Alpha Decay Study of Bi Isotopes

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Introduction

Alpha decay process provides peculiar information about the spectroscopy of very neutron deficient nuclei in the region Z>82. It is considered that from the decay data of ground and isomeric states detailed structure information on energy levels can be determined. From the detailed analysis of the proton, alpha and cluster radioactivity it is possible to get information on structure and nuclear mass of some exotic nuclei which are not yet experimentally observed. In the present work we have calculated alpha decay half life of 8 experimentally known Bi isotopes in the region A=191-195, 209, 211-214 for their ground state to ground state transition with mutual angular momentum $\ell = 5$. Also we have predicted for those which are not experimentally known in the region A=189, 197-208 for $\ell = 5$ state. The alpha-daughter potential has been presented by analytical potential given by Ginnochio and developed by Sahu [1]. The calculations have been performed in the unified fission like approach. Decay constant is given by $P = P_0 T$ where P_0 is the assault frequency calculated by using zero point vibration energy data [2]. T is the transmission probability through the barrier has been calculated by using the exact expression instead of commonly used WKB approximation method given in ref. [1].

Potential model

The asymmetric form of analytical potential presented in ref. [1] has six parameters λ_1, ν_1, V_{01} and λ_2, ν_2, V_{02} representing flatness, range and height on either side of the barrier. In our calculations parameters of the potential are fixed at $\lambda_1 = 3.2,\ \nu_1 = 2.2$ in the inner region and at $\lambda_2 = 1.2$ in the outer region. The parameter ν_2 representing the range of the barrier in the outer region is varied to reproduce the experimental half life. Resulting form of potential barrier is shown in fig. 1.

Details of Calculation

We have calculated the alpha decay half lives for 8 experimentally known Bi isotopes by the variation of just a single parameter ν_2 so as to obtain the experimental alpha decay half life. Thus we have obtained the values of range parameter ν_2 corresponding to best fit to the experimental data. From these known data we have calculated the minimum rms deviation. Minimum deviation of σ=0.93 has been obtained corresponding to ν_2=28.094. Using this value of range parameter alpha decay half lives has been calculated for 8 experimentally known Bi isotopes. Results are shown in table 1. Also predictions have been made for those Bi isotopes which are experimentally unknown.

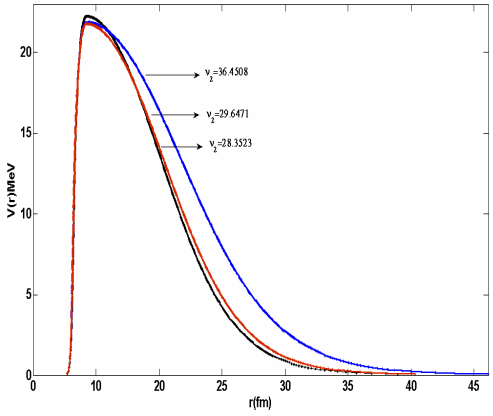

Fig. 1 Resultant potential barrier for three limiting value of Bi isotopes.

Result and discussion

In table 1 we have shown the calculated alpha decay half lives of experimentally known Bi isotopes corresponding to ν_2=28.094. From table 1 it has been observed that in some cases our calculated alpha decay values are in close agreement with experimental data, however in some cases slight discrepancy is observed. This discrepancy can by removed by further change in the parameters of the barrier.

Table 1 alpha decay half life calculated by present model for the range parameter ν_2=28.094, obtained corresponding to minimum deviation σ=0.93.

Nuclei	$Log_{10}(t_{1/2})$ Exp. (Sec.)	$Log_{10}(t_{1/2})$ Cal.(present work) (Sec.)	$Log_{10}(t_{1/2})$ Ref.[3]
^{191}Bi	2.849	3.8516	2.6064
^{193}Bi	4.503	4.7440	4.4579
^{195}Bi	6.785	5.6536	6.5289
^{209}Bi	26.77	11.6806	26.5079
^{211}Bi	2.187	3.6705	2.3560
^{212}Bi	4.571	4.7398	4.5315
^{213}Bi	5.149	5.1492	5.119
^{214}Bi	7.161	5.8989	7.2201

In fig. 2 we have plotted the alpha decay half lives for all calculated and predicted Bi isotopes in the region discussed above. Calculations has been done corresponding to ν_2=28.094. From fig.2 it has been observed that alpha decay half lives are perfect inverse reflection of decay energy or Q-values. Highest half has been observed for ^{209}Bi, reflecting the shell closure effect at N=126. Thus it can be concluded that alpha activity of ^{211}Bi is much more than its neighboring isotope ^{209}Bi.

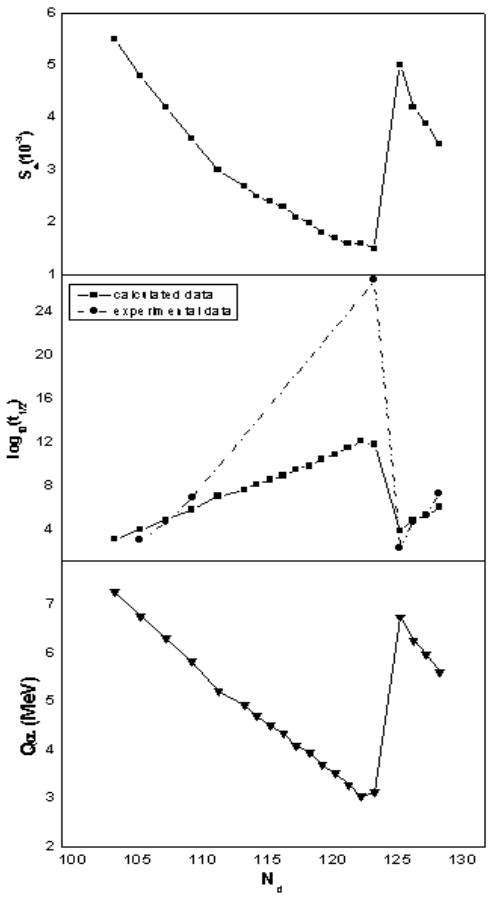

Fig.2 (a), Q_α value (b), logarithm of alpha decay half life and (c), preformation probability, S_α have been plotted against neutron number of the thallium isotope (daughter nucleus).

References

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[2] D. N. Poenaru *et al*, Z. Phy.A-Atomic Nuclei **325**(1986)435.
[3] O A P Tavares *et al* J. Phys. G: Nucl.Part.phys.**31** (2005)129.