Proton radioactivity of $^{241-251}$Db

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Introduction

In the line of stability, the excess protons still adequately bound to the nucleus with the nuclear forces, hence direct emission of proton is not possible. However, while beyond the line of stability the protons are no longer bound by the nuclear forces. In order to study the proton emission beyond the stability line Conclaves et al., [1] studied two-proton radioactivity in the mass number A<70 using liquid drop model. Earlier [2-3] studied proton emission from the deformed nuclei. One proton, two proton, β decay [4-8] were studied using droplet model and WKB approximation. Giusti et al., [9] established theoretical frame work for the emission of two protons in electron induced reactions. Using generalized liquid drop model and WKB approximation, Dong et al., [10] theoretically studied proton decay half-lives of spherical proton emitters.

Previous workers [11-12] theoretically studied half-lives of proton radioactivity. Earlier workers [13-17] were studied ternary fission, binary fission, cluster radioactivity and alpha decay in the superheavy region using different proximity functions. From the available literature, it is essential to study the proton radioactivity in the Dubnium. Hence, in the present work we made a first attempt to study proton radioactivity in the isotopes of Dubnium.

Theory:

The half-lives of proton is studied using the following expression,

$$T_{1/2} = \frac{hLn(2)}{2\pi\Gamma} \quad (1)$$

here Γ is the decay width and it is calculated using the relation

$$\Gamma = \frac{S\bar{F}h^2\bar{P}}{16\pi^2 m} \quad (2)$$

here S, F and P are spectroscopic, normalisation and penetration factor respectively and in detail explained in previous work [18].The average normalization factor is expressed as [18]

$$\bar{F} = \frac{2}{\pi}\int_0^{\pi/2} F(\theta)d\theta \quad (3)$$

where F(ɵ) is angle dependent normalization factor.

$$\bar{P} = \int_0^{\pi/2} P(\theta)\sin(\theta)d\theta \quad (4)$$

The total potential is the sum of nuclear, coulomb and centrifugal terms [16].

Results and discussions:

The amount of energy released during one-proton radioactivity is studied using the mass excess values available in the literature [16,19]. We have also studied penetration factor (P), normalization factor (F) and logarithmic half-lives for proton decay in the heavy nuclei of $^{241-251}$Db. We have also studied the spontaneous fission half-lives and alpha decay half-lives of the heavy nuclei of $^{241-251}$Db. The comparison of the proton decay with the spontaneous fission and alpha decay half-lives are as shown in figure 1. From the figure we have observed that the spontaneous fission half-lives are smaller compared to proton and alpha decay.

The figure 2(a) explains the variation of amount of energy released with the mass number of parent nuclei and it decreases with increase in the mass number of parent nuclei, 2(b), 2(c) represents the penetration probability and normalization factor with the mass number of parent nuclei and both decreases with the increase in mass number of parent nuclei and 2(d) depicts the variation of logarithemic half-lives with the product of atomic number and energy released during proton decay.

We have studied proton decay in the heavy nuclei $^{241\text{-}251}$Db. From the figure 1 and 2 it is observed that the proton decay half-lives are also longer than that of spontaneous fission and alpha decay. The competition of proton decay with different decay modes such as alpha decay and spontaneous fission reveals that proton decay is not dominant decay mode in the heavy nuclei $^{241\text{-}251}$Db.

Fig. 1: The variation of logarithemic half-lives of the proton decay, spontaneous fission and alpha decay with the mass number of parent nuclei

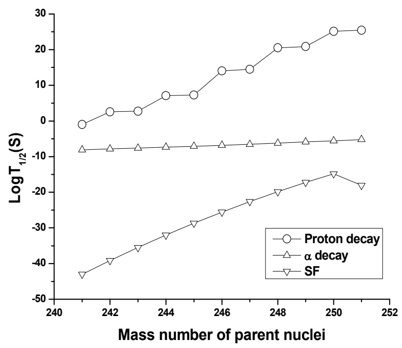
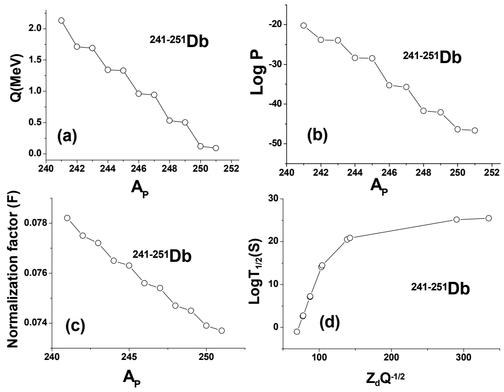


Fig. 2: The variation of amount of energy released, penetration probability and normalization factor with the mass number of parent nuclei and the variation of logarithemic half-lives with the product of atomic number and energy released during proton decay.



Conclusions:

To summarize the present work, we have studied amount of energy released during the proton decay, penetration probability, normalization factor and logarithemic half-lives in the heavy nuclei of $^{241\text{-}251}$Db. We have also compared present work with the spontaneous fission and alpha decay. From the results we can conclude that the heavy nuclei of $^{241\text{-}251}$Db are having half-lives greater than the spontaneous fission and alpha decay. Hence, the heavy nuclei $^{241\text{-}251}$Db is stable against the proton decay.

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