Low-spin states of ^{250}Cf populated in the electron capture decay of 2.22-h ^{250}Es

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Low-spin states of ^{250}Cf have been investigated by measuring γ rays and conversion electrons associated with the electron capture decay of 2.22-h ^{250}Es. Mass-separated ^{250}Es samples produced by the ^{249}Cf(d,n) reaction were used for these measurements. The γ-ray spectra were measured with a 25-cm^3 coaxial Ge(Li) spectrometer and the electron spectra were measured with a cooled Si(Li) detector. Multipolarities of intense transitions in ^{250}Cf were deduced and logft values of electron capture transitions were derived from measured electron capture intensities. On the basis of the results of the present investigation the following bandheads were identified in ^{250}Cf: E (keV),$K,I\pi = 871.6$, 2,2 −; 1031.9, 2,2 +; 1154.2, 0,0 +; 1175.5, 1,1 −; 1210.0, 2,2 −; 1244.4, 2,2 +; 1266.5, 0,0 +; and 1658.1, 2,2 +. The 2.22-h state in ^{250}Es has been given a spin-parity assignment of 1 − with configuration $\{n[734]9/2-; p[633]7/2+\}_{1-}$.

[RADIOACTIVITY ^{250}Es [from ^{249}Cf(d,n)]; measured $T_{1/2}$, E_γ, I_γ, E_{ce}, I_{ce}. ^{250}Cf deduced levels, logft (EC), γ multipolarity, I, π. Mass-separated ^{250}Es. Cooled Si(Li) electron spectrometer.]

I. INTRODUCTION

Two isomers of ^{250}Es are known[1] to exist: the 8.6-h isomer with spin-parity of 6+ and the 2.2-h isomer with spin-parity assignment of 1−. The decay scheme of the long-lived isomer was thoroughly investigated by Freedman *et al.*[2] and in this study several high-K rotational bands were identified in ^{250}Cf. The only information known[1] about the short-lived isomer is that its electron capture (EC) decay strongly populates the ^{250}Cf ground state and the γ-vibrational state at 1031.9 keV.

In the present work much larger amounts of mass-separated ^{250}Es samples have been used to study the low-spin level structure of ^{250}Cf. Gamma-ray and conversion-electron spectra were measured with high-resolution Ge(Li) and Si(Li) spectrometers and the results of these measurements were used for spin-parity and configuration assignments. The information obtained from the present investigation when combined with results of the ^{250}Cf(d,d') reaction[3] provides a definite identification of most of the vibrational states in ^{250}Cf. In the present paper we describe these measurements in detail and discuss the spin-parity assignments to the observed levels.

II. SOURCE PREPARATION

The ^{250}Es samples for the present measurements were produced by the irradiation of ~3 mg of ^{249}Cf with 18- MeV deuterons in the Argonne 60-in. cyclotron. The irradiation time varied between 3 and 5 h, and the average beam current density was 30 μA/cm^2. The irradiated ^{249}Cf was dissolved in concentrated HCl, evaporated to dryness, and redissolved in 0.05 M HCl. The solution was loaded on a cation-exchange resin column and the actinides were eluted with ammonium α-hydroxy isobutyrate solution.[4] This procedure separated Es from Cf and other actinide elements. Two such columns were used to obtain essentially californium-free Es samples. Fission products were removed by a liquid-liquid extraction chromatographic procedure.[5] The chemically purified Es was either placed on a 1-mm thick quartz disk or run through the Argonne electromagnetic isotope separator[6] to produce thin isotopically pure ^{250}Es sources.

III. EXPERIMENTAL PROCEDURES AND RESULTS

A. γ-ray spectroscopy

Several γ-ray spectra of ^{250}Es samples were measured with a 25-cm^3 Ge(Li) spectrometer using mass-separated sources as well as samples which were not run through the isotope separator. Intensities of intense γ rays and Cf K x rays were determined from the spectra of mass-separated sources, whereas the samples not run through the isotope separator were used to obtain intensities of weak transitions. In addition to the 2.2-h ^{250}Es, the sample also contained the 8.6-h isomer, which has intense γ rays up to 900 keV. Because several γ rays and Cf K x rays are in coincidence with the 810 and 829 keV transitions in ^{250}Cf, the γ-ray spectrum contained sum peaks in the 1.0 to 1.3 MeV region. For some spectra the contribution of sum peaks was minimized by placing the source ~10 cm away from the detector or by placing absorbers between the source and the detector. Intensities in Table I represent the intensities of the

TABLE I. 2.22-h ^{250}Es γ rays and K x rays.

Energy (keV)	Photon intensity (% per 2.22-h ^{250}Es EC decay)	Transition (initial → final level)
109.8 ± 0.1	22.2 ± 1.6	Cf K_{α_2}
115.0 ± 0.1	34.7 ± 2.4 } total =	Cf K_{α_1}
129.7 ± 0.2	13.1 ± 0.9 } 74.7 ± 5.2	Cf $K_{\beta_1'}$
133.7 ± 0.2	4.7 ± 0.4	Cf $K_{\beta_2'}$
586.6 ± 0.3	0.40 ± 0.10	1658.1 → 1071.2
626.0 ± 0.3	1.2 ± 0.1	1658.1 → 1031.9
659.5 ± 0.3	0.48 ± 0.09	
803.0 ± 0.3	0.44 ± 0.09	
828.9 ± 0.1	5.6 ± 0.9	871.6 → 42.7
889.9 ± 0.2	0.45 ± 0.07	1031.9 → 141.9
929.4 ± 0.3	0.10 ± 0.07	1071.2 → 141.9
989.2 ± 0.1	13.6 ± 0.9	1031.9 → 42.7
1028.5 ± 0.3	0.25 ± 0.07	1071.2 → 42.7
1031.9 ± 0.1	10.8 ± 0.8	1031.9 → 0
1047.8 ± 0.5	~0.1	1189.4 → 141.9
1068.2 ± 0.5	~0.1	1210.0 → 141.9
1103.0 ± 0.3	0.09 ± 0.03	1244.4 → 141.9
1111.5 ± 0.3	0.27 ± 0.04	1154.2 → 42.7
1133.0 ± 0.3	0.70 ± 0.09	1175.5 → 42.7
1146.7 ± 0.3	0.20 ± 0.03	1189.4 → 42.7
1154.9 ± 0.3	0.10 ± 0.02	1296.6 → 141.9
1167.3 ± 0.2	3.0 ± 0.2	1210.0 → 42.7
1175.5 ± 0.2	1.60 ± 0.09	1175.5 → 0
1201.7 ± 0.2	1.25 ± 0.09	1244.4 → 42.7
1223.8 ± 0.2	0.33 ± 0.03	1266.5 → 42.7
1244.4 ± 0.2	0.35 ± 0.03	1244.4 → 0
1253.9 ± 0.5	~0.05	1296.6 → 42.7
1615.3 ± 0.3	1.80 ± 0.17	1658.1 → 42.7
1658.1 ± 0.3	1.05 ± 0.09	1658.1 → 0

2.2-h ^{250}Es γ rays only; contributions from sum peaks have already been removed.

The 828.9- and 1028.5-keV γ rays belong to the decay of both isomers. Intensities of these γ rays in the decay of the 2.2-h ^{250}Es were obtained by subtracting the contributions of the 8.6-h isomer from the intensities determined from an early spectrum. The contributions of the 8.6-h isomer were obtained from a spectrum measured 1 d after the irradiation. The gamma-ray spectrum of a mass-separated ^{250}Es sample measured with a 25-cm^3 coaxial Ge(Li) spectrometer is shown in Fig. 1. Energies and intensities of γ rays were determined from hand-plotted graphs and also with the computer code SAMPO,[7] and these are given in Table I. The errors denote one standard deviation σ. γ rays were assigned to the decay of the 2.2-h ^{250}Es on the basis of their decay with the characteristic half-life of ^{250}Es (2.2 h) and the fact that they were present in the spectrum of the mass-separated sample. Intensities in Table I are expressed in photons per 100 ^{250}Es (2.2 h) EC decays and these were obtained by equating the total γ-ray, conversion-electron, and direct EC intensities feeding the ground state to 100%.

B. Electron spectroscopy

Conversion-electron spectra of several mass-separated sources were measured with a cooled Si(Li) spectrometer.[8] The spectrometer consists of an 80-mm^2 × 3-mm lithium-drifted silicon detector and has a resolution [full width at half maximum (FWHM)] of 1.0 keV at 100 keV and 1.6 keV at 600 keV electron energy. The ^{250}Es electron spectrum measured with the Si(Li) spectrometer is shown in Fig. 2. Decay of the spectrum was followed for two days in order to distinguish 2.2-h

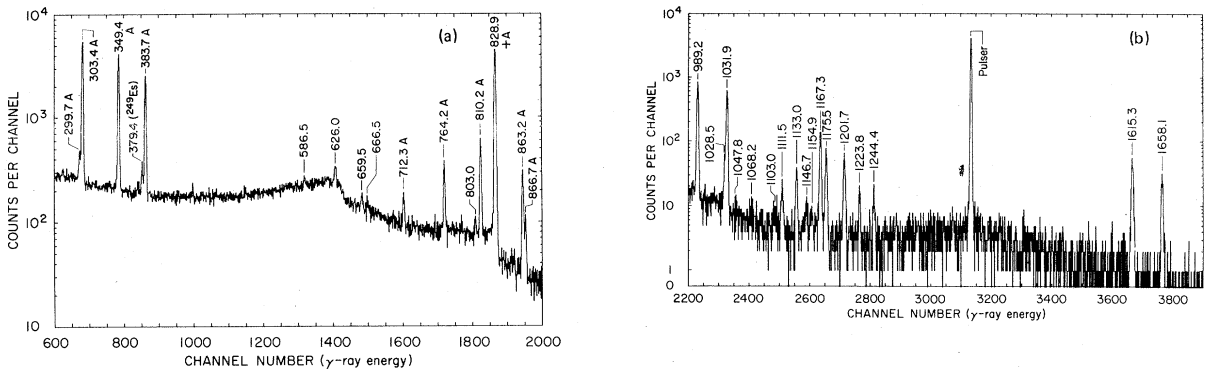

FIG. 1. (a) Low-energy portion of a ^{250}Es γ ray spectrum and (b) high-energy portion of a ^{250}Es γ-ray spectrum measured through a 230-mg/cm^2 Al absorber with a 25-cm^3 coaxial Ge(Li) detector. The source was mass separated and it was placed ~10 cm away from the detector end cap. Energy scale is ~0.44 keV per channel. *A* denotes the 8.6-h ^{250}Es isomer.

^{250}Es transitions from those associated with the decay of the 8.6-h isomer.

Energy calibration of the spectrometer was made with the electron lines of the 8.6-h ^{250}Es present in the spectrum and a reference pulser. Electron binding energies used to obtain transition energies from the measured electron energies were taken from Ref. 9. The efficiency-geometry product of the detector was measured with calibrated ^{203}Hg and ^{137}Cs standards. Electron intensities were obtained by normalizing the *K* conversion coefficient of the 989.2-keV γ ray to the theoretical[10] value for a pure *E*2 transition. This normalization is justified by the fact that the experimental *K* conversion coefficient of this transition measured by Vandenbosch *et al.*[11] is in excellent agreement with the theoretical[10] value.

Transition energies, electron intensities, conversion coefficients, and derived multipolarities are given in Table II. The transition multipolarities were deduced by comparing the experimental conversion coefficients with respective theoretical[10] values.

C. Half-life

The half-life of the low-spin ^{250}Es isomer was determined by following the decay of the 989.2-keV γ ray measured with a 25-cm^3 Ge(Li) spectrometer at a fixed geometry. A least-squares fit to the peak areas gave a half-life of 2.22 ± 0.05 h. This is in good agreement with the previously measured value[1] of 2.1 ± 0.2 h.

IV. DECAY SCHEME

A. Electron capture transition probabilities

Gamma-ray and conversion-electron intensities associated with the EC decay of the 2.2-h ^{250}Es

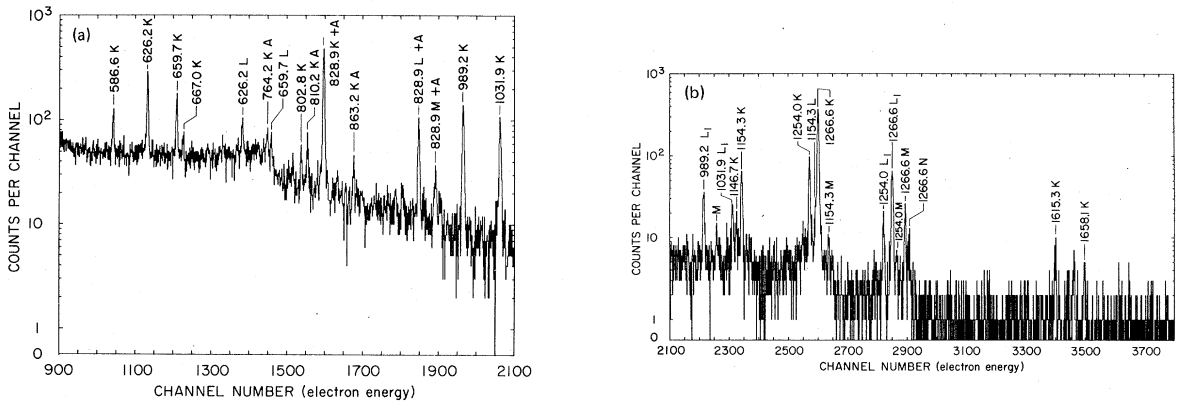

FIG. 2. (a) Low-energy conversion-electron spectrum and (b) high-energy portion of the electron spectrum of a mass-separated ^{250}Es sample measured with a cooled Si(Li) spectrometer. Efficiency-geometry product of the detector was 1.10%. Energy scale is 0.44 keV per channel. *A* denotes 8.6-h ^{250}Es isomer.

TABLE II. Internal conversion lines in the EC decay of 2.22-h ^{250}Es.

Electron energy (keV)	Shell	Transition energy [a] (keV)	Electron intensity (% per EC decay)	Conversion coefficient	Theoretical $E1$	Theoretical $E2$	Theoretical $M1$	Multipolarity
36.0±0.2	M	42.7±0.2	7.5 ±0.4					
41.2±0.2	N		2.8 ±0.3					
451.6±0.3	K	586.6	0.072±0.009	0.18	9.7(−3)	0.028	0.23	$M1$
491.2±0.2	K	626.2	0.22 ±0.02	0.18	8.6(−3)	0.025	0.20	$M1$
600.2±0.3	L		0.053±0.009	0.044	1.6(−3)	0.011	0.041	
524.8±0.3	K	659.8	0.12 ±0.01	0.25	7.9(−3)	0.023	0.17	
633.6±0.3	L		0.028±0.007	0.058	1.5(−3)	9.8(−3)	0.035	
667.8±0.3	K	802.8	0.029±0.006	0.066	5.6(−3)	0.016	0.10	$M1$
854.1±0.2	K	989.1	0.156 (norm)	1.15(−2)	3.9(−3)	1.15(−2)	0.06	$E2$
963.3±0.2	L		0.039±0.005	2.9(−3)	7.1(−4)	3.2(−3)	0.012	
982.4±0.4	M		0.012±0.004	8.8(−4)				
896.9±0.2	K	1031.9	0.115±0.009	1.07(−2)	3.6(−3)	1.07(−2)	0.05	$E2$
1005.8±0.3	L		0.029±0.004	2.7(−3)	6.6(−4)	3.0(−3)	0.011	
1026.1±0.5	M		0.010±0.003	9.3(−4)				
1011.7±0.4	K	1146.7	0.015±0.003	0.075	3.0(−3)	9.0(−3)	0.039	$E0+E2$
1019.3±0.2	K	1154.3	0.079±0.006					$E0$
1127.6±0.6	L_1+L_2		0.015±0.004					
1147.4±0.5	M		0.009±0.003					
1152.6±0.6	N		~0.004					
	K	1167.3	≤0.015	≤0.005	3.0(−3)	8.7(−3)	0.037	$E1$
	K	1175.5	≤0.006	≤0.004	3.0(−3)	3.6(−3)	0.036	$E1$
1119.0±0.2	K	1254.0	0.10 ±0.009	~2				$E0+E2$
1227.9±0.3	L_1+L_2		0.020±0.003					
1247.3±0.5	M		0.007±0.002					
1131.6±0.2	K	1266.6	0.49 ±0.03					$E0$
1240.6±0.2	L_1+L_2		0.095±0.007					
1259.8±0.3	M		0.026±0.003					
1264.8±0.5	N		0.009±0.002					
1480.2±0.5	K	1615.2	(7±3)(−3)	3.9(−3)	1.7(−3)	5.0(−3)	0.016	$E2$
1522.5±0.5	K	1657.5	(5±2)(−3)	4.8(−3)	1.6(−3)	4.9(−3)	0.015	$E2$

[a] Transition energies were obtained by adding the measured electron energies and appropriate binding energies from Ref. 9.

were measured in relative units normalized at the 989.2-keV photon intensity as 100. Transition intensities in ^{250}Cf were then obtained by adding γ-ray intensities and corresponding electron intensities. For transitions whose electron lines were not observed, theoretical[10] intensities for assumed pure multipolarities deduced on the basis of the level scheme were used. The EC population at each excited state was obtained from the difference between γ plus electron outfeed and infeed at that level. Using the experimental EC intensity and the theoretical[12] K/total capture ratio, we determined the number of K-shell holes generated by electron capture at each level. The sum of these K-shell vacancies and those created by internal conversion were then subtracted from the K-shell vacancies derived from the measured K x-ray intensity (fluorescence yield[13] ω_K used was 0.973). This difference gave the K capture intensity to the ^{250}Cf ground state which after correction for capture[12] from higher shells gave the EC population to this state.

The photon, electron, and EC intensities in percent per 2.2-h ^{250}Es EC decay were obtained by normalizing the total EC population to all the ^{250}Cf levels to 100%. The logft values were calculated by the procedure described by Major and Biedenharn[14] using an EC decay energy[15] of 2.07 MeV, and these along with EC intensities are given in Fig. 3.

B. Configuration assignments

In this section we discuss the basis for spin-parity and configuration assignments to the observed levels in ^{250}Cf. The assignments made in the present study are in agreement with the assignments made in the β^- decay studies[16-18] of ^{250}Bk. The present spin-parity assignments are based mainly on measured transition multipolarities and logft values of EC transitions.

1. 2.22-h state in ^{250}Es

In the β^- decay[11] of ^{250}Bk a state at 1031.9 keV was observed and it was given K, $I^\pi=2,2+$ assign-

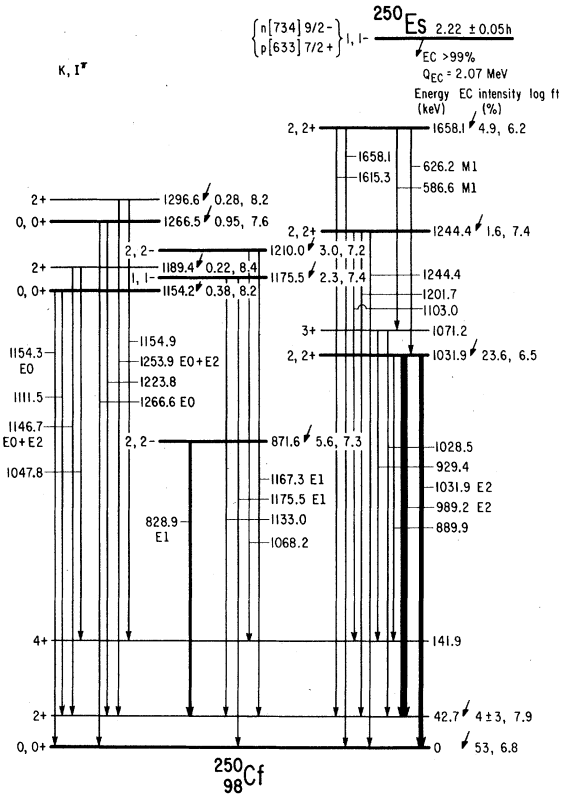

FIG. 3. Level diagram of ^{250}Cf constructed on the basis of the present investigation. Only low-spin states, populated in the electron capture decay of the 2.2-h ^{250}Es are shown.

ment. Our results confirm this assignment. In actinide nuclei a logft value of <8 implies that the β transition involves a spin change (ΔI) of 0 or 1 between the parent and daughter states.[19] The observed logft values of EC transitions to the ^{250}Cf ground state and the 1031.9-keV state (see Fig. 3), therefore fix the spin of the 2.22-h state in ^{250}Es as 1. The same argument also restricts the spins of states in ^{250}Cf with logft values of <8 to 0, 1, and 2.

The ground state of ^{249}Cf ($N=151$) is known[19] to be the $\frac{9}{2}^-[734]$ neutron orbital and the ground states of Es ($Z=99$) nuclei[19] are either the $\frac{7}{2}^+[633]$ proton orbital (in ^{249}Es and ^{253}Es) or the $\frac{3}{2}^-[521]$ state (in ^{251}Es). Thus the configurations for the ^{250}Es isomers should contain the $\frac{9}{2}^-[734]$ neutron state and the $\frac{7}{2}^+[633]$ or $\frac{3}{2}^-[521]$ proton state. Since the spin of the 2.22-h ^{250}Es state has already been established as 1, this state is given a configuration assignment of $\{n[734]\frac{9}{2}^-; p[633]\frac{7}{2}^+\}_{1-}$. For the 8.6-h ^{250}Es state, Freedman *et al.*[2] have deduced a spin-parity of 6+ with configuration $\{n[734]\frac{9}{2}^-; p[521]\frac{3}{2}^-\}_{6+}$. According to the Gallagher-Moszkowski[20] rule, the 1− state (for which $\Sigma=0$) is expected to lie above the 8− state formed by the coupling of the same two orbitals, and the $\{n[734]\frac{9}{2}^-; p[521]\frac{3}{2}^-\}_{3+}$ state should lie above the $\{n[734]\frac{9}{2}^-; p[521]\frac{3}{2}^-\}_{6+}$ configuration. These considerations indicate that the 8.6-h state ($K\pi=6+$) represents the ^{250}Es ground state and the 1− state lies above the 6+ state and therefore represents an isomeric state.

2. *Positive parity states*

The 1031.9- and 1071.2-keV states were given K, I^π assignments of 2,2+ and 2,3+, respectively, by Vandenbosch *et al.*[11] Our results are consistent with these assignments. This band is strongly populated in the ^{250}Cf(d,d') reaction and the $B(E2)$ value deduced from the (d,d') reaction cross section establishes it as the γ-vibrational band.

The $M1$ multipolarity of the 586.6- and 626.2-keV transitions and the deexcitation pattern of the 1658.1-keV state to the ground state band make it an $I^\pi=2+$ state. The 1658.1- keV state is given $K, I\pi=2,2+$ assignment because no $I=0$ or 1 level has been observed in the vicinity of this level. The same assignment was also made in the β^- decay studies[16] of ^{250}Bk.

The 1244.4-keV level deexcites to the $I=0$, 2, and 4 members of the ground state band suggesting a spin parity of 2+ for this level. The energy of the (12.44.4 → 141.9) transition was found to be 1103.3 ± 0.1 keV in Ref. 16, which is 0.8 keV larger than the expected energy of 1102.5 keV. In our spectra we measure the energy of this γ ray as 1103.0 ± 0.3 keV, which is in good agreement with the expected value. Also the intensity of this γ ray measured in the present work is only one third of the value quoted in Ref. 16. These observations suggest that 1103.3-keV peak in the ^{250}Bk γ-ray spectrum contains an additional γ ray. The 1244.4-keV state was not excited in the ^{250}Cf(d,d') reaction, indicating that this state is a two-quasiparticle state.

The electric monopole ($E0$) character of the 1154.3- and 1266.6-keV transitions and ($E0+E2$) multipolarity of the 1146.7- and 1253.9-keV γ rays establish the spin parity of the 1154.2- and 1266.5-keV levels as 0+ and that of the 1189.4- and 1296.6-keV levels as 2+, respectively. These $K\pi=0+$ bands have been discussed in detail elsewhere.[21] The 1154.2-keV excited 0+ state was interpreted as the lowest neutron pair vibration and the 1266.5-keV state was interpreted as a $K\pi=0+$ two-quasiparticle state.

3. *Negative parity states*

The state at 871.6 keV was given[2] $K, I^\pi=2,2-$ assignment on the basis of the $E1$ multipolarity of

the 828.9-keV transition in the decay of 8.6-h ^{250}Es. The $I^\pi = 3-$ member of this band was excited in the ^{250}Cf(d,d') reaction with large $B(E3)$ value indicating that this band is a $K\pi = 2-$ octupole-vibrational band.

The 1175.5-keV state deexcites to the ground state and to the 42.7-keV level by $E1$ transitions. This observation restricts the spin parity of the 1175.5-keV state to 1−. The γ-ray branching ratio favors a $K = 1$ assignment [$I_{1175}/I_{1133} = 2.29$ (exp); 2.23 (for $K = 1$)[22]; 0.56 (for $K = 0$)[22]]. The same spin-parity assignment was also made by Reich *et al.*[16] This state and a state at 1211 ±1 keV, which was excited in the ^{250}Cf(d,d') reaction, were assigned[3] to the $I = 1$ and 3 members of the $K\pi = 1-$ octupole vibrational band because of the enhance $B(E3)$ value (19.3 single-particle units) for the excitation of the 1211-keV level. The large cross section to the 1211-keV level can only occur by an $E2$ or $E3$ excitation which restricts its spin parity to 2+ and 3−. The 2+ assignment for the 1211-keV state is ruled out because the $K\pi = 2+$ γ-vibrational band has been identified at 1031.9 keV.

We have not identified the 2− member of the $K\pi = 1-$ band at 1175.5 keV. However, there is some indication that it exists at ~1189 keV. The measured intensity of the 1146.7 keV (1189.4 − 42.7) γ ray is 0.20% whereas one estimates an intensity of 0.07% from the 1146.7 K electron intensity and from the X value [$X = B(E0;0,0+ \rightarrow 0,0+)/B(E2;0,0+ \rightarrow 0,2+)$] deduced for the 0,0+ state at 1154.2 keV. Thus the existence of only one 1189.4-keV ($K, I^\pi = 0,2+$) level does not account for the observed intensity of the 1146.7-keV γ ray. The excess intensity comes from another level at ~1189 keV, which most likely is the $K, I^\pi = 1,2-$ level. Since we have not made a definite identification of the $K, I^\pi = 1,2-$ state, this level has not been shown in Fig. 3.

It has been shown by Reich *et al.*[16] that the 1167.3-keV γ ray is in coincidence with the 42.7-keV transition. We have deduced the multipolarity of the former transition as $E1$. These facts plus the observed logft value of 7.2 for the EC transition to the 1210.0-keV state restrict the spin parity of this state to 1− and 2−. The deexcitation pattern of this state, which is quite similar to that of the 871.6-keV level (strong transition to the 0,2+ state and very weak branching to the 0.0+ and 0,4+ levels), strongly favors an $I^\pi = 2-$ assignment. Thus the 1210.0 ±0.1 keV level observed in the present decay study cannot be the same state as the 1211 ±1 keV state identified in the ^{250}Cf(d,d') reaction because the measured[3] $B(E3)$ value for the excitation of the 1211-keV level requires a 3− assignment for this state. The 1210-keV state was also populated in the ^{249}Cf(d,p) reaction[23] and it has been given a two-quasiparticle assignment of the $\{n[734]\frac{9}{2}^-; n[622]\frac{5}{2}^+\}_2$- configuration.

The very weak 1068.2-keV γ ray observed in this work as well as by Reich *et al.*[16] could represent either the 2,2− → 0,4+ or 1,3− → 0,4+ transition. According to the Alaga[22] rule, the 2,2− → 0,0+, 1210.0-keV $M2$ γ ray should be 13 times more intense than the 2,2− → 0,4+, 1068.2 keV $M2$ γ ray. We have obtained an upper limit of 0.1% for the intensity of the 1210.0 and/or 1211 keV γ ray. The fact that we do not observe ~1.0% intensity for the 1210.0-keV γ ray suggests that the 1068.2-keV γ ray is most likely not the 2,2− → 0,4+ transition. A more plausible explanation is that the 1068.2-keV γ ray represents the 1,3− → 0,4+ transition and the companion 1,3− → 0,2+ transition is indistinguishable from the intense 1167.3-keV γ ray. The 1,3− → 0,0+, 1211-keV $E3$ γ ray, despite its enhancement, will be too weak to be observed in our γ ray spectrum.

The small rotational constant ($\hbar^2/2\mathcal{I} = 3.5$ keV) of the $K, I^\pi = 1-$ band at 1175.5 keV can be explained in terms of Coriolis interaction between this band and the band at 1210.0 keV. Since the two $I^\pi = 2-$ levels of the two bands are only ~10 keV apart before the interaction, even a small Coriolis interaction matrix element can have a large effect on the level spacings of the two bands. It has been shown by Ahmad *et al.*[3] that a Coriolis matrix element of 1.0 (chosen for the best fit) and a rotational constant of 5.5 keV can fairly well reproduce the observed level energies. This calculation also predicts the energy of the 1,2− level at 1188.5 keV, which is in agreement with the value of ~1189 keV indicated by the excess 1146.7 keV γ ray intensity. This two-band interaction will not affect the branching ratio of γ rays deexciting the 1− level at 1175.5 keV. As discussed in Ref. 3, the matrix element of 1.0 used in this calculation is in agreement with the value estimated on the basis of the possible two-quasiparticle state components of the two bands.

Although the present two-band Coriolis interaction calculation provides an explanation for the compression of the $K^\pi = 1-$ band, it does not represent the complete picture because it does not include the $K\pi = 0-$ and the 871.7 keV ($K\pi = 2-$) bands. A more detailed calculation involving the $K\pi = 0-$, 1−, 2−, 3− vibrational bands and the $K\pi = 2-$ band at 1210.0 keV is needed for the complete understanding of the negative-parity states in ^{250}Cf.

V. CONCLUSION

In the present study several $K\pi = 0$, 1, and 2 bands have been identified in ^{250}Cf. By combining

the results of this work with the results of previous[3,16,21] investigations, we have been able to deduce the character of these states. Two $K\pi = 0+$ bands have been identified: the 0+ state at 1154.2 keV has been interpreted[21] as the lowest neutron pair vibration, and the 1266.5-keV state has been assigned to the $\{n[624]\frac{7}{2}^+; n[613]\frac{7}{2}^+\}_{0^+}$ configuration. The $K\pi = 2-$ band at 871.6 keV and the 1− band at 1175.5 keV were interpreted as the octupole vibrations on the basis of large cross section in the ^{250}Cf(d,d') reaction.[3] The 2− state at 1210.0 keV is given the $\{n[734]\frac{9}{2}^-; n[622]\frac{5}{2}^+\}$ configuration assignment. The (d,d') reaction[3] indicates that the 2+ band at 1031.9 keV is the γ vibrational band and the 2+ states at 1244.4 and 1658.1 keV are two-quasiparticle states. However, definite configuration assignments could not be made to these two states.

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