Decay modes of Berkelium

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Introduction

Half-lives and branching ratio of cluster radioactivity and alpha decay is systematically studied using coulomb and proximity potential model. The study of decay constant, half-lives and branching ratio enables us to predict most dominant decay mode for Bk. Cluster radioactivity is a kind of spontaneous emission of cluster whose mass is heavier than that of an alpha particle. In 1980 Sandulescu et al., [1] predicted cluster radioactivity decay mode. In 1899 alpha decay was described by Rutherford and discovered in France by Henri Becquerel [2]. Santhosh et al., [3] compared alpha decay and cluster radioactivity by using semi empirical model. Zongqiang et al., [4] systematically studied cluster radioactivity half-lives for 100Sn.Budaca et al., [5] studied alpha decay half-lives of superheavy nuclei. Manjunatha and Sowmya [6] compared spontaneous, ternary, cluster radioactivity and alpha decay of Z=126. Zhang and Wang [7] studied competition between alpha decay and spontaneous fission. Since cluster radioactivity and alpha decay are physically analogical process, we predicted most prominent decay mode of superheavy nuclei. Aim of the present work is to study of different decay modes such as alpha decay, beta decay, cluster decay and spontaneous fission in Berkelium.

II. THEORETICAL FRAME WORK

The interacting potential between two nuclei of fission fragments is taken as

$$V = \frac{Z_1 Z_2 e^2}{r} + V_p(z) + \frac{\hbar^2 l(l+1)}{2\mu r^2} \quad (1)$$

Here Z_1 and Z_2 are the atomic numbers of projectile and target and r is the distance between centres of the projectile and target. The term l represents the angular momentum, and μ the reduced mass. The proximity potential (V_P) given by Blocki *et al.* [8] as

$$V_p(z) = 4\pi\gamma b\left[\frac{C_1 C_2}{C_1 + C_2}\right]\Phi(\xi) \quad (2)$$

where the nuclear surface tension coefficient is given by,

$$\gamma = 0.9517[1 - 1.7826(N-Z)^2 / A^2]\ \text{MeV/fm}^2 \quad (3)$$

here N, Z, and A are the neutron, proton, and mass number of the parent and Φ represents the proximity function. Myers and Swiatecki [9] modified the proximity potential using the concepts of droplet model, nuclear radii and surface tension coefficients. Using the droplet model, matter radius C_i was calculated. The half-life of cluster and alpha decay is given by

$$T_{1/2} = \frac{\ln 2}{\lambda} = \frac{\ln 2}{\upsilon P} \quad (4)$$

Where $\upsilon = \frac{\omega}{2\pi} = \frac{2E_\upsilon}{h}$ and E_υ is the empirical vibration energy.

The spontaneous fission half-lives are calculated using the expression given by the Bao et al., [10]. β^- decay process occurs in proton rich nuclei. Zhang et al., [11] constructed a semi-empirical formula for β^- decay. We have used this formula to calculate half-lives of β^- decay. To calculate the halflives for β^+ decay, we have used the semi empirical formula proposed by Zhang et al., [11].

IV.Results and discussions

We have studied the decay modes such as alpha decay, cluster decay and spontaneous fission in Berkelium. Figure 1 shows the variation of decay constant (λ) for different decays with the mass numbers of the parent nuclei. From this figure, it is observed that number of particles decay per second is more for alpha decay than that of the other decay modes. Figure 2 shows the variation of energy released (Q) during different decay process with mass number of the parent nuclei. For almost all decay process, Q values decreases with increasing mass number. To identify the dominant decay mode we have also calculated the branching ratios with respect to alpha decay. The calculated branching ratios for different isotopes of Berkelium is as shown in figure 3. We have identified the dominant decay modes for Berkelium of isotopes of mass number range 235<A<255. The identified decay modes are as shown in table 1. The predicted decay properties are useful in the study of nuclear structure of Berkelium.

Fig. 1: Variation of decay constant (λ) with the mass numbers of the parent.

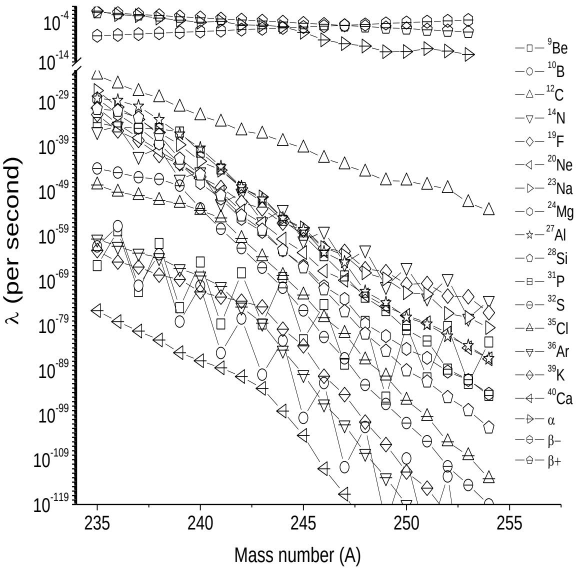

Fig. 2: Variation of energy released with mass number of the parent.

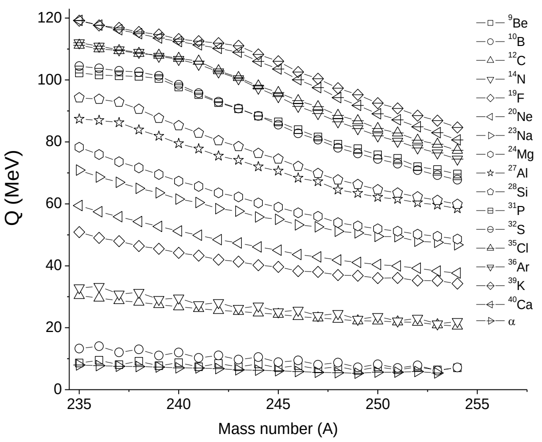

Fig. 3: Branching ratios for different isotopes of Berkelium

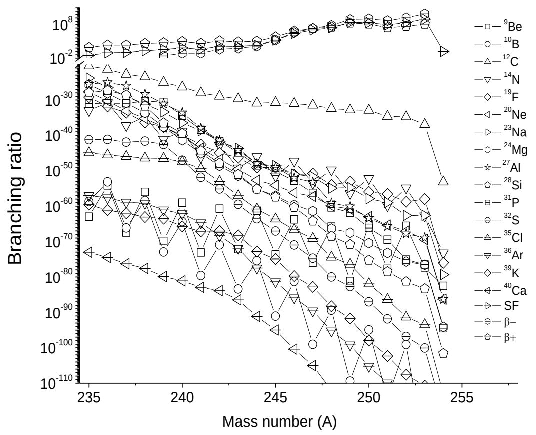

Table 1: decay properties of Berkelium

A	$\log T_{1/2}$				Decay mode
	Alpha	SF	β-	β+	
^{235}Bk	1.00	3.69	7.27	1.34	α
^{236}Bk	1.90	3.91	7.05	1.59	β+
^{237}Bk	2.18	4.11	6.83	1.89	β+
^{238}Bk	2.81	4.30	6.60	2.14	β+
^{239}Bk	3.29	4.46	6.38	2.44	β+
^{240}Bk	3.85	4.60	6.16	2.69	β+
^{241}Bk	3.63	4.73	5.93	2.99	β+
^{242}Bk	4.52	4.83	5.71	3.24	β+
^{243}Bk	4.56	4.92	5.49	3.54	β+
^{244}Bk	4.95	4.99	5.26	3.80	β+
^{245}Bk	6.41	5.04	5.04	4.10	β+
^{246}Bk	8.27	5.07	4.82	4.35	β+
^{247}Bk	4.23	5.09	4.59	4.65	α
^{248}Bk	4.35	5.08	4.37	4.90	α
^{249}Bk	11.28	5.06	4.15	5.20	β-
^{250}Bk	11.23	5.03	3.93	5.45	β-
^{251}Bk	10.51	4.97	3.70	5.75	β-
^{252}Bk	11.09	4.90	3.48	6.00	β-
^{253}Bk	11.97	4.81	3.26	6.30	β-

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