Study of the α decay of ^{249}Bk

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A magnetic α spectrograph has been used to study the α decay of the isotope berkelium 249. Energies and intensities were determined for ten α groups. An energy-level diagram of the nucleus ^{245}Am has been constructed from the experimental data. The results indicate the existence of three rotational bands with quantum numbers $5/2^-[523\downarrow]$, $5/2^+[642\uparrow]$, and $7/2^+[633\uparrow]$.

INTRODUCTION

An energy-level diagram of the nucleus ^{245}Am can be plotted from data obtained from analysis of the α spectrum of ^{249}Bk ($T_{1/2,\beta}$ = 314 days).[1,2] The α-decay branch of this isotope is $\sim 10^{-5}$ of the total number of decays. This hinders the study of the ^{249}Bk α spectrum, particularly when searching for α groups of low intensity. Consideration of the few data on α groups of this isotope indicates substantial discrepancies in the values of energy and intensity given by various authors.[1,3-6] Therefore we undertook a further study of ^{249}Bk α decay for the purpose of determining more reliably the energies and intensities of the α lines. Particular attention was devoted to a careful radiochemical purification of berkelium from unwanted impurities.

1. PREPARATION OF SOURCE, APPARATUS

The source of berkelium for the α-spectroscopic measurements was prepared directly after radiochemical purification of this element from foreign impurities. Berkelium was evaporated in vacuum onto a glass substrate. The area of the active layer was 3 × 60 mm for a surface density ~ 0.3 μg/cm^2.

In performing the experiments we used a magnetic α spectrometer with double focusing of the α-particle beam at an angle[8] of $\approx 255°$. The energy standard was the energy of the α_0 group of ^{249}Bk (E_{α_0} = 5437.3 ± 1.0 keV).[7] The relative accuracy in determination of the energy of the individual α lines of the ^{249}Bk spectrum in these experiments was $\sim 0.04\%$.

2. SPECTRUM OF α PARTICLES FROM ^{249}Bk

With the prepared berkelium source we carried out several runs of duration from 25 to 100 hours with different solid angles of the α spectrograph ($\Omega_1 = 8 \times 10^{-4}$ and $\Omega_2 = 5 \times 10^{-4}$ of 4π).

The α spectrum of ^{249}Bk is shown in Fig. 1. The abscissa gives the particle energy in keV, and the ordinate the number of α particles. Each α line is denoted by a letter α_i, where the subscript corresponds to the value of the energy level of the daughter nucleus (^{245}Am).

The α spectrum of ^{249}Bk was studied over a wide range of α-particle energies, from 5450 to 4650 keV. However, in the energy intervals ΔE_α = 5300–5160 keV and ΔE_α = 5030–4650 keV we observed no α lines whose intensity exceeds 0.01% of the total number of α particles recorded. We note that the line α_{290} shown in Fig. 1 apparently does not belong to the ^{249}Bk spectrum.

The results of analysis of the α spectrograms recorded are shown in the table. Here we have indicated the energies of the individual α groups (E_α, keV), their intensities (I_α, %), the hindrance factors (HF), and the energy-level values of ^{245}Am.

3. ENERGY-LEVEL DIAGRAM OF ^{245}Am

The data shown in the table permit an energy-level diagram to be constructed for the nucleus ^{245}Am (Fig. 2). In the lower part of the figure we have shown two

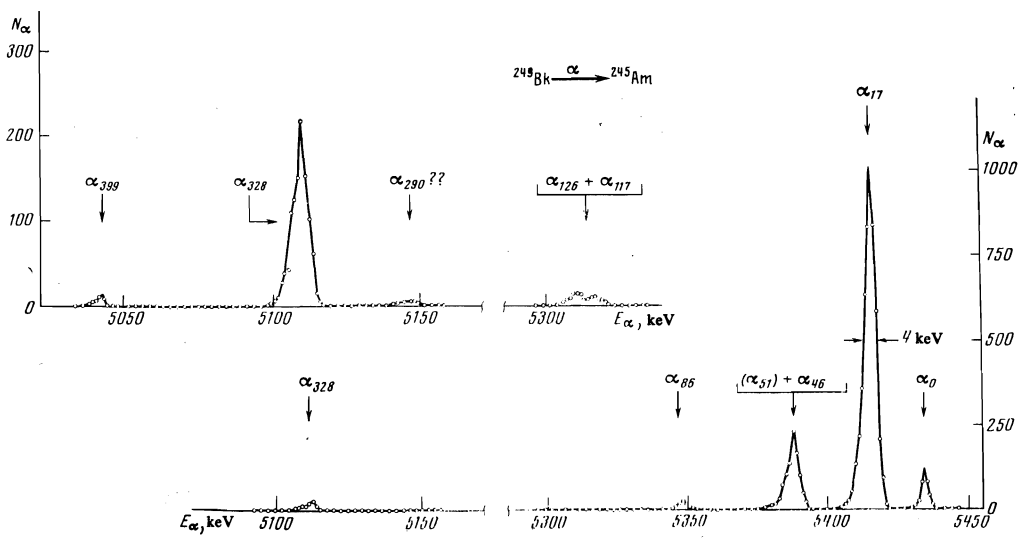

FIG. 1

Characteristics of α lines from the decay $^{249}Bk^{\alpha} \rightarrow {}^{245}Am$

α_i, i	E_α, keV*	I_α, %*	HF **	E_{lev}, keV*	Note
0	5437	4.8	180	0	$5/2-[523\downarrow]$
17	5421	74.8	9	17	$5/2+[642\uparrow]$
46	5393	} 16.0	} 30	46	
51	~5387			~51	
86	5352	1.5	180	86	
117	5322	0.048	3600	117	
126	5314	0.074	2100	126	
290?	~5151	(0.038)	(400)	(290)?	
328	5114	1.8	5	328	$7/2+[633\uparrow]$
399	5045	0.04	80	399	

*Average value of three measurements.

**In calculation of the hindrance factor the percentage content of the α branch of ^{249}Bk was taken as [1] 2.2×10^{-3} %.

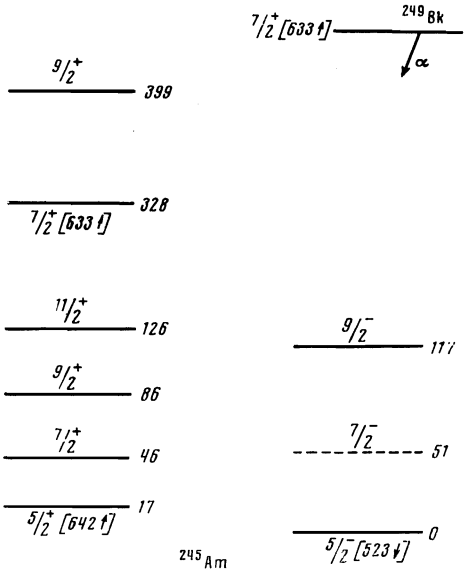

FIG. 2

bands with the following level energies:

first band: 0, (51), 117 keV;

second band: 17, 46, 86, 126 keV.

On the basis of the well known Nilsson diagrams for odd Z ($82 \leq Z \leq 126$), and also from the results of Komov, Malov, and Solov'ev,[9] we can suggest that the most probable quantum numbers of these bands are respectively $5/2^-[523\downarrow]$ and $5/2^+[642\uparrow]$.

In the upper part of Fig. 2 we have shown a band whose initial level (E_{lev} = 328 keV) is populated by a favorable α transition (HF= 5). Therefore the quantum numbers of this level should be identical to the quantum numbers of the ground state of the nucleus ^{249}Bk, i.e., $7/2^+[633\uparrow]$. The second member of this band is the level with E_{lev} = (399 ± 2) keV.

Since the ground-state band has negative parity, it cannot interact with the members of the other two bands. Consequently, from the experimental data it is easy to determine the spin of the ground state of ^{245}Am; it turned out to be 5/2.

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