Estimated α-decay half-lives of even-even Z=120 SHEs in the range of neutron number 172 ≤ N ≤ 186

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Introduction

The super heavy elements formed by either way of cold fusion or hot fusion process, are primarily decay through alpha-particle emission and after successive emission of alpha-particles it undergoes to spontaneous fission. Alpha particle emission from super heavy elements is an important and unique part of all the decay process. Different theoretical approaches are using alpha-decay characteristics as a tool to investigate the nuclear structure information of the unstable nuclei such as the ground state energy, the ground state and isomeric state half-life, the nuclear spin and parity, the nuclear deformation, the clustering, the shell effects and the interaction between nuclei.

The question about the next doubly magic nucleus beyond the ^{208}Pb (Z = 82, N = 126) has attracted much attention in the nuclear structure physics for both theoreticians and experimentalists. Theoretical models predict that the next magicity for the proton number should occur at Z = 114, 120, and/or at 126 and for the neutron number it should be either at N = 172 and/or 184 [1].

In the present paper, Isospin Cluster Model [1] is used, which is an extended version of the Preformed Cluster Model, where the excess of neutron and proton numbers are taken in account effectively of a nucleus in decay calculations. The appropriate value of nuclear surface tension coefficient in proximity potential [2] which plays an important role to estimate the nuclear attraction between two nuclear surfaces is also reviewed [1].

Isospin Cluster Model

The Isospin Cluster Model is an extension of the Preformed Cluster Model (PCM) [3] uses the dynamical collective coordinates of mass and charge asymmetries and on the basis of Quantum Mechanical Fragmentation Theory. The decay constant in PCM is defined as

$$\lambda = \frac{\ln 2}{T_{1/2}} = P_0 \nu_0 P \qquad (1)$$

Here P_0 is the cluster preformation probability and P is the barrier penetrability which refer, respectively, to the η- and R-motions, ν_0 is the barrier assault frequency. P_0 are the solutions of the stationary Schrodinger equation in,

$$\left\{-\frac{\hbar^2}{2\sqrt{B_{\eta\eta}}}\frac{\partial}{\partial\eta}\frac{1}{\sqrt{B_{\eta\eta}}}\frac{\partial}{\partial\eta}+V_R(\eta)\right\}\psi^{(\nu)}(\eta)=E^{(\nu)}\psi^{(\nu)}(\eta) \qquad (2)$$

Which on proper normalization are given as

$$P_0 = \sqrt{B_{\eta\eta}}\left|\psi^{(0)}(\eta(A_i))\right|^2 \left(2/A\right) \qquad (3)$$

The WKB tunneling probability calculated is P= P_iP_b with

$$P_i = \exp\left[-\frac{2}{\hbar}\int_{R_a}^{R_i}\{2\mu[V(R)-V(R_i)]\}^{1/2}dR\right] \qquad (4)$$

$$P_b = \exp\left[-\frac{2}{\hbar}\int_{R_i}^{R_b}\{2\mu[V(R)-Q]\}^{1/2}dR\right] \qquad (5)$$

The nuclear charge radius is given by the Eqn. given below;

$$R_{00i} = \sqrt{\frac{5}{3}}\left\langle r^2\right\rangle^{1/2}$$

$$=1.240A_i^{\frac{1}{3}}\left\{1+\frac{1.646}{A_i}-0.191\times\left(\frac{A_i-2Z_i}{A_i}\right)\right\} fm$$

$$(i=1,2)$$

The fragmentation potential ($V_R(\eta)$ in eq (2) is calculated simply as the sum of Coulomb interaction, the nuclear proximity potential V_p and the ground state binding energies of two nuclei:

$$V(R_a,\eta) = -\sum_{i=1}^{2} B(A_i,Z_i) + \frac{Z_1Z_2e^2}{R_a} + V_P \qquad (6)$$

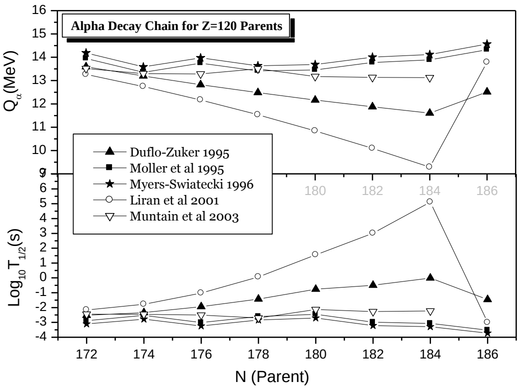

Fig.1 The different Q values and $Log_{10}T_{1/2}$ for alpha particle transitions are plotted as a function of the parent neutron number (N).

The proximity potential [2] between two nuclei is defined as

$$V_p = 4\pi\bar{C}\gamma b\phi(\xi) \qquad (7)$$

Where γ is the specific nuclear surface tension and defined as

$$\gamma = \gamma_0\left[1 - k_s\left(\frac{N-Z}{A}\right)^2\right] MeV\ fm^{-2} \qquad (8)$$

The values of γ_0 *and* k_s are used from ref [4-7].

Calculation and Results

We have calculated the α-decay half-lives of even-even Super Heavy Elements $^{292\text{-}306}120$ within the range of Neutron numbers 172 ≤ N ≤ 186. In this calculation the Q-values are taken from various theoretical models [8-12].

From the figure 1, it has been observed that the maximum half-life is for the $^{304}120$ parent nucleus against the alpha decay process. This parent nucleus indicates more stability as compared to the other nuclei. This stability can be attributed to either the magicity of protons at Z = 120 or of neutrons at N = 184 or to both (Z=120, N=184). The study of half-lives of different decay modes tells about the shell effects [13]. A higher value of half-life indicates the presence of shell stabilized parent nucleus, whereas a comparatively low value of half-life tells the same about the daughter and alpha particles.

In conclusion, to illustrate the role of the Q value, the decay half-lives are calculated within the ICM using different Q values taken from [8-12] and compared with the results of ICM calculations. The results shows extra stability at (Z=120, N=184) super heavy element.

References

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