Decay studies of rare-earth nuclei to superheavy elements and the associated shell effects

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Since the discovery of ^{14}C-decay from ^{223}Ra by Rose and Jones [1] in 1984 many other ^{14}C decays from other radioactive nuclei (^{221}Fr, ^{221,222,224,226}Ra, ^{223,225}Ac and ^{226}Th) and some 12 to 13 neutron-rich clusters, such as ^{20}O, ^{23}F, $^{22,24\text{-}26}$Ne, ^{28,30}Mg and ^{32,34}Si, have been observed experimentally for the ground state decays of translead ^{226}Th to ^{242}Cm parents[2], which all decay with the doubly closed shell daughter ^{208}Pb or its neighboring nuclei. Theoretically, it was predicted in 1980 by Sandulescu et al., [3] on the basis of quantum mechanical fragmentation theory (QMFT). Cluster decays of rare-earth nuclei are studied here with a view to look for neutron magic shells for the $_{50}$Sn nucleus as the daughter product always. For a wide range of parent nuclei considered here (from Ba to Pt) ^{12}C from ^{112}Ba and ^{78}Ni from ^{210}Pt parent are predicted to be the most probable clusters (minimum decay half life) referring to ^{100}Sn and ^{132}Sn daughters respectively. Also, ^{22}Mg decay of ^{122}Sm is indicated at the second best possibility for ^{100}Sn-daughter decay. In addition to these well known magic shells (Z= 50, N=50 and 82), a new magic shell at Z= 50, N=66 (^{116}Sn-daughter) is indicated for the ^{64}Ni decay from ^{180}Pt parent. The decay half-lives are expected to be minimum for the magic daughters, this idea was utilized earlier for the sub shell closed $_{40}$Zr daughter [4]. Also, the synthesis of superheavy elements and their decay studies are a long-term goal of nuclear structure physics. These days advancement in the radioactive nuclear beam facilities has open the door to reach the center of the island of superheavy elements. The recently observed α-decay chains $^{293-294}$117 were produced by the fusion reactions with target ^{249}Bk and projectile ^{48}Ca and the earlier $^{288\text{-}287}$115 α-decay chains are observed with ^{243}Am target and the ^{48}Ca beam at Dubna, in Russia [5,6]. The Preformed Cluster Model (PCM) [7] is used for the α-decay as well as cluster decay calculations for all the parents. The alpha decay half-lives of superheavy elements are compared with the experimental and other theoretical results. Also, role of the Q-value in half-life is studied; a small change in the Q-value produces a large variation in half-life, which indicates the sensitivity of half-lives towards the Q-values.

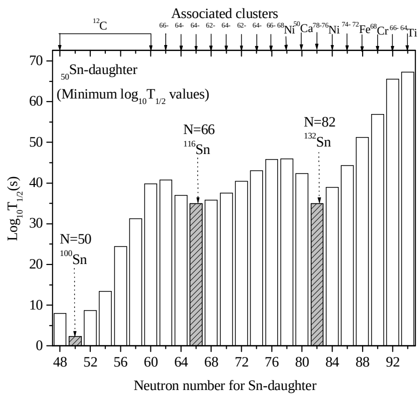

Fig.1.Histogram of $\mathrm{Log}_{10}T_{1/2}$(s) versus $_{50}$Sn daughter neutron number N_1 for the most probable clusters emitted from various Ba to Pt parents with $_{50}$Sn as a daughter nucleus always. The associated clusters are shown on the top panel.

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