Alpha decay half-lives and Q-values of superheavy element Z=108

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Introduction

Currently nuclear physics is passing through an exciting period, when one after another new super heavy elements (SHE) are being discovered. Recently, synthesis of Z=117 superheavy element is a step towards the island of superheavy mass region. The synthesis of superheavy elements has apparently possible due to advancement in the recent technology and with more promising beam 48Ca. In the last several decades significant progress has been achieved both experimentally and theoretically in investigations of superheavy elements.

The nuclear structure of superheavy elements are based on various theoretical models, such as shell model, the fission like model, and the cluster model. Recent microscopic calculations predict long-lived super heavy elements in a variety of shapes, including spherical, axial and, tri-axial configurations. The alpha decay process was first introduced by Gamow, Condon and Gurney in 1920's as a quantum tunneling effect. In 1969 Nilsson et al. predicted that the longest fission half-life centre rather symmetrical around the nucleon numbers Z=114, N=184.[1-4]. Many authors predicted, that proton number Z= 114, 120, 126 and the neutron number N= 162, 172, 184 in the superheavy mass region are the next magic number beyond the Z=82 and N=126 number. Macroscopic-microscopic calculations shows an especially large negative shell corrections for the ground states of nuclei at and near Z=108 and N=126 number, considered as a deformed shell. Alpha decay is the most prominent tool to investigate the super heavy nuclei.

In this work, by using Preformed Cluster Model (PCM) the half lives values of Z=108 isotopes and compared with experimental results.

The preformed cluster decay model

The preformed cluster model (PCM) uses the dynamical collective coordinates of mass and charge asymmetries η and η_z on the basis of Quantum Mechanical Fragmentation Theory. The decay constant λ in PCM is defined as

$$\lambda = \frac{\ln 2}{T_{1/2}} = P_0 \nu_0 P \qquad (1)$$

Here P_0 is the cluster preformation probability and P is the barrier penetrability which refer, respectively, to the η- and R- motions. ν_0 is the barrier assault frequency. P_0 are the solutions of the stationary Schrodinger equation in η,

$$\left\{-\frac{\hbar^2}{2\sqrt{B_{\eta\eta}}}\frac{\partial}{\partial\eta}\frac{1}{\sqrt{B_{\eta\eta}}}\frac{\partial}{\partial\eta}+V_R(\eta)\right\}\psi^{(\nu)}(\eta)=E^{(\nu)}\psi^{(\nu)}(\eta) \qquad (2)$$

Which on proper normalization are given as

$$P_0 = \sqrt{B_{\eta\eta}}\left|\psi^{(0)}(\eta(A_i))\right|^2 \left(2/A\right) \qquad (3)$$

The fragmentation potential ($V_R(\eta)$ in eq (2) is calculated simply as the sum of Coulomb interaction, the nuclear proximity potential and the ground state binding energies of two nuclei:

$$V(R_a,\eta) = -\sum_{i=1}^{2} B(A_i,Z_i) + \frac{Z_1 Z_2 e^2}{R_a} + V_P \qquad (4)$$

With B's taken from the 2003 experimental compilation of Audi et al and from the 1995 calculations of Moller et al. Thus, full shell effects are contained in our calculations that come from the experimental and/or calculated binding energies.

The assault frequency ν_0 is given simply as

$$\nu_0 = \left(2E_2/\mu\right)^{1/2} / R_0 \qquad (5)$$

With E_2=(A_1/A)Q, the kinetic energy of lighter fragment, for the Q- value shared between the two products as inverse of their masses.[5]

Calculation and Results

The decay studies shows that half-lives of the alpha decay as well as cluster decay works as a tool in nuclear structure physics to show the presence of shell effects of the parents as well as of daughter nuclei.

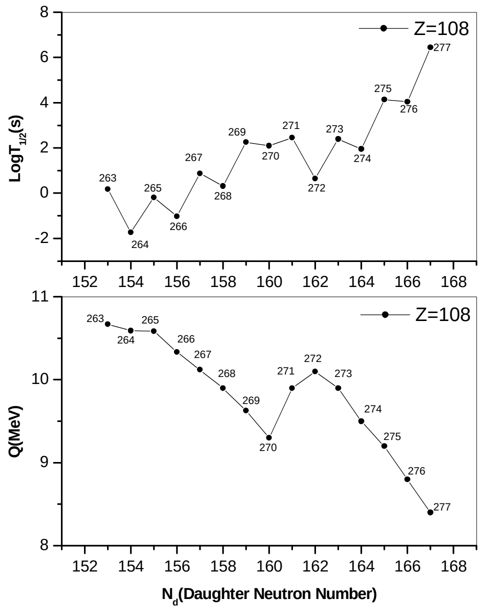

Fig.1 Plot between $Log_{10}T_{1/2}$ (s) and Q-value (in MeV) with daughter neutron based on the calculation of PCM.

A higher value of the half-life indicates the presence of shell stabilized parent nucleus, whereas a comparatively low value of half-life tells the same about the daughter and cluster nuclei [6]. Here in fig1 we calculate the alpha decay half-life time and Q value for element Z=108 isotopes. From Fig.1 (a) a deep in the decay half life appears at N=162 neutron number with higher Q-values.. In the Fig2 PCM calculation results are compared with the available experimental data which follow the same trend and are good in agreement.

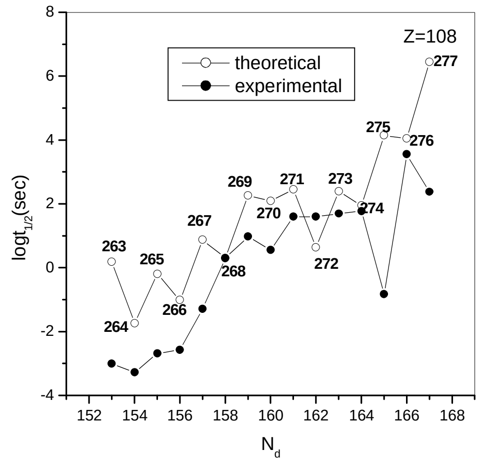

Fig 2. The calculated (PCM) α-decay half-lives are compared with expermental results .

References

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