Study of heavy particle radioactivity of ^{294}118

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Introduction

In heavy-particle radioactivity, emitted particles may have atomic number Ze>28 and $Z_e^{\max} = Z - 82$. Poenaru and Gherghescu [1] observed shorter half-lives and a larger branching ratios for heavy particle emission from superheavy elements. Nagaraja et al.,[2] also identified heavy particle radioactivity from superheavy element Z=126 under modified generalised liquid drop model formalism. The logarithmic half-lives of HPR are calculated using eight different proximity functions, these are compared to experimental results. The Coulomb and proximity potential models have been used [3] to investigate the feasibility of alpha decay and heavy particle decay from even-even superheavy nuclei with Z = 116-124. A comparison of their predicted half lives with that of empirical formulas shows good agreement.

The Coulomb and proximity potential models were also used [4] to study cluster radioactivity of even–even superheavy nuclei with Z =122–132. Sowmya et al., [5] investigated the various decay modes of superheavy nuclei ^{281}Ds. The cluster and alpha decay half-lives of the superheavy nuclei Z = 120 were studied by Nagaraja et al.,[6]. In the super-heavy nuclei region $^{299-306}$122, Cluster decay of He, Li, Be, Ne, N, Mg, Si, P, S, Cl, Ar, and Ca isotopes was studied by Manjunatha et al., [7]. The logarithmic half-lives of cluster decay were also compared to those of other models like Univ NRDX and Horoi. The systematics of 12C emission in superheavy nuclei with Z = 104–130 are also studied by previous researcher [8]. There is a scope to study the heavy particle radioactivity in the nuclei with atomic number Z=118. Hence, the aim of the present work is to study heavy particle radioactivity in superheavy nuclei ^{294}118.

Theoretical Frame work

The half-lives of heavy particle radioactivity in the superheavy nuclei ^{294}118 is studied using the following equation;

$$T_{1/2} = \hbar \ln(2)/\Gamma \qquad (1)$$

here Γ is the decay width and it is evaluated as follows;

$$\Gamma = \frac{1}{4\pi}\int \gamma(\theta,\phi)\, d\Omega \qquad (2)$$

where $\gamma(\theta,\phi)$ is the partial width of heavy particle emission. The total width in terms of θ as follows;

$$\Gamma = \int_0^{\pi/2} \gamma(\theta)\sin(\theta)\, d\theta \qquad (3)$$

here $\gamma(\theta) = \hbar\xi\, t(Q,\theta,\ell)$[is the width of the heavy particle emitted in the direction of θ. The penetration probability is as follows;

$$t(Q,\theta,\ell) = \left\{1 + \exp\left[\frac{2}{\hbar}\int_{r_2(\theta)}^{r_3(\theta)} dr \sqrt{2\mu\left(V(r,\theta,\ell,Q) - Q\right)}\right]\right\}^{-1} \qquad (4)$$

here $r_2(\theta)$ and $r_3(\theta)$ are the turning points and the total potential $V(r,\theta,\ell,Q)$ is evaluated as explained in detail in literature [9] using Ng0 proximity potential.

Results and Discussions:

The heavy particle radioactivity of a superheavy heavy nuclei ^{294}118 is determined by taking sum of repulsive coulomb potential, attractive nuclear potential and centrifugal potential. The amount of energy released during heavy particle radioactivity is evaluated using recent mass excess values. The possibility of heavy particle emissions were considered using the condition that $Z_e^{\min} = 28$ and $Z_e^{\max} = Z - 82$ i.e the heavy particle emission from the superheavy element Z=118 is up to Z=36. The figure 1 shows the variation of amount of energy released during heavy particle radioactivity with mass number of heavy particle emitted. From this figure it is observed that as the mass number of heavy particle increases the Q-values also increases. Which shows that the Q-values directly depend on the heavy particle emitted.

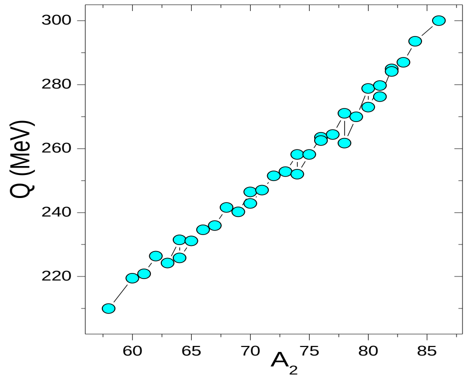

Fig 1: Variation of Q-values during heavy particle radioactivity with mass number of heavy particle emitted from the parent nuclei ^{294}118.

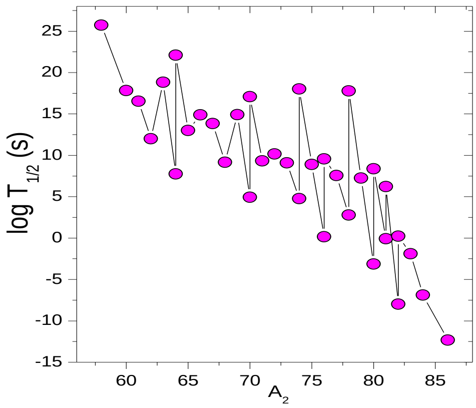

Fig 2: A plot of log$T_{1/2}$ of heavy particle radioactivity from the parent nuclei ^{294}118 with that of mass number of heavy particle emission.

The half-lives evaluated during cluster and heavy particle radioactivity are plotted as a function of mass number of cluster and heavy particle radioactivity and it is presented in figure 2. From this figure it is observed that the heavy particle emission of ^{86}Kr shows shorter half-lives when compared to their neighboring ones. This may be due to the shell closure effects of both daughter and heavy particle emission i.e ^{208}Pb+^{86}Kr nuclei. Among which the daughter nuclei is doubly magic nuclei.

Conclusions:

The heavy particle radioactivity of superheavy element ^{294}118 is studied using Coulomb and proximity potential model. The logarithmic half-lives of heavy particle radioactivity from ^{294}118 is shorter for ^{86}Kr emission. The corresponding daughter nuclei is ^{208}Pb. Shorter half-lives due to doubly magic nuclei ^{208}Pb (Z=82, N=126). This study finds an important role in the identification of decay mode of superheavy element Z=118.

References

[1] D. N. Poenaru, R. A. Gherghescu. Phys. Rev. Lett.. 107.062503 (2021).
[2] A.M.Nagaraja, H.C.Manjunatha, N.Sowmya, L.Seenappa, P.S.Damodara Gupta, N.Manjunatha S. Alfred CecilRaj. Nucl. Phy. A. 1015, 122306 (2021).
[3]K.P.Santhosh B.Priyanka. Nucl. Phy. A. 929 , 20-37 (2014).
[4] K.P. Santhosh, InduSukumaran. Can.J. Phys. 95, 1 (2017).
[5] N.Sowmya, H.C.Manjunatha, N.Dhananjaya and A. M. Nagaraja. J.Radioanal. Nucl. Che. 323, 1347 (2020).
[6] A. M. Nagaraja, H. C. Manjunatha, N. Sowmya, N. Manjunath and S. Alfred Cecil Raj. E. Phys. J. Plus. 135,814 (2020)
[7] H.C. Manjunatha , S. Alfred Cecil Raj, A.M. Nagaraja, and N. Sowmya. J. Nucl. Phys. Mat. Sci. Rad. A. 8, 1 (2020).
[8] H. C. Manjunatha, N. Sowmya and A. M. Nagaraja. M. Phys. Lett.. 35, 06,2050016(2020).
[9] G.R.Sridhar, H.C.Manjunatha, N.Sowmya, P.S. Damodara Gupta, H.B. Ramalingam, Eur. Phys. J. Plus 135:291 (2020).