α
$^{304}120$	12.76728	-5.1563	-5.0604	-4.5140	-5.0652	6.5672	α
$^{300}118$	11.95991	-4.0984	-3.8044	-3.3243	-3.8650	0.4753	α
$^{296}116$	10.89668	-2.0150	-1.7334	-1.3799	-1.8963	-4.2823	SF
$^{310}122$	13.4606	-6.234	-6.000	-5.384	-5.974	10.042	α
$^{306}120$	13.7917	-7.402	-7.235	-6.509	-7.118	2.500	α
$^{302}118$	12.0449	-3.976	-4.039	-3.513	-4.092	-3.619	α
$^{298}116$	10.7744	-1.463	-1.430	-1.068	-1.617	-8.404	SF
$^{312}122$	12.1665	-3.4991	-3.1243	-2.6762	-3.2745	5.2889	α
$^{308}120$	12.9704	-5.6640	-5.5679	-4.9284	-5.5561	-2.2801	α
$^{304}118$	13.1264	-6.6791	-6.4810	-5.7571	-6.3984	-8.4260	SF
$^{314}122$	12.1208	-3.4124	-3.0441	-2.5728	-3.2058	-0.1769	α
$^{310}120$	11.5029	-2.4905	-2.1231	-1.6927	-2.3211	-7.7727	SF
$^{316}122$	11.6628	-2.2120	-1.9255	-1.5025	-2.1602	-6.3550	SF

Q-values and half-lives associated are unique for each chain.

In decay chain, the nuclei produced in subsequent steps have different Z and A values. Some of the nuclei produced are close to neutron magic numbers. The variation of alpha decay curve in decay chain, exhibits next minimum in the half-life curves at N=186, 178 & 164. This could be seen as rapid decay of nuclei at this step to attain closed-shell configuration, which suggest the subshell or shell closure at N=184, 176 & 162. Among this N=184 is a magic number which is a common predication from different formalism[4-10]. Also the two closely lying magic numbers 176 and 184, agrees well with the predictions of two-center shell model approach[31]. It is to be noted that, theoretical decay chains are indicating that magicity imprint would be present in the decay chain, and the magicity in superheavy region could be established if similar signatures could be seen in experimentally detected decay chains.

4 Conclusions

In the present work, we have carried out a detailed study on decay chain originating from Z=122 superheavy nuclei using Cubic plus Proximity potentials and improved transfer matrix method to calculate the tunneling probability. To get accurate predictions on half-life, Q-value from WS-4 mass model is used, which has least error in binding energy of superheavy nuclei than other mass models. The model calculated half-life is in good agreement with empirical formula values. The decay chains from isotopes $^{298\text{-}300,\ 302,\ 304\text{-}306,\ 308\text{-}310,\ 312,314}122$ is likely to contain 7α, 5α, 4α, 3α, 2α and 1α decays. The trends in decay chain are providing signatures of subshell and shell closure in superheavy region. The predictions in the present study may have an impact in the experimental synthesis and detection of the new isotopes in near future.

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