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Significance of Spin in Super Heavy Elements

J. Umai Parvathiy[1]
[1]Associate Professor PG Department of Physics, Sri Sarada College for Women,Tirunelveli-11, Affiliated to Manonmaniam Sundaranar University, Tirunelveli-12, India.

Abstract: The analysis for the existence of an island of long lived super heavy nuclei is the current on-going research work in the field of nuclear physics. Nuclear structure and properties are studied by means of nuclear decay. Naturally, alpha decay serves as an ideal tool, for the identification of new super heavy elements via observation of alpha decay chains. The precise measurement of alpha decay properties of super heavy nuclei leads to the identification of "Island of Stability" and provides information about their structure, shell effects and stability, nuclear spin, parity, nuclear deformation, etc. In the present work ground state (g.s.) decay properties of super heavy elements in Trans-actinide region are evaluated with and without applying deformation effects using Cubic plus Yukawa plus Exponential (CYE) model which is successful in predicting the decay properties of trans-actinide elements by two sphere approximation. The model is enhanced by incorporating spin and also its impact in half life time values are studied. The results obtained are compared theoretical and also with the available experimental values.
Keywords: Alpha decay, Half-lives, Spin, Trans-Actinides.

I. INTRODUCTION

The existence of an island of super heavy nuclei is predicted by a number of theoretical methods. S.B Durate et al. [1] applied effective liquid drop model to predict alpha decay. Stability of super heavy elements depends on various factors such as nuclear shapes, deformations, energy, angular momentum etc. Stability is analysed by the accurate measurement of half life time of alpha decay which serves as an ideal tool [2]. In the present work half life time measurement is done based on Cubic plus Yukawa plus Exponential (CYE) model by two sphere approximation [3,4] which has the basis from unified fission model. This model uses a Cubic potential in the pre-scission region connected by Coulomb plus Yukawa plus exponential potential in the post-scission region with zero point vibration energy.

This model is enhanced further with the implementation of angular momentum value. The calculation of alpha decay half -lives without deformation for the trans-actinide elements [5] is now extended by the addition spin.

II. THEORETICAL FORMALISMS

In order to study the properties of Trans-actinide elements a realistic model called as the Cubic plus Yukawa plus Exponential (CYE) model was used. It has a cubic potential for the overlapping region which is smoothly connected Yukawa plus exponential potential for the region after separation. Then the potential as a function of r for the post-scission region is given by

$$V(r) = \frac{Z_1 Z_2 e^2}{r} + V_n(r) - Q\,, \qquad r \geq r_t \qquad (1)$$

Half-life time of the system is calculated using the formula

$$T = \frac{1.423 \times 10^{-21}(1+\exp K)}{E_v}$$

Here E_v is the Zero point vibration energy.

Inclusion of spin in the coulomb potential [6] is given by

$$V(r) = \frac{Z_1 Z_2 e^2}{r} + V_{CF}\ ;$$

$$\text{where,}\quad V_{cf}(r) = \frac{l(l+1)\hbar^2}{2\mu r^2}$$

$$V(r) = \frac{Z_1 Z_2 e^2}{r} + \frac{l(l+1)\hbar^2}{2\mu r^2}$$

III. ALPHA DECAY HALF LIVES OF SUPER HEAVY ELEMENTS

In our earlier work [7, 8, 9] we have calculated the half life time values of few super heavy elements using CYE model. In this work the half life time values of SHE in the range Z=104 to 121 (Trans – Actinide elements) are calculated using two sphere

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approximation and also including the deformation effects both in parent and daughter nucleus. The Q values for this calculation are taken from the references [10] & [11] and the values for deformation parameters are taken from the reference [12]. In Table 1& 2, we have calculated and presented the half-life time values without and with deformation effects. The results are compared with the available theoretical and experimental values. The inclusion of deformation effects decreases the half-life time values. In most of the cases the calculated half-life time values approaches the experimental values due to the inclusion of deformation effects. Figures 1 & 2 predicts about the contour plot of half-life time values of Trans-Actinide elements with atomic number Z = 104 to 121 using CYE model without and with deformation effects.

IV. SPIN INCORPORATION IN HALF LIFE TIME CALCULATION

Long-lives of alpha decaying super heavy elements can be analysed by the tunnelling of alpha particle through the potential barrier. Since during alpha decay an angular momentum change is involved. Inclusion of angular momentum (l) to the centrifugal barrier plays a prominent role here. Now the transitions may be impeded due to the transfer of angular momentum which in turn makes the decay as angular momentum hindered. This angular momentum hindered transition (i.e) with the addition of centrifugal potential is the new transition potential. This new transition potential due to the addition of centrifugal potential energy increases the thickness of the centrifugal barrier [13] which in turn increases the half life time of the super heavy element. Now with the new transition potential impeded due to transferring of angular momentum is incorporated and the half life time is calculated using CYE model for super heavy elements in the range Z=104 to 121 (Trans – Actinide elements). The results obtained are compared with the theoretical and available experimental data. Figure 3, shows the contour plot of half-life time values incorporating spin. Here the number of contours as well as the area of inner closed contour is very much reduced when compared to the contour plot incorporating deformation. This predicts that there is an increase in the half life time value of the nucleus due to the inclusion of spin.

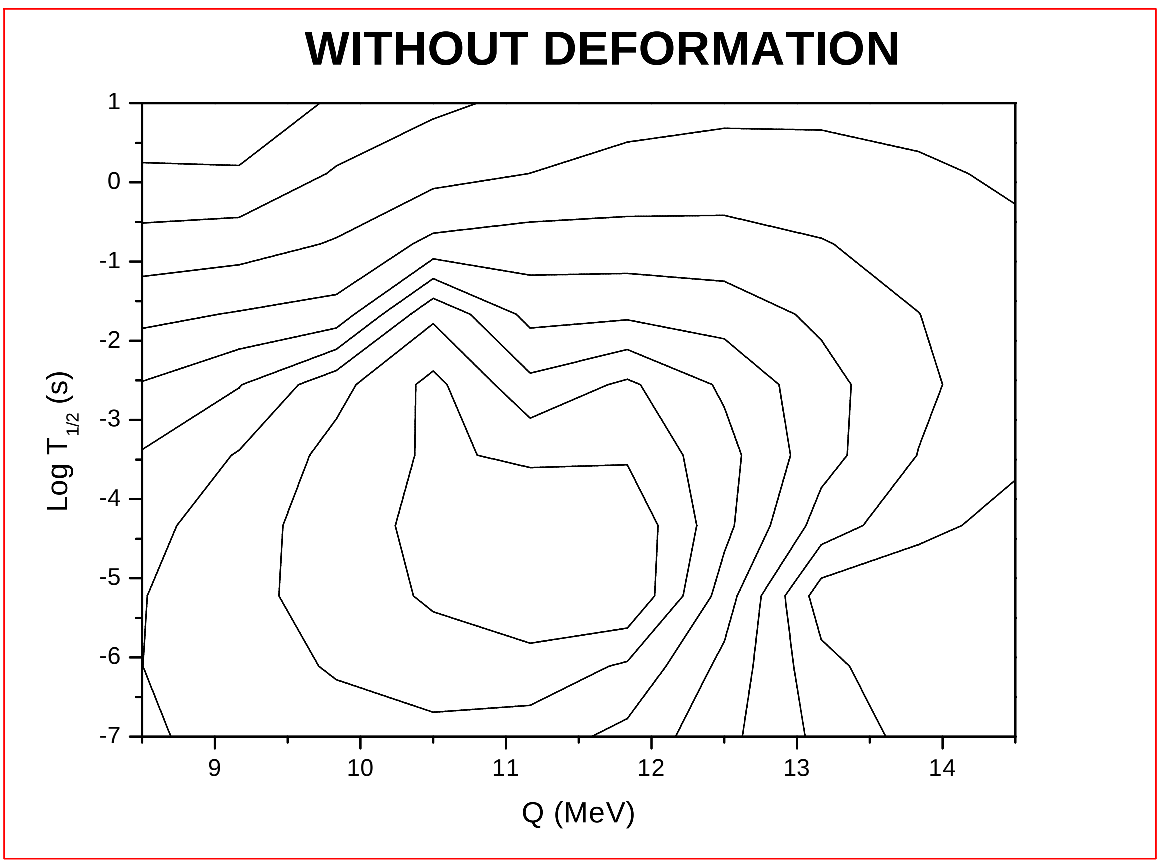


Figure 1 shows the contour plot of half-life time values of Trans-Actinide elements without deformation.

Table1. Comparison between calculated Half-life time values without deformation with theoretical and experimental results using CYE model.

Nucleus	Q(MeV)	Log $T_{1/2}$ (s)		
		This work CYE model without deformation	VSS[14]	Exp [15-23]
$^{255}Rf_{104}$	8.953	0.76	1.038	0.204
$^{256}Db_{105}$	9.197	0.37	0.699	0.230
$^{259}Sg_{106}$	9.815	-1.13	-0.773	-0.319
$^{262}Bh_{107}$	10.576	-2.87	-3.498	-2.097
$^{266}Ha_{108}$	10.381	-2.07	-3.868	-2.638
$^{270}Mt_{109}$	10.227	-1.36	-2.089	-2.301
$^{267}Da_{110}$	11.823	-4.89	-4.405	-5.523
$^{272}Ro_{111}$	11.029	-2.77	-2.265	-2.824
$^{277}Co_{112}$	11.666	-4.04	-3.495	-3.1155
$^{285}Ni_{113}$	9.927	-1.28	0.906	0.738
$^{286}Fl_{114}$	10.373	-0.20	-0.790	-0.886
$^{289}Ms_{115}$	10.504	-0.26	-0.058	-0.658
$^{290}Li_{116}$	11.042	-1.36	-1.921	-2.167
$^{293}Ts_{117}$	11.233	-1.56	-1.331	-1.824
$^{294}Og_{118}$	11.862	-2.78	-3.313	-3.046
$^{292}X_{119}$	13.17	-5.30	-4.71[23]	-
$^{287}X_{120}$	13.98	-6.49	-6.07[23]	-
$^{299}X_{121}$	14.14	-6.70	-6.39[23]	-

Table 2. Comparison between calculated Half-life time values with deformation using CYE model with theoretical and experimental results.

Nucleus	Q(MeV)	Log $T_{1/2}$ (s)		
		This work CYE model with deformation	VSS[14]	Exp [15-23]
$^{255}Rf_{104}$	8.953	0.33	1.038	0.204
$^{256}Db_{105}$	9.197	-0.03	0.699	0.230
$^{259}Sg_{106}$	9.815	-1.41	-0.773	-0.319
$^{262}Bh_{107}$	10.576	-3.04	-3.498	-2.097
$^{266}Ha_{108}$	10.381	-2.13	-3.868	-2.638
$^{270}Mt_{109}$	10.227	-1.32	-2.089	-2.301
$^{267}Da_{110}$	11.823	-4.87	-4.405	-5.523
$^{272}Ro_{111}$	11.029	-2.73	-2.265	-2.824
$^{277}Co_{112}$	11.666	-3.85	-3.495	-3.1155
$^{285}Ni_{113}$	9.927	-0.69	0.906	0.738
$^{286}Fl_{114}$	10.373	-0.01	-0.790	-0.886
$^{289}Ms_{115}$	10.504	-0.31	-0.058	-0.658
$^{290}Li_{116}$	11.042	-1.40	-1.921	-2.167
$^{293}Ts_{117}$	11.233	-1.35	-1.331	-1.824
$^{294}Og_{118}$	11.862	-2.48	-3.313	-3.046
$^{292}X_{119}$	13.17	-5.30	-4.71[23]	-
$^{287}X_{120}$	13.98	-6.29	-6.07[23]	-
$^{299}X_{121}$	14.14	-6.54	-6.39[23]	-

Table 3 Comparison between calculated Half-life time values using spin by CYE model with theoretical and experimental results.

Nucleus	Q(MeV)	Log $T_{1/2}$ (s)			
		This work CYE model with spin	$l\hbar$	VSS[14]	Exp[15-23]
$^{255}Rf_{104}$	8.953	0.91	1	1.038	0.204
$^{256}Db_{105}$	9.197	0.53	3	0.699	0.230
$^{259}Sg_{106}$	9.815	-0.92	1	-0.773	-0.319
$^{262}Bh_{107}$	10.576	-2.66	0	-3.498	-2.097
$^{266}Ha_{108}$	10.381	-1.86	0	-3.868	-2.638
$^{270}Mt_{109}$	10.227	-1.13	4	-2.089	-2.301
$^{267}Da_{110}$	11.823	-4.91	2	-4.405	-5.523
$^{272}Ro_{111}$	11.029	-2.56	0	-2.265	-2.824
$^{277}Co_{112}$	11.666	-3.79	5	-3.495	-3.1155
$^{285}Ni_{113}$	9.927	0.73	3	0.906	0.738
$^{286}Fl_{114}$	10.373	-0.19	0	-0.790	-0.886
$^{289}Ms_{115}$	10.504	-0.29	3	-0.058	-0.658
$^{290}Li_{116}$	11.042	-1.03	0	-1.921	-2.167
$^{293}Ts_{117}$	11.233	-1.56	1	-1.331	-1.824
$^{294}Og_{118}$	11.862	-2.77	0	-3.313	-3.046
$^{292}X_{119}$	13.17	-5.31	0	-4.71[23]	-
$^{287}X_{120}$	13.98	-6.47	3	-6.07[23]	-
$^{299}X_{121}$	14.14	-6.27	5	-6.39[23]	-

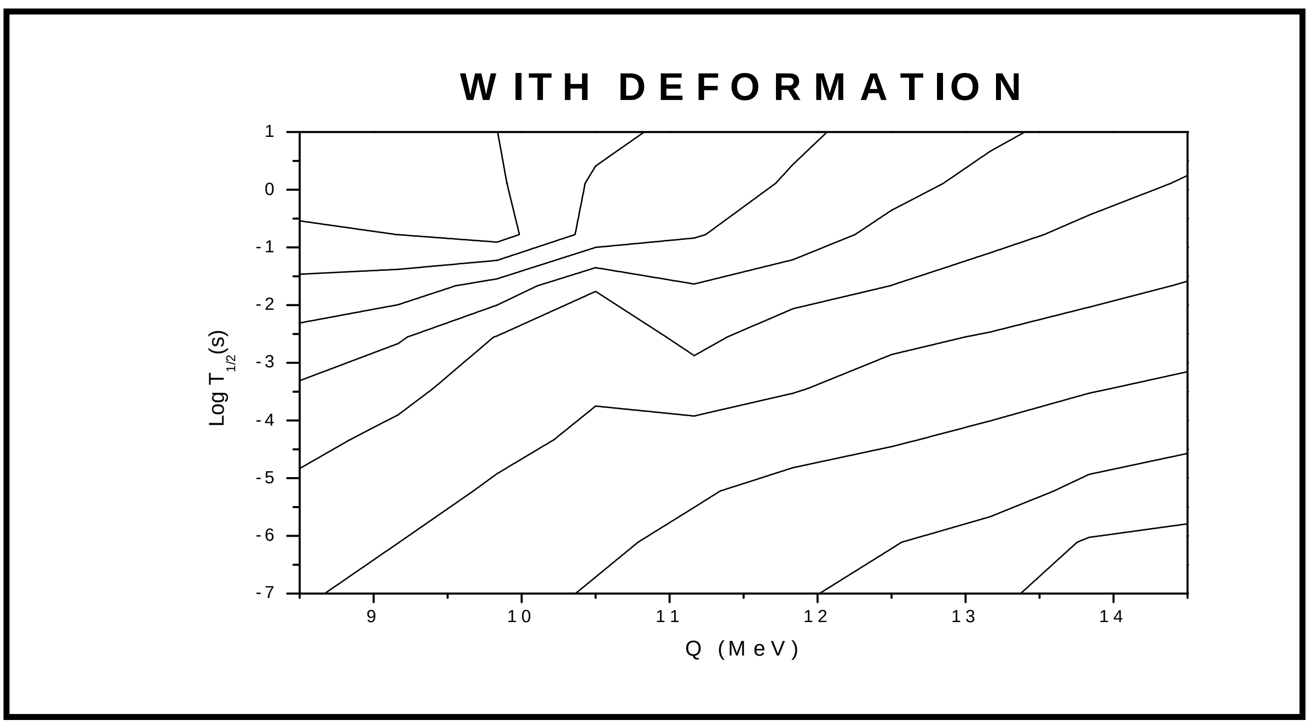


Figure 2 shows contour plot of half- life time for Trans-Actinide elements with deformation.

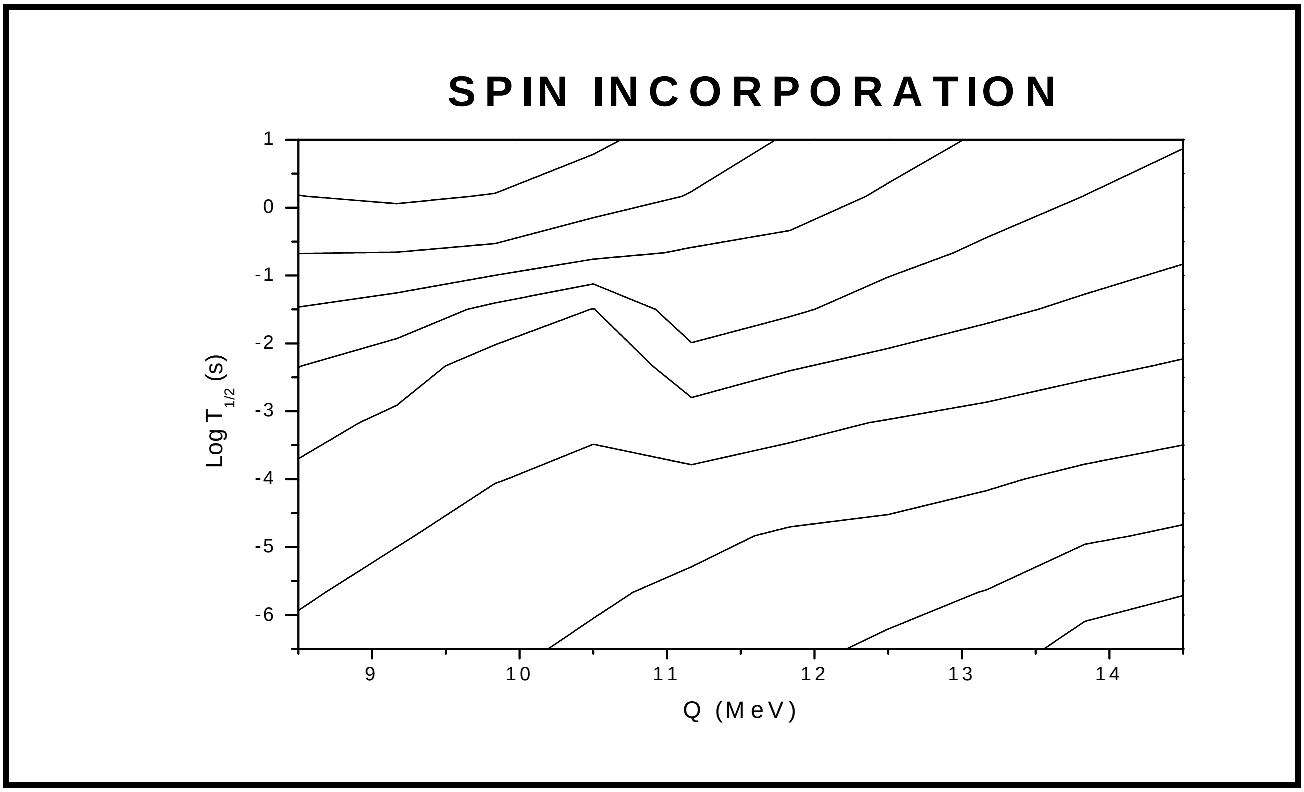


Figure 3 shows contour plot of half- life time for Trans-Actinide elements with spin incorporation.

V. RESULTS AND DISCUSSION

In this work the alpha decay half-life for Trans-Actinide elements are calculated using Cubic plus Yukawa plus Exponential model and contour plot for the half life time values of Trans-Actinide elements are shown in Figures 1 ,2& 3. The sequential theoretical calculation of alpha decay half life time excellently agrees with the experimental results and also with the theoretical values. In the contour plot of half-life time values incorporating spin the number of contours as well as the area of inner closed contour is very much reduced when compared to the contour plot incorporating deformation. Further the consistency of the calculation is well reached and this brings out an increased stability of the nucleus in the Trans-Actinide region.

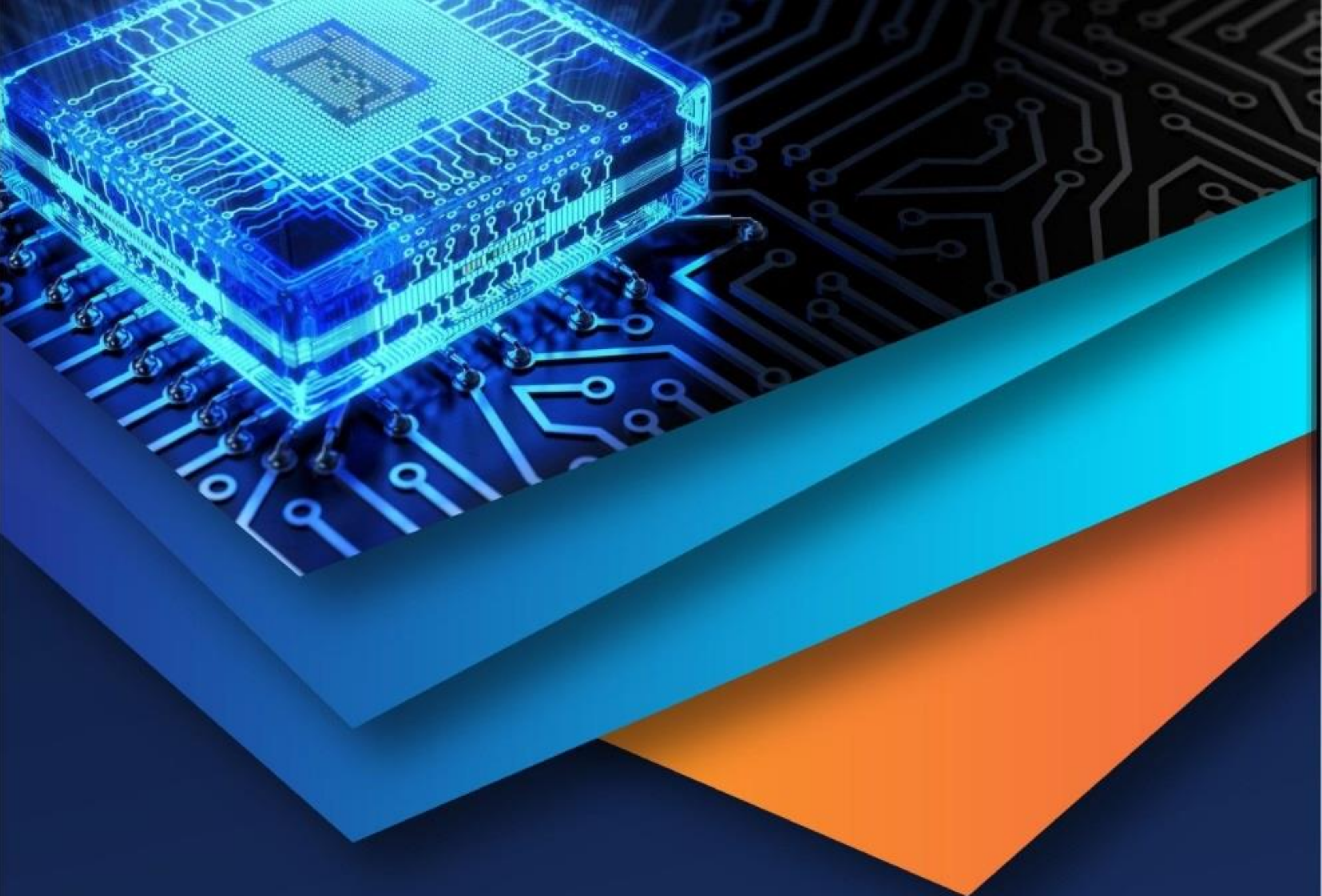
VI. CONCLUSION

The calculated half life time values of super heavy elements with the interplay of spin by the modification done in the thickness of the barrier reveals that this effect causes longevity and stability of super heavy elements. That is, this pronounced enlargement of half life time values increases the possibility for these nuclei to reach the spherical super heavy elements.

REFERENCES

[1] Durate S.B, Tavares O.A.P., Goncalves M, Rodriguez O, Guzman F, Barbosa T.N., Garcia F and Dimarco A, Nuclear and Particle physics 30 1487-1494 (2004)
[2] Naoki Tajima, N Suzuki, Phys. Rev C64, 037301 (2001)
[3] Shanmugam G and Kamalakaran B, Physical ReviewC38, 1377 (1988).
[4] ShanmugamG,CarmelvigilaBai G.M and Kamalaharan B, Physics Review C51, 2616, (1995)
[5] Carmel VigilaBai G.M, UmaiParvathiyJ, Pramana, Vol.84, No.1, 113(2015)
[6] Tayal D.C, Nuclear Physics, Himalaya Publishing House, (2012).
[7] J.Umai Parvathiy and G.M.Carmel Vigila Bai, “Decay Chain of Z = 120 Nuclei and its Stability”,Proceedings of National Conference - KAAS, ISBN No. 978 – 93 – 81658-10-9 (2014).
[8] J.Umai Parvathiy and G.M.Carmel Vigila Bai, “Decay properties of odd-Z Trans Actinide elements”, Proceedings of National Seminar, (ETTEP-15), ISBN No 978-81 92-9308-2-4, (2015).
[9] Deformation Consequences in Super heavy elements”, J. Umai Parvathiy, International Journal of Scientific Research in Physics and Applied Sciences, Volume 5, Issue-4, (2017) with ISSN: 2348-342
[10] V.Benaline Sheeba,’Half – Life predictions for Decay modes of Super heavy elements’,M.Phil. Thesis, , Manonmaniam Sundaranar University, Tirunelveli-12, (2006)

[11] S.B.Durate, O.A.P, Tavares, M.Goncalves, O.Rodriguez, F.Guzman, T.N.Barbosa, F. Garcia and A.Dimario, Nuclear and particle Physics 30, 1487 – 1494 (2004).
[12] P.Moller, J.R.Nix, W.D.Myers, and W.J.Swiatecki, Atomic Data and Nuclear Data Tables 59, 185 (1995
[13] Shanmugam G, Sudhakar S and Niranjani S, Proceedings of the DAE Symposium on Nuclear Physics 57 (2012).
[14] V.E.Viola and G.T.Seaborg, J.Inorganic Nucl.Chem.28, 741 (1966)
[15] Budaca A.L., SiliSteanu I, Romanian Reports in Physics vol .63, Supplement, P.1147 - 1166, (2011).
[16] OganessianYu.Ts., Utyonkov V.K., Dimitriev S.N. et al., Phys. Rev. C72, 034611 (2005)
[17] OganessianYu.Ts., Pure Appl. Chem. 78,889 (2006)
[18] OganessianYu.Ts., AbdulinF.Sh. and Bailey P.D. et al., Phys. Rev. Lett. 104, 0142502 (2010)
[19] Yu.Ts.Oganessian et al., Phys.Rev. C87, 014302 (2013).
[20] Hofmann S. et al., Eur.Phys.J.A14, 147 (2002)
[21] Hofmann S and Munzenberg G, Rev. Mod. Phy.72,733 (2000)
[22] Hofmann S et al., Zeit, Phys. A 354,229 (1996)
[23] Morita K, Marimoto K, Kaji D, et al., Jap. Phys. Soc.J.73,2593(2004).



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