α-decay half lives of ^{294}118 nucleus

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Introduction

The existence of super heavy elements has been a longstanding fundamental scientific problem. By the end of the 1960s, it had been concluded that the existence of the heaviest nuclei with with Z=114, N=184 to be the centre of an island of long-lived super heavy nuclei determined by the shell effects [1-3]. The existence of long lived superheavy nuclei (SHNs) is controlled mainly by spontaneous fission and α-decay processes. But the α- decay mode is one of the most important decay mode for SHNs and is reliable to findout the new SHNs from unknown parent nuclei to known nuclei. So many experiments and various theoretical approaches has been done in last four decades to enhance the stability in superheavy neclei region [4]. The first decay chain of the isotope ^{294}118 was observed in 2002 [5]. Adam Sobiczewski obtained the properties of nuclei appearing in these chains theoretically by using phenomenological model [6]. All the results obtained are in relatively good accuracy of measured properties of the nuclei in the chains, especially of the half-lives. A systematic and comprehensive study of the α-decay chains of super heavy elements (Z = 118) is presented here using Royer formula [7,8]. We also study the strong dependence of the calculated half-lives to the choice of parameters Q of the α-nucleus potential and how the half-life is sensitive to the orbital angular momentum L. In this work we have taken the Q-value from P. moller [9]. But the sensityvity of Q value claculated from relativistic mean field formalism will be presented at the symposium.

Theoretical Framework

We have used the axially deformed relativistic mean field formalism [10,11] with the successful NL3 parameter set. The relativistic Lagrangian density for a nucleon-meson many body system is,

$$L = \bar{\psi}(i\partial - M)\psi + \frac{1}{2}\partial_\mu\sigma\partial^\mu\sigma - U(\sigma) - \frac{1}{4}\Omega_{\mu\nu}\Omega^{\mu\nu}$$
$$+\frac{1}{2}m_\omega^2\omega_\mu\omega^\mu - \frac{1}{4}R_{\mu\nu}R^{\mu\nu} + \frac{1}{2}m_\rho^2\rho_\mu\rho^\mu - \frac{1}{4}F_{\mu\nu}F^{\mu\nu}$$
$$-g_\sigma\bar{\psi}\sigma\psi - g_\omega\bar{\psi}\omega\psi - g_\rho\bar{\psi}\rho\tau\psi - e\bar{\psi}A\psi$$

The analytical formulas of Royer

The alpha decay half-lives have been derived by G .Royer. Analytically he was determined the potential energy by alpha emission within a liquid drop model including proximity effects between emitted alpha particle and the daughter nucleus. Then alpha emission half-lifes are deduced from the WKB barrier penetration probability as for a spontaneous asymmetric fission. By the help of logarithmic analytical formula we can find out the half-lifes of heavy and super heavy nuclei. After Royer Dong et al it was reconsidered by adding angular momentum term, and converted into a new version i.e. in terms of the centrifugal contribution to the α-nucleus potential [7,8] as;

$$\log_{10}(T_{1/2}) = a + bA^{1/6}\sqrt{Z} + \frac{cZ}{\sqrt{Q_\alpha}} + \frac{l(l+1)}{\sqrt{(A-4)(Z-2)A^{-2/3}}} \quad (1)$$

Where A is the mass number of the parent nucleus and Z is the charge number of the parent nucleus. The Q_α reperesents the energy released during the reaction. The constant a, b and c are fitting parameters and the details are in Ref. [7,8].

Results and Discussions

Here we plot $\log_{10}(T_{1/2})$ against the neutron number of the daughter nuclei in the corresponding α chains in Fig.2 and the respective Q-values in Fig.1. The α-decay half-lives are evaluated using the analytical formulas of Royer with an angular momentum term and compared with the results obtained from Ref. [9].

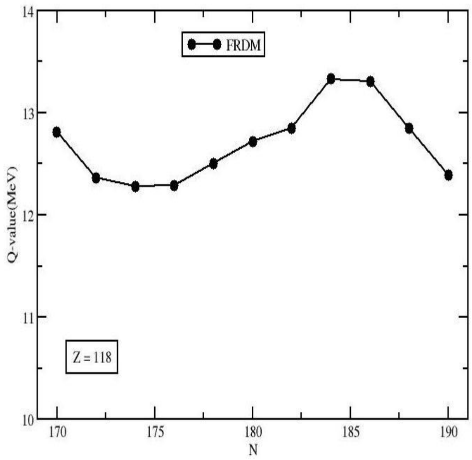

Fig.1 The experimental Q_α values with the daughter neutron number [9].

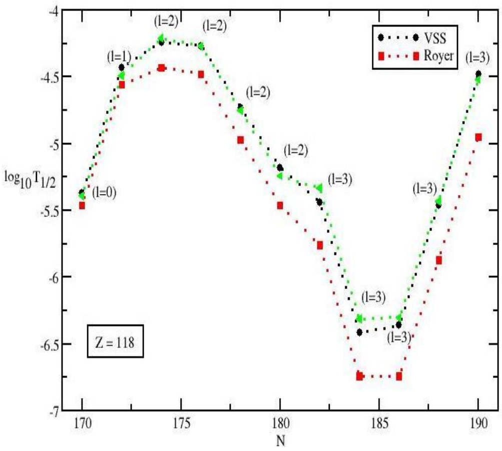

Fig.2 The half life calculation ($\log_{10}T_{1/2}$) for the $^{290-310}118$ isotopes verses daughter neutron number (N)

Conclusions

In conclusion, a systematic study of α-decay half-lives of superheavy nuclei has been carried out. The half-lives obtained by using these *Q* values and sensitive dependence of the half-lives on L values however, brings the half-lives closer to the experimental values. The plots for $\log_{10}(T1/2)$ against the neutron number of the daughter in the corresponding decay reveals that, for most of the decays, the half life is minimum for the decay leading to a daughter with N = 184. The predictions on the α-decay half lives of Z = 118 may be of great use for further experimental investigation in the super heavy region.

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