Cluster Radioactivity of Z=125 super heavy nuclei

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Introduction

The decay of clusters of nucleons from very heavy nuclei was suggested by Sandulescu *et al.* [1] in 1980. The spontaneous emission of nuclei heavier than alpha particle from radioactive nuclei without accompanied by the emission of neutrons is called cluster radioactivity (CR) or exotic radioactivity. In 1984,for the first time, Rose and Jones [2] experimentally observed ^{14}C emission from ^{223}Ra.using solid state counter telescope. This new type of radioactivity is analogous to α decay where the decaying particle tunnels through the potential barrier. A lot of work has been done by various authors to calculate the half-life of these exotic decay processes.

A survey of literature reveals the fact that halflife values for different modes of cluster decay have been calculated using different theoretical models such as the Analytical super asymmetric fission model(ASAFM), Preformed cluster model (PCM), Coulomb and Proximity potential model (CPPM) etc., [3-7]. Recently, some semiempirical formulae, i.e, single line of Universal curve (UNIV) for alpha and cluster radioactive decay [8] and Universal Decay law (UDL) [9] have also been proposed to explain cluster decay data. Superheavy nuclei produced up to now decay mainly by α emission and spontaneous fission. For atomic numbers larger than 121 cluster decay and spontaneous fission may compete with α decay. Hence there is a need to make reliable calculations for the cluster decay half-lives of superheavy nuclei to predict the possible isotopes super heavy nuclei. So, in the present work, we have studied the decay of clusters such as ^{8}Be, ^{10}Be, ^{12}C, ^{14}C, ^{16}C, ^{18}O, ^{20}O, ^{22}Ne, ^{24}Ne, ^{25}Ne, ^{26}Ne, ^{28}Mg, ^{30}Mg, ^{32}Si, ^{34}Si, ^{36}Si, ^{40}S, ^{48}Ca, ^{50}Ca and ^{52}Ti from the super heavy nuclei Z=125.

Present work

Starting from the R-matrix theory and the microscopic mechanism of the charged-particle emission, a new universal decay law (UDL) for α-decay and cluster decay modes was introduced by Qi et al., [9]. The model was presented two parameters (χ and ρ) that depend on the atomic and mass numbers of the daughter and emitted particles as well as the Q value. UDL relates the half-life of monopole radioactive decay with the Q values of the outgoing particles as well as the masses and charges of the nuclei involved in the decay and can be written in the logarithmic form as,

$$log_{10}(T_{1/2}) = a\chi' + b\rho' + c$$

$$\chi' = Z_C Z_d \sqrt{\frac{A}{Q_c}}$$

$$\rho' = \sqrt{A Z_c Z_d (A_d^{1/3} + A_c^{1/3})}$$

$$A = \frac{A_c A_d}{A_c + A_d}$$

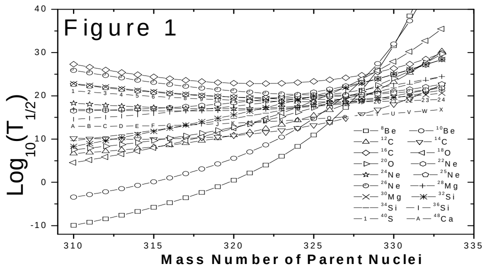
the constants a = 0.4314, b=−0.4087 and c =−25.7725 are the coefficient sets of above equation , determined by fitting to experiments of both α and cluster decays [9]. As this relation holds for the monopole radioactive decays of all clusters, it is called the Universal Decay Law (UDL) [9]. The decay half lives in the emission of clusters such as ^{8}Be, ^{10}Be, ^{12}C, ^{14}C, ^{16}C, ^{18}O, ^{20}O, ^{22}Ne, ^{24}Ne, ^{25}Ne, ^{26}Ne, ^{28}Mg, ^{30}Mg, ^{32}Si, ^{34}Si, ^{36}Si, ^{40}S, ^{48}Ca, ^{50}Ca and ^{52}Ti from the various superheavy parent isotopes $^{310\text{-}333}$125 have been calculated by using the universal decay law.

Results and discussion

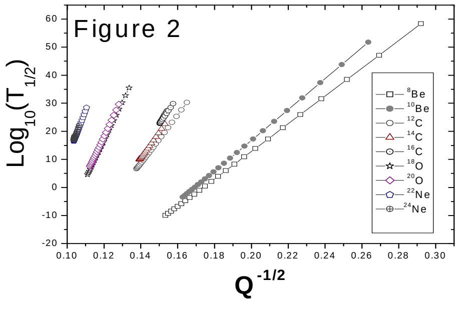
The energy released in decay transitions between the ground state energy levels of the parent nuclei and the ground state energy levels of the daughter nuclei is given as

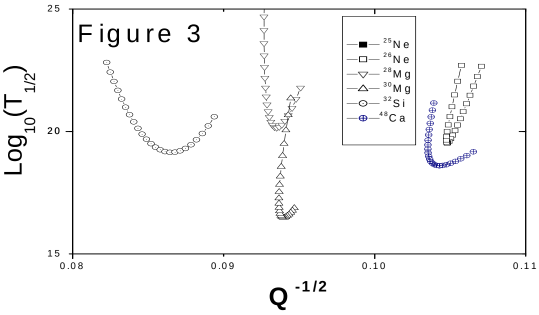
$$Q = \Delta M_p - (\Delta M_\alpha + \Delta M_d) + k(Z_p^\varepsilon - Z_d^\varepsilon)$$

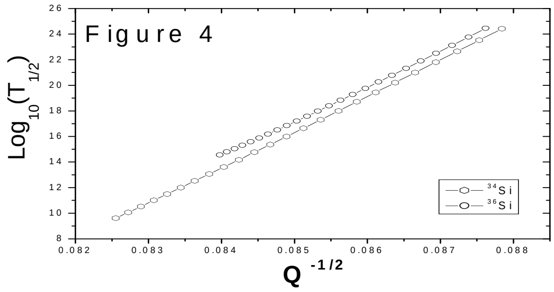
where ΔM_p, ΔM_d, and ΔM_α are the mass excess of the parent,daughter, and α particle, respectively. The Q values for cluster decays are calculated using the experimental mass excess values of Wang et al., [10] and some of the mass excesseswere taken from Koura–Tachibana–Uno–Yamada (KTUY) [11], as those experimental mass excesseswere unavailable in Ref. [10]. In the above equation the values of k = 8.7 eVand $\varepsilon = 2.517$ for nuclei with $Z \geq 60$; and k = 13.6 eVand $\varepsilon = 2.408$ for nuclei with $Z < 60$, have been derived from data reported by Huang et al., [12]. Figure1 represents the computed half life versus mass number of the parent with Z=125 emitting various clusters ranging from ^{8}Be to ^{52}Ti.



Figures 2-4 gives the Geiger–Nuttal plots of $\log_{10}(T_{1/2})$ vs. $Q^{-1/2}$ for ^{8}Be, ^{10}Be, ^{12}C, ^{14}C, ^{16}C, ^{18}O, ^{20}O, ^{22}Ne, ^{24}Ne, ^{25}Ne, ^{26}Ne, ^{28}Mg, ^{30}Mg, ^{32}Si, ^{34}Si, ^{36}Si, ^{40}S, ^{48}Ca, ^{50}Ca and ^{52}Ti from the various superheavy parent isotopes $^{310\text{-}333}$125. These plots are found to be linear for ^{8}Be, ^{10}Be, ^{12}C, ^{14}C, ^{16}C, ^{18}O, ^{20}O, ^{22}Ne, ^{34}Si, ^{36}Si and ^{40}S with different slopes and intercepts. These plots are found to be not exactly linear for clusters such as ^{24}Ne, ^{25}Ne, ^{26}Ne, ^{28}Mg, ^{30}Mg and ^{32}Si.







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