^{298}114, The predicted doubly magic nuclei in the SHE

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Introduction

In the early stage of the nuclear development, one of the main objectives in this field is to reproduce the so-called magic numbers. The spontaneous decay of radioactive nuclei with the emission of fragments heavier than α- particle is termed as cluster radioactivity. This phenomenon was first predicted by Sandulescu [1] in 1980s on the basis of Quantum mechanical fragmentation theory (QMFT). The exploration of cluster radioactivity in Super Heavy Island did not receive much attention, because of the instability of nuclei in this region. From theoretical point of view, the extension of the periodic table towards the super heavy 'island of stability' is very important for testing and developing nuclear structure models.

The main physical interest to the present study comes from the fact that cluster radioactivity makes a bridge between these two extreme nuclear many body phenomena strongly differing by nucleon number, decay mechanism and properties of the emitted fragments. For this reason the information obtained from the cluster radioactivity goes beyond nuclear effects. In these new radioactive modes, almost all the residual nuclei resulting from cluster emission have been found to be the doubly magic ^{208}Pb or very close to it (lead radioactivity). Recently other island of cluster radioactivity having residual nuclei close to doubly magic ^{100}Sn (tin radioactivity) has been predicted theoretically and confirmed experimentally [2]. So far observed cluster radioactivity are from trans-lead and trans-tin region. In the present work we would like to explore the possibility of cluster emission from the other region preferably in the super heavy region. We have computed the alpha and cluster decay half lives of various even-even isotopes (with Z ranging from 116 to 126) in the super heavy region in which the decay leads to Z = 114 daughter, using Coulomb and Proximity potential [3] as interacting barrier.

The model

The interacting potential barrier for a parent nucleus exhibiting exotic decay is given by

$$V = Z_1 Z_2 e^2/r + V_p(z) + \frac{\hbar^2 l(l+1)}{2\mu r^2} \quad \text{for } Z>0 \qquad (1)$$

Here Z_1 and Z_2 are the atomic numbers of daughter and emitted cluster; 'r' is the distance between fragment centers, l the angular momentum, μ the reduced mass and Vp is the proximity potential

The barrier penetrably P is given as:

$$P = \exp\{-\frac{2}{\hbar}\int_a^b \sqrt{2\mu(V-Q)}dz\} \qquad (2)$$

The turning points 'a' and 'b' are given by $V(a) = V(b) = Q$, where Q is the energy released. The half life time is given by

$$T_{1/2} = \ln 2/\nu P. \qquad (3)$$

where, ν = 2Ev/h, represent the number of assaults on the barrier per second and E_v, the empirical zero point vibration energy.

Results discussion and conclusion

We have studied the cluster radioactivity of various isotopes in super heavy region based on the potential barrier determined by two sphere approximation [4], as the sum of coulomb and nuclear proximity potentials for the touching and separated configuration (z>0). Here z is the distance between near surface of the fragments. The possibility to have a cluster decay process is,

$$Q = M(A,Z)-M(A_1,Z_1)-M(A_2,Z_2) > 0 \qquad (4)$$

Where, M(A,Z), $M(A_1,Z_1)$ and $M(A_2,Z_2)$ are the atomic masses of the parent, daughter and cluster nuclei respectively. Thus the cluster radioactivity is energetically possible only if Q value is positive. The proper choice of the Q-value or half lives will give the information about magicity. In the present work Q-values are computed using experimental binding energies of Audi and Wapstra [5] and some values are taken from the tables of KTUY [6].

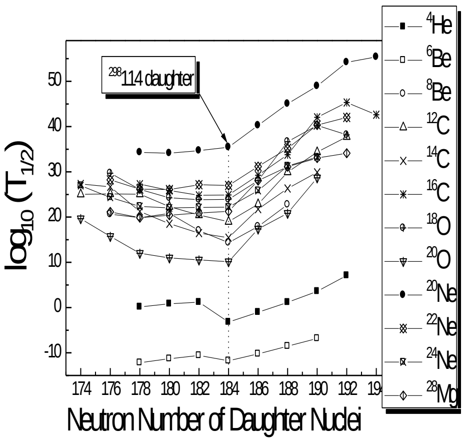

Fig. 1 Computed half life time versus neutron number of daughter nuclei for various cluster emissions leading to Z=114 daughter nuclei.

The radioactive decay (^{4}He, ^{6,8}Be, ^{12,14,16}C, ^{18,20}O, ^{20,22,24}Ne and ^{28}Mg) of various even-even isotopes with Z=116-126 leading to Z = 114 daughter nuclei was studied by taking the coulomb and proximity potentials as the interacting barrier. One of the fundamental factors in the study of superheavy elements is the prediction and/or production of doubly magic nucleus, in the superheavy mass region. Figures 1 and 2 represent the plot of computed half life time and barrier penetrability for clusters like ^{4}He, ^{6,8}Be, ^{12,14,16}C, ^{18,20}O, ^{20,22,24}Ne, ^{28}Mg against the neutron number of the daughter nuclei. It is found that these two figures are mirror reflections of one another. That is a peak in barrier penetrability appears as a dip in half lives or vice versa. In half life plots, the half life times decreases and reaches to a minimum value at ^{298}114and then increases. The reverse effect is also shown in the barrier penetrability plots. A radioactive decay having small half life time value or greater barrier penetrability indicates the doubly magic behaviour of the daughter nuclei[7]. Hence we would like to mention that the daughter nuclei ^{298}114 (Z=114, N = 184) is the next predicted spherical doubly magic nucleus in super heavy region after the experimentally observed doubly magic isotopes ^{208}Pb (Z=82, N=126). In addition with this we would like to mention that many authors [8, 9] predicted the spherical doubly magic behavior of ^{298}114 (Z=114, and N=184) isotopes in the superheavy region.

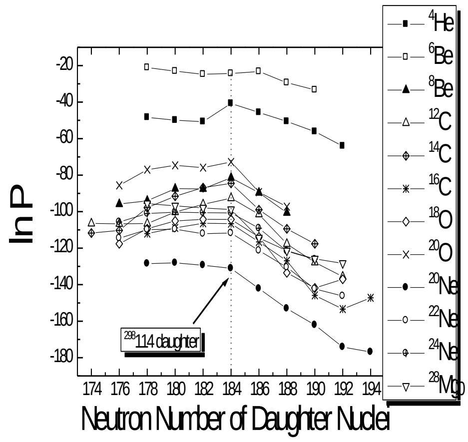

Fig.2 Computed barrier penetrability versus neutron number of daughter nuclei for various cluster emissions leading to Z=114 daughter nuclei

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