Existence of proton halo nuclei via cluster radioactivity

R. K. Biju[1],* M. K. Preethi Rajan[2] and K. P. Santhosh[3]
[1]Department of Physics, Pazhassi Raja N S S College, Mattanur- 670702, INDIA
[2]Deptartment of Physics, Payyanur College, Payyanur-670327, INDIA
[3]School of Pure and Applied Physics, Kannur University, Payyanur Campus, Payyanur-670327, INDIA
** email: bijurkn@gmail.com*

Introduction

Exotic isotopes along the neutron and proton drip lines are important for understanding the formation of elements and they constitute tests of understanding nuclear structure. The proton- and neutron-rich regimes in the chart of nuclei are therefore the focus of existing and forthcoming experimental facilities around the world. An atomic nucleus is called a halo nucleus (nuclear halo) when it has a core nucleus surrounded by a halo of orbiting protons or neutrons, which makes the radius of the nucleus appreciably larger than that predicted by the liquid drop model. The field of halo nuclei has generated much excitement and many hundreds of papers were produced since its discovery in the mid-1980s. The first halo nucleus to be produced in the laboratory was ^{6}He, as long ago as 1936, using a beam of neutrons on a ^{9}Be target[1]. Some of the examples for proton halo nuclei are ^{13}N, ^{17}F, ^{17}Ne, ^{26}P, ^{27}S etc. The present works aims to explore the possibility of production of proton halo nuclei against cluster radioactivity [2]. In this work, we have studied the decay possibility of proton halo nuclei (^{13}N, ^{17}F, ^{17}Ne, ^{26}P, ^{27}S) from different even-even $^{260-280}$110, $^{264-284}$112, $^{268-288}$114 and $^{278-298}$116 isotopes using Coulomb and Proximity potential [2] 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:

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

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

In this model the interacting potential for the post scission region is taken as the sum of coulomb and proximity potential and for the overlap region we use simple power law interpolation. Q-values are computed using experimental binding energies of Audi and Wapstra [3] and some values are taken from the tables of KTUY [4].

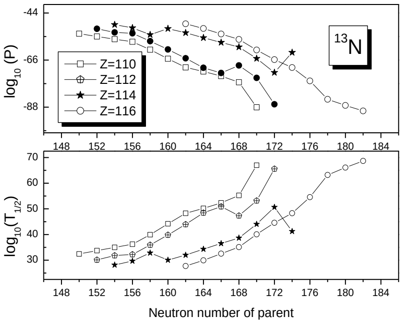

Fig. 1 Computed half life time and barrier penetrability versus neutron number of parent nuclei for ^{13}N emissions from different even-even parents with Z ranging from 110 to 116.

Figures 1 to 5 represent the computed half life time and barrier penetrability versus neutron number of parent nuclei for ^{13}N, ^{17}F, ^{17}Ne, ^{26}P and ^{27}S from different even-even $^{260-280}$110, $^{264-284}$112, $^{268-288}$114 and $^{278-298}$116 isotopes respectively. It is found from the plots that some of the decays has half life time values less than or equal to 10^{30} sec and is probable for emission. It is also found that these figures are mirror reflections of others. That is a peak in barrier penetrability appears as a dip in half lives or vice versa. In addition with this there is a peak in half life time and a dip in barrier penetrability at N=172. The minimum value of barrier penetrability is obtained at N= 172 which also refer to the stability of the parent nuclei at N=172. That is shell structure effect is evident in these plots in terms of largest barrier penetrability value.

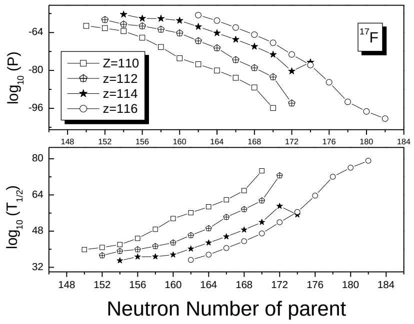

Fig. 2 Computed half life time and barrier penetrability versus neutron number of parent nuclei for ^{17}F emissions from different even-even parents with Z ranging from 110 to 116.

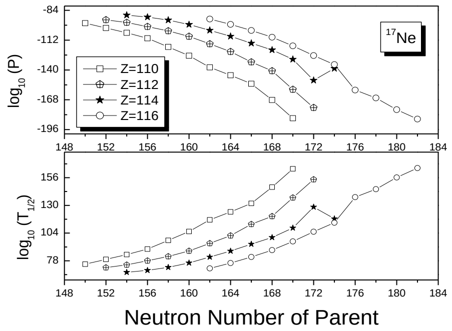

Fig.3 Computed half life time and barrier penetrability versus neutron number of parent nuclei for ^{17}Ne emissions from different even-even parents with Z ranging from 110 to 116.

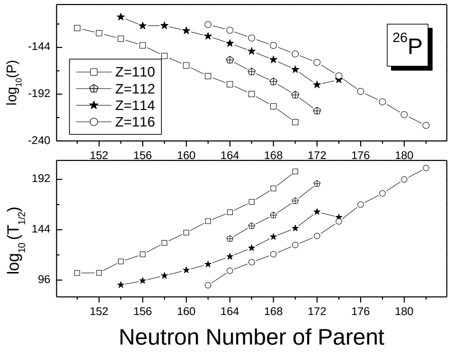

Fig. 4 Computed half life time and barrier penetrability versus neutron number of parent nuclei for ^{26}P emissions from different even-even parents with Z ranging from 110 to 116.

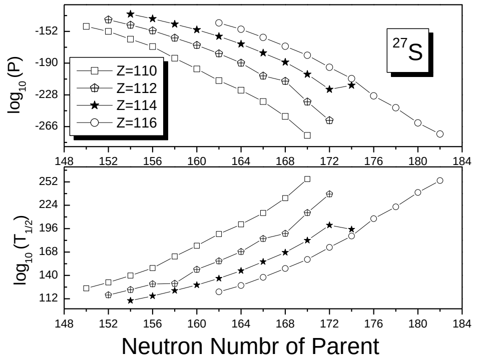

Fig. 5 Computed half life time and barrier penetrability versus neutron number of parent nuclei for ^{27}S emissions from different even-even parents with Z ranging from 110 to 116.

References

[1] T Bjerge et al, Nature **138**, 400 (1936)
[2] R K Biju et al,Pramana J.Phys.**70**,617(2008)
[3] G Audi et al, Nucl. Phys. A**595**, 409 (1995)
[4] H Koura, Prog.Theor.Phys.**113**, 305 (2005)

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