Revamped Half-lives of Super heavy Elements (SHE) in Trans-Actinide Region

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Introduction

Analyzation of alpha decay properties and identification of "Island of Stability" has illuminated the theories of nuclear physics. This fundamental scientific research is the current on-going work in the field of super heavy elements. In order to study the decay properties of super heavy elements a realistic model [1] called as Cubic plus Yukawa plus Exponential [2] (CYE) model is used here. This model uses a cubic potential in the pre-scission region connected by coulomb plus Yukawa plus Exponential potential in the post scission region.

Formalism

The potential encountered by the alpha particle is purely coulomb. This potential as a function of r which is the mass distance of the fragments for the post-scission region is given by

$$V(r) = \frac{Z_d Z_e e^2}{r} + V_n(r) - Q, \quad r \geq r_t$$

With the impact of higher multi-pole deformation parameter, hexa contra tetra pole (β_6) [3] given by

$$\beta_{lm} = \frac{\sqrt{4\pi} \int R(\theta,\emptyset)\, y_l^m(\theta,\emptyset)\, d\Omega}{\int R(\theta,\emptyset)\, y_0^0(\theta,\emptyset)\, d\Omega}$$

and with the inclusion of angular momentum[4] and rotational energy, the enhanced half life of Trans-actinides with Z=107 to 120 are calculated here using CYE model. Now the altered interacting potential barrier for the parent nucleus exhibiting alpha decay is given by

$$V(T) = V_{post}(r) + \frac{\hbar^2\, l(l+1)}{2\mu r^2} + E_{rot}$$

The second term is the additional centrifugal contribution to the barrier, which will reduce the tunneling probability and the third term rotational energy is determined within the right-body moment of inertia ansatz[5].

The half life time of the system is calculated using the equation

$$\frac{1.423\, x\, 10^{-21}\ (1 + \exp\ K)}{E_v}$$

Results and Discussions

Half life of Trans-actinide elements without deformation [6] is further enhanced with the inclusion of β_6 , spin and rotational energy using CYE model. The calculated values are compared with the experimental values [7-16].

Table 1.

Nucleus	LOG T	
	CYEModel (β_6, spin & E_{rot})	Exp. Values
^{272} 107	26.6s	11.8s
^{274} 109	195ms	440^{+810}_{-170} ms
^{278} 111	3.4 ms	$4.2^{+7.5}_{-1.7}$ ms
^{283} 112	12.38s	$3.8^{+1.2}_{-0.7}$ s
^{282} 113	18.4ms	73^{+134}_{-29} ms
^{289} 114	10.33s	$2.7^{+1.4}_{-0.7}$ s
^{287} 115	180 ms	32^{+155}_{-14} ms
^{293} 116	3.5 ms	$53^{+62}_{-1.9}$ ms
^{293} 117	.002m s	27^{+12}_{-6} ms
^{294} 118	2.6ms	$0.89^{+1.07}_{-0.31}$ ms
^{298} 120	46 ms	0.030ms

The comparison reveals that our results agrees well with the experimental data. Table-1, gives the comparison between half-lives predicted by CYE model with the experimental data. Thus the Alpha decay half life for few Trans-actinides are calculated by the application of CYE model with the revamped transitional potential obtained by incorporating higher multi-pole deformation parameter (β_6), spin and rotational energy which enhances the stability of the nucleus. This pronounced enlargement of half life time of these nuclei, paves the way for researchers to reach the spherical super heavy element.

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