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Levels of ^{246}Cm from the β^--Decay Sequence ^{246}Pu(11 days)^{246m}Am(25 min)^{246}Cm†

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^{246}Pu produced by multiple neutron capture during an underground explosion was recovered and subjected to extensive chemical separations. γ rays in the decay sequence ^{246}Pu(β^-)-^{246m}Am(β^-)^{246}Cm were investigated by use of several Ge(Li) detectors. In all, 158 γ rays were observed, up to 2.2 MeV. Of these, 114 were ascribed to the decay of ^{246m}Am. A decay scheme was deduced, including 37 levels. Bands in ^{246}Cm have been identified with the following bandhead energies: g.s. $K^\pi=0^+$; 841.70 keV $K^\pi=2^-$, octupole; 1078.90 keV $K^\pi=1^-$, octupole; 1124.42 keV $K^\pi=2^+$, γ; 1249.81 keV $K^\pi=(0^-$, octupole); 1348.89 keV $K^\pi=1^-$; 1452.06 keV $K^\pi=(1^+)$; 1593.80 keV $K^\pi=2^{(-)}$; 1604.31 keV $K^\pi=1^-$.

I. INTRODUCTION

The nucleus ^{246}Cm is doubly even and well into the region of heavy deformed nuclei ($A \geqslant 230$). Past studies[1-6] have yielded information on the ground-state rotational band and revealed octupole bands with $K^\pi=1^-$ and 2^-. In doubly even deformed nuclei, one expects to find collective bands of quadrupole (β and γ) and octupole character. Several collective $K^\pi=0^+$, 2^+ and 0^-, and 1^-, and 2^- bands have been observed[7] in this region. In nuclei with $A>246$, experimental information is sparse; bands are observed in ^{250}Cf and ^{254}Fm with $K^\pi=2^+$. Bandheads that have been determined are in reasonable agreement with theoretical predictions.[8]

At energies above 900 keV, one expects to find two-quasiparticle as well as collective states. However, the nuclei with $A \gtrsim 246$, it is seldom possible to populate these levels by β-decay due to inadequate decay energy. The decay of ^{246}Am is an important exception.

Past studies of ^{246}Am decay[1-6] have suffered from limitations in source intensity and detector performance. We used the high neutron flux of a thermonuclear explosion to produce a ^{246}Pu source of adequate intensity to be studied on a variety of high-resolution detector systems. The decay of ^{246}Pu proceeds by β emission to ^{246m}Am, which in turn undergoes β decay to ^{246}Cm with a 25-min half-life. In our source, the ^{246m}Am decay was in equilibrium with the 10.9-day ^{246}Pu.

II. EXPERIMENTAL PROCEDURES

A. Source Production and Preparation

The ^{246}Pu used in our study was obtained from fused cavity debris of the event Hutch, a heavy-element-production underground nuclear detonation. Several samples of fused debris were leached with acid[9] and combined into three fractions which were subjected to four cycles of tributyl phosphate extraction, diisooctyl phosphate extraction, and hydrochloric acid anion exchange. The fractions then were combined and processed according to the following sequence: (1) coprecipitation as a reduced lanthanum fluoride, (2) dissolution of the precipitation in 7 M HNO_3 saturated with H_3BO_3, (3) loading of the solution into an anion column, (4) washing once with 7 M HNO_3, (5) washing twice with 10 M HCl, and (6) elution with a 10 M HCl to 0.5 M HI solution. After four interations of the sequence, the combined solution was evaporated to dryness on an acrylic-coated aluminum counting planchet.

B. Detection Techniques

Several Ge(Li) detectors and the Livermore Compton-suppression system[10] were used during this investigation. Energy and intensity measurements were made with a 6-cc planar with resolution ranging from 1.5 keV at low energies to 2.3 keV at ^{60}Co. A 20-cc five-sided coaxial detector with a resolution of 3 keV at ^{60}Co was employed for intensity and half-life determinations, and because of its greater efficiency was particularly useful in the analysis of weak lines. Energy measurements of peaks above 1900 keV were made with this detector. Compton-suppressed data were taken for energies up to 800 keV. The region 300 keV was investigated most effectively by means of a 1-cc thin-window Ge(Li) detector with a resolution of 650 eV at 60 keV (^{241}Am). Use was made of conventional low-noise preamplifiers and amplifiers, and Nuclear Data 4096-channel pulse-height analyzers. Zero and gain were stabilized with an ultrastable mercury relay pulser.[11] The conversion gain employed was 0.6 keV/channel in general and 0.14 keV/channel for the thin-win-

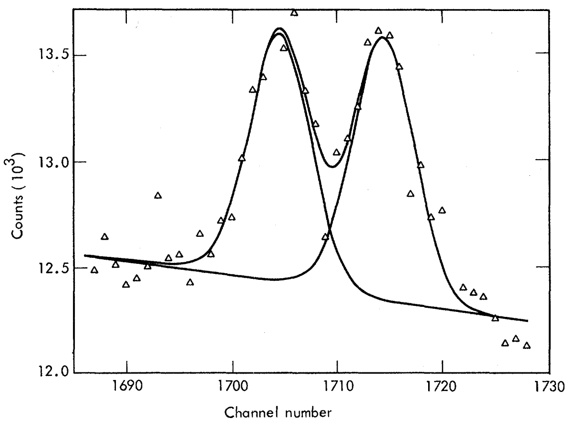

FIG. 1. Doublet at 237.19–238.61 keV from the thin-window spectrum.

dow detector measurements.

Peak locations and areas were determined with the aid of a least-squares-fitting computer code. A photopeak representation was used which included the combination of a Gaussian and a modified exponential tail on a first- or second-order polynomial background. The energy dependence of the Gaussian width and low-energy tail parameter was obtained from a polynomial fit to parameters determined from representative, well-isolated peaks. The code was particularly useful in optimum fitting of multiple peaks. An example is shown in Fig. 1. Statistical errors associated with the goodness of fit were also determined by the code. The errors in γ-ray energy (intensity) were determined by combining the errors in peak location (area) in quadrature with the errors in the energy (relative efficiency) calibration.

Energy calibration of prominent Am and Cm lines was accomplished by accumulating spectra of calibration sources simultaneously with the source under investigation. The prominent lines then were used as an internal calibration in order to determine the energies of the weaker lines. The nonlinearity of the electronic system was determined using a precision step pulser[11] fed in at the preamplifier. A ninth-order polynomial was fitted by least squares to the pulser peak channel locations and pulser input voltages. This fit, together with the channel locations and energies

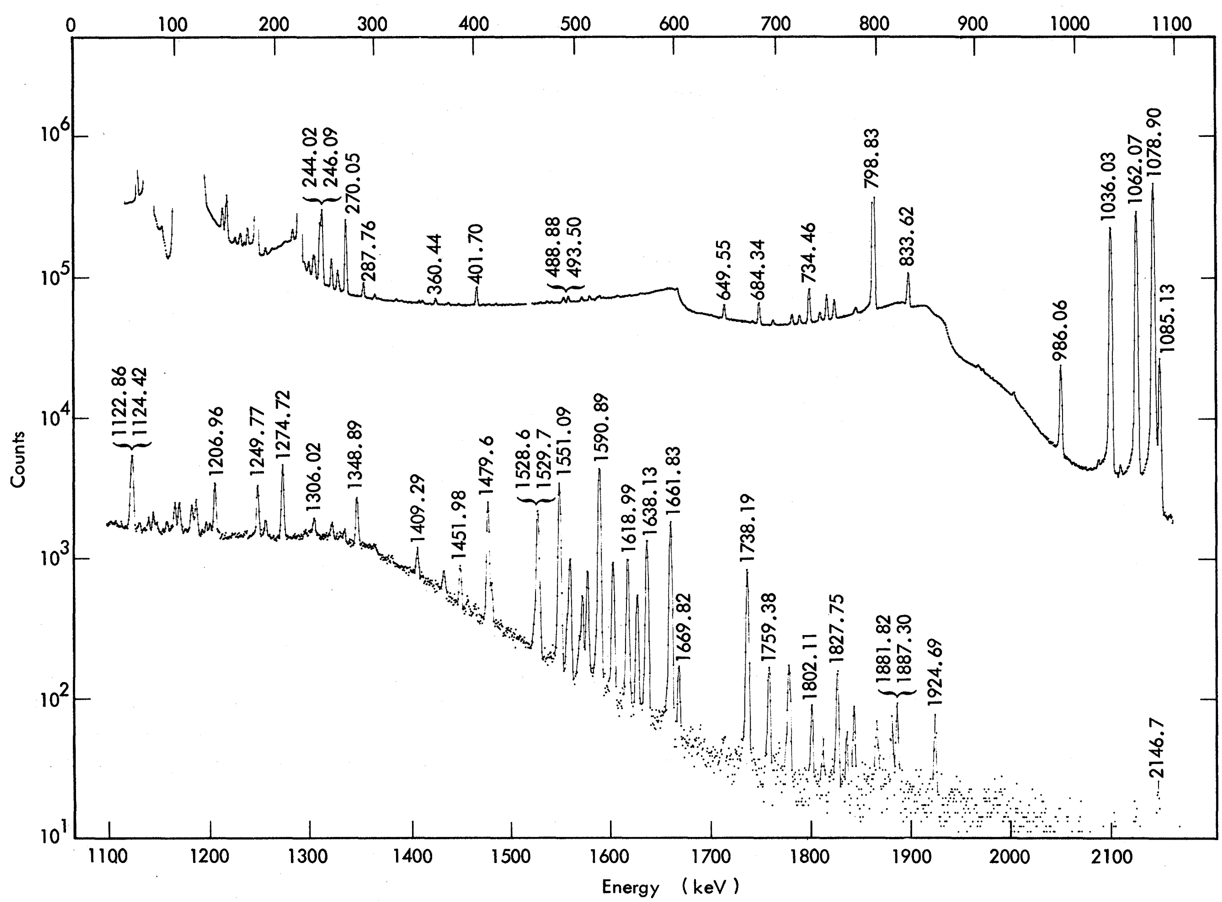

FIG. 2. γ-ray singles spectrum.

TABLE I. γ-ray calibration standards and source lines used as internal standards.

Source	E_γ
^{241}Am	59.536 ± 0.001
^{109}Cd	88.034 ± 0.010
^{57}Co	122.046 ± 0.020
^{141}Ce	145.442 ± 0.006
^{139}Ce	165.852 ± 0.010
Am line	179.94 ± 0.02
Am line	223.75 ± 0.02
^{203}Hg	279.191 ± 0.008
^{51}Cr	320.080 ± 0.013
^{198}Au	411.795 ± 0.009
^{137}Cs	661.627 ± 0.020
Cm line	798.84 ± 0.04
^{54}Mn	834.81 ± 0.03
^{88}Y	898.04 ± 0.04
Cm line	1036.03 ± 0.04
Cm line	1062.07 ± 0.04
^{65}Zn	1115.51 ± 0.07
^{60}Co	1173.23 ± 0.03
^{22}Na	1274.55 ± 0.04
^{60}Co	1332.508 ± 0.015
^{88}Y	1836.13 ± 0.04

of the standard lines, was used to determine the energies of the prominent unknown lines.

The relative-efficiency curves for the detectors were determined by using standard γ-ray sources calibrated by the International Atomic Energy Agency. These sources included ^{241}Am, ^{57}Co, ^{203}Hg, ^{137}Cs, ^{54}Mn, ^{22}Na, ^{60}Co, and ^{88}Y. Relative-intensity measurements of ^{24}Na and ^{180}Hf γ rays were also used to determine the shape of the relative-efficiency curves. The uncertainty in accuracy of the primary standards was less than 1%. The errors adopted for the relative-efficiency curves were 5% below 300 keV, 3% from 300 to 1400 keV, and 5% above 1400 keV.

TABLE II. γ rays in ^{246}Pu decay.

E_γ (keV)	I_{rel}	Transition From	To
27.58 ± 0.02	14.1 ± 1.5	43.81	16.23
43.81 ± 0.02	100 ± 5	43.81	g.s.
66.60 ± 0.02	1.02 ± 0.07	299.35	232.76
75.64 ± 0.02	0.72 ± 0.10	299.35	223.75
149.42 ± 0.03	0.23 ± 0.19	223.75	74.33
158.42 ± 0.03	0.14 ± 0.03	232.76	74.33
179.94 ± 0.02	38.8 ± 1.9	223.75	43.81
189.00 ± 0.04	0.19 ± 0.03	232.76	43.81
216.55 ± 0.04	0.45 ± 0.07	232.76	16.23
223.75 ± 0.02	94 ± 7	223.75	g.s.
232.75 ± 0.03	0.32 ± 0.05	232.76	g.s.
255.54 ± 0.03	0.92 ± 0.07	299.35	43.81
299.34 ± 0.06	0.12 ± 0.03	299.35	g.s.

III. EXPERIMENTAL RESULTS

Figure 2 shows a typical spectrum taken on the 6-cc diode. The capability of the thin-window diode is illustrated by the doublet shown in Fig. 1. In previous work,[4] these peaks were unresolved.

Several detectors, including the thin-window diode, were used to calibrate intense Am and Cm lines. The standard sources, and lines used as internal standards, are listed in Table I. γ rays assigned to ^{246}Pu decay are listed in Table II, with their relative intensities and placements in the decay scheme. A previous report[12] of the ^{246}Pu decay scheme deduced from γ rays observed in this work included four new levels at 16.23 ± 0.03, 74.33 ± 0.05, 232.76 ± 0.03, and 299.35 ± 0.04 keV, in addition to prominent levels at 43.81 ± 0.02 and 223.75 ± 0.02 keV observed in other studies.[1,3] Level characteristics were presented in the earlier report[12] and will not be described further here. γ rays assigned to ^{246m}Am decay are listed in Table III, with those which could not be placed in either decay scheme.

Intensity values given in Tables II and III were derived largely from the 20-cc spectra. At low energies, 6-cc and thin-window results were used. Half-life information was obtained by comparing spectra taken 50 days apart, with counting times of 2 and 8 days, respectively. Relative half-lives were determined by comparing intensity changes with that of the 798.83-keV peak. All γ rays listed in these tables were found to have half-life values that are, to within error, the same as that of the 798.83-keV transition. Except where noted, relative half-life values were within ±10%. In addition to those listed in Tables II and III, six γ rays in the spectra had a half-life of 9.5 ± 0.8 days: 61.58 ± 0.07, 62.66 ± 0.03, 145.85 ± 0.02, 150.32 ± 0.02, 163.02 ± 0.05, and 164.07 ± 0.04 keV. These were not placed in any decay scheme.

IV. LEVEL SCHEME FOR ^{246}Cm AND DISCUSSION

We propose the ^{246}Cm level scheme shown in Figs. 3 and 4. This scheme is based primarily on the consistent results we attain by using the accurate energy values from our γ-ray spectra. We also make use of previous work[3,4] on coincidence measurements of the more intense peaks in ^{246m}Am decay and coincidence and conversion-electron measurements of ^{246}Bk decay. Relative β-decay intensities were determined from the required intensity balance for the population and decay of levels. Logft values were computed by assuming the 7% of the total decay goes to the 2^+ level of the ground-state band (see Sec. IV A). β-decay information is summarized in Table IV.

TABLE III. γ rays in ^{246m}Am decay.

E_γ (keV)	I_{rel}	Transition From	Transition To
99.2 ± 0.2 [a]	0.60 ± 0.10	142.00	42.87
138.48 ± 0.11	0.05 ± 0.01		
170.96 ± 0.03	0.48 ± 0.05	1249.81	1078.90
195.60 ± 0.10 [a]	0.06 ± 0.02	1300.48	1104.94
(228.4 ± 0.4) [a]	0.10 ± 0.09	1104.94	876.48
237.19 ± 0.04	0.52 ± 0.06	1078.90	841.70
238.61 ± 0.03	0.53 ± 0.05	1366.66	1128.03
244.02 ± 0.02	2.47 ± 0.17	1348.89	1104.94
246.09 ± 0.02	3.5 ± 0.2		
251.29 ± 0.11	0.09 ± 0.02	(1128.03	876.48)
261.67 ± 0.03	0.56 ± 0.09	1366.66	1104.94
263.20 ± 0.11	0.12 ± 0.06	1104.94	841.70
270.05 ± 0.02	3.66 ± 0.18	1348.89	1078.90
287.76 ± 0.03	0.45 ± 0.05	1366.66	1078.90
(293.6 ± 0.2) [a]	0.017 ± 0.007	(1593.80	1300.48)
321.06 ± 0.06	0.061 ± 0.013	1621.55	1300.48
344.03 ± 0.12	0.074 ± 0.018	1593.80	1249.81
347.24 ± 0.09	0.10 ± 0.02	1452.06	1104.94
354.62 ± 0.19 [a]	0.03 ± 0.02	1604.31	1249.81
360.44 ± 0.05	0.22 ± 0.02	1526.06	1165.73
373.41 ± 0.07 [a]	0.09 ± 0.03	(1478.42	1104.94)
383.84 ± 0.17 [a]	0.06 ± 0.03	1633.73	1249.81
401.70 ± 0.03	0.95 ± 0.06	1526.06	1124.42
421.21 ± 0.12	0.08 ± 0.03	1526.06	1104.94
456.12 ± 0.08 [a]	0.08 ± 0.03	(1621.55	1165.73)
465.8 ± 0.2	0.09 ± 0.03	1593.80	1128.03
472.31 ± 0.10	0.13 ± 0.04	1348.89	876.48
476.95 ± 0.15	0.07 ± 0.02	1601.31	1124.42
488.88 ± 0.07	0.34 ± 0.05	1593.80	1104.94
493.50 ± 0.05	0.43 ± 0.05	1621.55	1128.03
505.59 ± 0.13 [a]	0.06 ± 0.05	1633.73	1128.03
507.06 ± 0.07 [a]	0.28 ± 0.06	1348.89	841.70
514.92 ± 0.09 [a]	0.33 ± 0.12	1593.80	1078.90
522.8 ± 0.2 [a]	0.06 ± 0.02	(1601.31	1078.90)
525.04 ± 0.09 [a]	0.28 ± 0.06	1366.66	841.70
528.5 ± 0.2 [a]	0.09 ± 0.04	1633.73	1104.94
542.99 ± 0.11	0.10 ± 0.03	1671.07	1128.03
554.7 ± 0.2 [a]	0.09 ± 0.04	1633.73	1078.90
565.89 ± 0.14	0.14 ± 0.04	1671.07	1104.31
568.3 ± 0.2 [a]	0.09 ± 0.04		
592.19 ± 0.06 [a]	0.05 ± 0.04	1671.07	1078.90
602.7 ± 0.5 [a]	0.6 ± 0.2		
649.55 ± 0.04	1.33 ± 0.08	1526.06	876.48
677.95 ± 0.15	0.17 ± 0.03	1601.31	923.24
684.34 ± 0.04	2.16 ± 0.14	1526.06	841.70
698.26 ± 0.08	0.42 ± 0.07	1621.55	923.24
702.0 ± 0.3 [a]	0.06 ± 0.03	1780.96	1078.90
717.22 ± 0.05	0.93 ± 0.10	1593.80	876.48
723.3 ± 0.2 [a]	<0.1	1802.35	1078.90
724.83 ± 0.05	0.86 ± 0.11	1601.31	876.48
734.46 ± 0.04	4.7 ± 0.2	876.48	142.00
745.17 ± 0.06	0.90 ± 0.14	1621.55	876.48
752.05 ± 0.04	3.2 ± 0.2	1593.80	841.70
759.60 ± 0.04	2.43 ± 0.17	1601.31	841.70
779.68 ± 0.06	0.27 ± 0.07	1621.55	841.70
781.24 ± 0.04	0.68 ± 0.10	923.24	142.00
798.83 ± 0.04	100 ± 5	841.70	42.87
820.3 ± 0.3 [a]	0.10 ± 0.09	1661.84	841.70
833.62 ± 0.04	7.3 ± 0.4	876.48	42.87
904.47 ± 0.14 [a]	0.20 ± 0.08	1780.96	876.48
(908.30 ± 0.18)	0.14 ± 0.08	(2032.74	1124.42)
939.14 ± 0.07	0.30 ± 0.09	1780.96	841.70
960.41 ± 0.15 [a]	0.05 ± 0.04	1802.35	841.70
986.06 ± 0.04	3.86 ± 0.19	1128.03	142.00
1023.5 ± 0.4	0.11 ± 0.04	1165.73	142.00
1036.03 ± 0.04	52 ± 3	1078.90	42.87
1045.7 ± 0.2 [a]	0.16 ± 0.04	1887.24	841.70
1062.07 ± 0.04	69 ± 4	1104.94	42.87
1078.90 ± 0.04	113 ± 6	1078.90	g.s.
1085.13 ± 0.07	6.2 ± 0.7	1128.03	42.87
1113.21 ± 0.07	0.021 ± 0.018		
1122.86 ± 0.07	0.45 ± 0.07	1165.73	42.87
1124.42 ± 0.06	0.93 ± 0.10	1124.42	g.s.
1131.6 ± 0.2 [a]	0.06 ± 0.03		
1148.59 ± 0.14 [a]	0.055 ± 0.011		
1158.42 ± 0.15	0.08 ± 0.03	1300.48	142.00
1166.91 ± 0.08 [a]	0.26 ± 0.04	(1209.81	42.87)
1176.5 ± 0.9	0.027 ± 0.010		
1185.2 ± 0.3 [a]	0.10 ± 0.05		
1198.11 ± 0.10 [a]	0.11 ± 0.04		
1201.92 ± 0.10 [a]	0.10 ± 0.05		
1206.96 ± 0.05	0.66 ± 0.07	1249.81	42.87
1209.82 ± 0.25 [a]	0.04 ± 0.03	(1209.81	g.s.)
1237.7 ± 0.3 [a]	0.046 ± 0.019		
1249.77 ± 0.05	0.64 ± 0.05	1249.81	g.s.
1257.58 ± 0.09	0.166 ± 0.018	1300.48	42.87
1274.72 ± 0.06	1.15 ± 0.07	(1317.59	42.87)
1303.4 ± 0.4 [a]	0.06 ± 0.03		
1306.02 ± 0.10	0.05 ± 0.02	1348.89	42.87
1323.98 ± 0.10	0.159 ± 0.017	1366.66	42.87
1336.36 ± 0.14 [a]	0.09 ± 0.02	1478.42	142.00
1348.89 ± 0.06	0.63 ± 0.04	1348.89	g.s.
1367.5 ± 0.3 [a]	0.06 ± 0.05	(1509.33	142.00)
1383.9 ± 0.2	0.033 ± 0.010	1526.06	142.00
1409.29 ± 0.12	0.149 ± 0.014	1452.06	42.87
1435.61 ± 0.13	0.105 ± 0.017	1478.42	42.87
1451.98 ± 0.08	0.20 ± 0.02	1452.06	g.s.
1459.16 ± 0.18 [a]	0.06 ± 0.01	1601.31	142.00
1466.5 ± 0.3 [a]	0.024 ± 0.012	(1509.33	42.87)
1479.6 ± 0.2	1.01 ± 0.10	1621.55	142.00
1483.18 ± 0.12 [a]	0.15 ± 0.06	1526.06	42.87
1528.6 ± 0.5 [a]	0.40 ± 0.08	1671.07	142.00
1529.7 ± 0.5	0.67 ± 0.11		
1551.09 ± 0.10	1.61 ± 0.08	1593.80	42.87
1558.68 ± 0.19 [a]	0.09 ± 0.03	1601.31	42.87
1561.44 ± 0.11	0.50 ± 0.08	1604.31	42.87
1570.51 ± 0.15 [a]	0.06 ± 0.04	(1712.62	142.00)
1573.78 ± 0.11 [a]	0.21 ± 0.05		
1578.83 ± 0.10 [a]	0.37 ± 0.04	1621.55	42.87
1590.89 ± 0.10	2.25 ± 0.11	1633.73	42.87
1604.31 ± 0.10	0.45 ± 0.03	1604.31	g.s.
1618.99 ± 0.10	0.57 ± 0.03	1661.84	42.87
1628.39 ± 0.15	0.241 ± 0.017	1671.07	42.87
1638.13 ± 0.10	0.69 ± 0.04	(1681.00	42.87)
1661.83 ± 0.10	1.01 ± 0.06	1661.84	g.s.
1669.82 ± 0.13	0.070 ± 0.008	(1712.62	42.87)

TABLE III *(Continued)*

E_γ (keV)	I_{rel}	Transition From	To	E_γ (keV)	I_{rel}	Transition From	To
1714.8 ±0.2 [a]	0.011±0.004	1856.76	142.00	1903.9 ±0.3 [a]	0.03 ±0.01		
1738.19±0.11	0.49 ±0.03	1780.96	42.87	1924.69±0.16	0.031±0.003	1924.69	g.s.
1759.38±0.12 [a]	0.087±0.013	1802.4	42.87	1990.0 ±0.3 [a]	0.005±0.002	(2032.7	42.87)
1769.5 ±0.5 [a]	0.15 ±0.12			2028.1 ±0.5 [a]	0.013±0.010	2170.9	142.00
1779.18±0.10 [a]	0.12 ±0.01			2032.7 ±0.5 [a]	0.006±0.004	(2032.7	g.s.)
1802.11±0.14	0.041±0.007	1802.4	g.s.	2058.8 ±0.3 [a]	0.004±0.002		
1813.88±0.12 [a]	0.014±0.004	1856.76	42.87	2068.2 ±0.3 [a]	0.004±0.002		
1827.75±0.12	0.083±0.009			2103.0 ±0.5 [a]	0.004±0.002	(2146.7	42.87)
1837.2 ±0.3	0.016±0.006			2124.1 ±0.5 [a]	0.025±0.019		
1844.24±0.17 [a]	0.038±0.008	1887.24	42.87	(2128.1 ±0.5) [a]	0.006±0.004	(2170.9	42.87)
1867.2 ±0.2	0.027±0.011			2146.7 ±0.3 [a]	0.010±0.004	(2146.7	g.s.)
1881.82±0.17	0.030±0.006	1924.69	42.87	2168.9 ±0.5 [a]	0.005±0.003		
1887.30±0.15	0.054±0.009	1887.24	g.s.				

[a] Half-life values differed from the 798.83-keV peak value by more than 10%. However, associated uncertainties also were large.

A. Ground-State Band

Energies of the 2^+ and 4^+ members of the ^{246}Cm ground-state rotational band are 42.87 and 142.00 keV. These energies have been established from the 4^+ to 2^+ γ ray of 99.2 keV and from differences in the energies of γ rays populating the 0^+, 2^+, and 4^+ members. The 6^+ and 8^+ members of the band at 295.9 and 501 keV, respectively, have been identified in previous studies[5,6] of the decay of a 39-min high-spin state in ^{246}Am (see Sec. IV M).

β decay to the 2^+ state has been measured by Smith *et al.*[2] at 7% ($\log ft = 8.1$) of the total decay. No β decay to the ground state or the 4^+ level was observed, which is consistent with either of the possible assignments for the ^{246}Am isomer (2^-; $\frac{5}{2}^+[642]\uparrow p - \frac{9}{2}^-[734]\uparrow n$ or 2^+; $\frac{5}{2}^-[523]\uparrow p - \frac{9}{2}^-[734]\uparrow n$).

B. $K^\pi = 2^-$ Band at 841.70 keV

Levels at 841.70 and 876.48 keV have been observed[3,4] in both ^{246m}Am and ^{246}Bk decay. Spin and parity assignments of 2^- and 3^-, respectively, were made on the basis of γ deexcitation and conversion-electron intensities. Logft values of 7.0 and 7.9 from the present work are consistent with the $K^\pi = 2^-$ collective-band assignment of Stevens *et al.*[3] The band was constructed by Soloviev and Siklos[8] from the two configurations $n-n$ $\frac{9}{2}^+[624]\uparrow - \frac{11}{2}^-[725]\uparrow$ and $p-p$ $\frac{7}{2}^+[633]\uparrow - \frac{3}{2}^-[521]\uparrow$, with a small admixture of the two-neutron $\frac{7}{2}^+[624]\downarrow - \frac{11}{2}^-[725]\uparrow$. The energy separation of the 2^- and 3^- levels leads to the prediction of a 4^- level at an energy [where $E_I = E_0 + AI(I+1)$] of 922.85 keV. A level is added in this work at 923.24 keV, based on a 781.24-keV transition to the 4^+ level of the ground-state band and the γ population from levels at 1601.31 and 1621.55 keV. The absence of transitions to other members of the ground-state band and the intensity balance which indicates no β feeding are consistent with a spin and parity of 4^-. Adding this level strongly supports the $K^\pi = 2^-$ band assignment.

C. $K^\pi = 1^-$ Band at 1078.90 keV

This band, which is populated in both ^{246m}Am and ^{246}Bk decay,[4] has levels at 1078.90, 1104.94, and 1128.03 keV. The spin sequence of 1^-, 2^-, 3^- is well established by the observed pattern of γ deexcitations and by conversion-electron measurements. The logft value of 6.3 for the 1078.90-keV level is consistent with an allowed decay or a first-forbidden decay with no K forbiddenness. Also, the relative reduced transition intensities to the ground-state band are in good agreement with the Alaga ratios for $K_i = 1$ to $K_f = 0$ as shown in Table V. Observed transitions between members of the 1078.90- and 841.70-keV bands should be of the same ($M1$) multipolarity for a K^π_i of 1^-. The similarity of the reduced transition intensities (Table V) supports the assignment.

The most reasonable two-quasiparticle assignment is that made by Stevens *et al.*[3] of the two-neutron state $\frac{7}{2}^+[624]\downarrow - \frac{9}{2}^-[734]\uparrow$ calculated by Soloviev and Siklos[8] to have an energy of 1.1 MeV. However, significant mixing of other configurations must be invoked to explain the intense γ population from the $K^\pi = 1^-$ band at 1348.89 keV (see Sec. IV G). Also, Orth[4] has pointed out that the logft of 7.1 from ^{246}Bk decay is not consistent with a hindered $\Delta\Lambda = 3$ transition associated with a pure two-quasiparticle state. Recent calculations of Neergaard and Vogel[13] indicate that a

$K^\pi = 1^-$ octupole state should be present at an energy of approximately 830 keV. This is considered the most probable assignment for the 1078.90-keV band. A more exact comparison with results of Neergaard and Vogel would require wave functions and state energies not given explicitly in Ref. 13.

D. $K^\pi = 2^+$ Band at 1124.42 keV

Levels at 1124.42 and 1165.73 keV appear to be fed very weakly or not at all by β decay. Neither is observed to decay to levels other than those of the ground-state band, and both are populated predominantly from a level at 1526.06 keV.

The level at 1124.42 keV was seen by Orth[4] in ^{246}Bk decay where transitions to the 0^+ and 2^+ members of the ground-state band are observed. In this work, the 0^+ transition is clearly observed, but the 2^+ transition is obscured by the intense 1078.90 – 1085.13-keV doublet. Possible level assignments are $1^\pm$ and 2^+. Orth[4] also measured the conversion coefficients of the 0^+ and 2^+ transitions from the 1124.42-keV level in ^{246}Bk decay and found them both to be in agreement with predictions for $E2$ transitions.

The 1165.73-keV level decays by transitions to the 2^+ and 4^+ levels of the ground-state band, thus indicating a spin and parity of $3^\pm$ or 4^+. A 2^+ assignment is unlikely because of the absence of a transition to the ground state. Consideration of the energy separation of the two levels (41.31 keV), as well as the possible spin and parity values, suggests a level sequence for the band of 2^+, 3^+ ($K^\pi = 2^+$) or 1^-, 3^- ($K^\pi = 0^-$). Of the two, the conversion-electron data, γ-transition and β-decay intensities, and level energies strongly favor the $K^\pi = 2^+$ assignment.

With the aid of Orth's ^{246}Bk decay data, we can obtain γ intensity ratios for deexcitation from both the 1124.42- and 1165.73-keV levels. These are shown in Table VI, where they are compared with Alaga ratios for the two possible band assignments $K^\pi = 2^+$ and 0^-. Agreement is good only for the $K^\pi = 2^+$ case. γ population of the 1124.42-keV band also favors the $K^\pi = 2^+$ assignment, as there

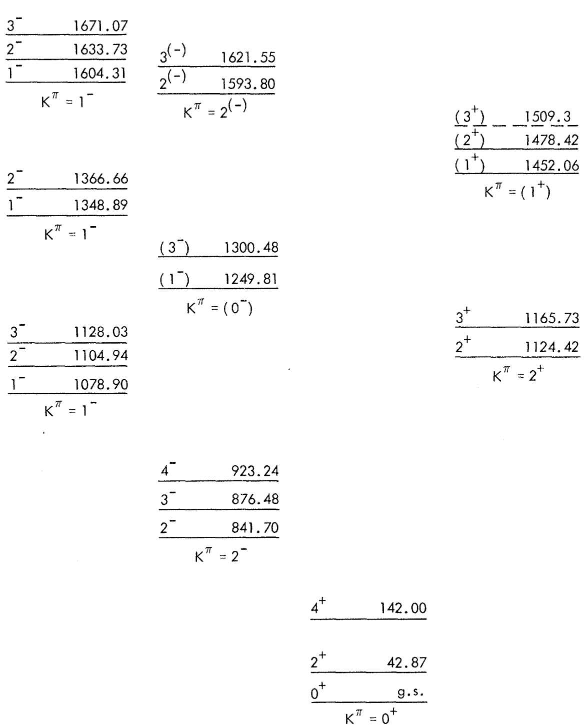

FIG. 4. Rotational bands in ^{246}Cm.

TABLE IV. β decay of ^{246m}Am.

Level	$I^\pi K$	E_β	%	Logft
0	0^+0			
42.87 ± 0.02	2^+0	2247	7 [a]	8.1
142.00 ± 0.04	4^+0			
841.70 ± 0.04	2^-2	1448	21.8	7.0
876.48 ± 0.04	3^-2	1414	1.68	7.9
923.24 ± 0.06	4^-2	1367	0.007	⩾10.1
1078.90 ± 0.04	1^-1	1211	38.1	6.3
1104.94 ± 0.05	2^-1	1185	14.7	6.7
1124.42 ± 0.06	2^+2	1166	⩽0.2	⩾8.6
1128.03 ± 0.05	3^-1	1162	1.9	7.6
1165.73 ± 0.08	3^+2	1124	0.040	⩾9.1
(1209.81 ± 0.07)		1080	0.074	8.9
1249.81 ± 0.05	(1^-0)	1040	1.1	7.7
1300.48 ± 0.11	(3^-0)	990	0.14	8.5 ± 0.2
(1317.59 ± 0.06)		972	0.71	7.8
1348.89 ± 0.06	1^-1	941	4.2	7.0
1366.66 ± 0.04	2^-1	923	1.2	7.4 ± 0.2
1452.06 ± 0.08	(1^+1)	838	0.119	8.3
1478.42 ± 0.10	(2^+1)	812	0.082	8.4
(1509.3 ± 0.3)	(3^+1)	781	0.020	9.0 ± 0.5
1526.06 ± 0.06	3^+3	764	1.6	7.0
1593.80 ± 0.10	(2^-2)	696	1.87	6.8
1601.31 ± 0.06	$3^\pm3$	689	0.96	7.3
1604.31 ± 0.06	1^-1	686	0.25	7.8
1621.55 ± 0.15	(3^-2)	668	0.99	7.0
1633.73 ± 0.10	2^-2	656	0.63	7.2
1661.84 ± 0.07	(1^-1)	628	0.39	7.4
1671.07 ± 0.10	3^-1	619	0.25	7.5
(1681.00 ± 0.10)	(2^-1)	609	0.19	7.6
(1712.62 ± 0.13)	(3^-1)	577	0.032	8.3 ± 0.2
1780.96 ± 0.10		509	0.27	7.2
1802.19 ± 0.12		488	⩾0.03	⩽8.1
1856.76 ± 0.12		433	0.0062	8.6
1887.24 ± 0.15		403	0.062	7.5
1924.69 ± 0.15		365	0.0151	8.0
(2032.7 ± 0.2)		257	0.037	7.1
(2146.7 ± 0.3)		143	0.0052	7.9 ± 0.2
(2170.9 ± 0.4)		119	0.0047	8.1 ± 0.6

[a] See Ref. 2.

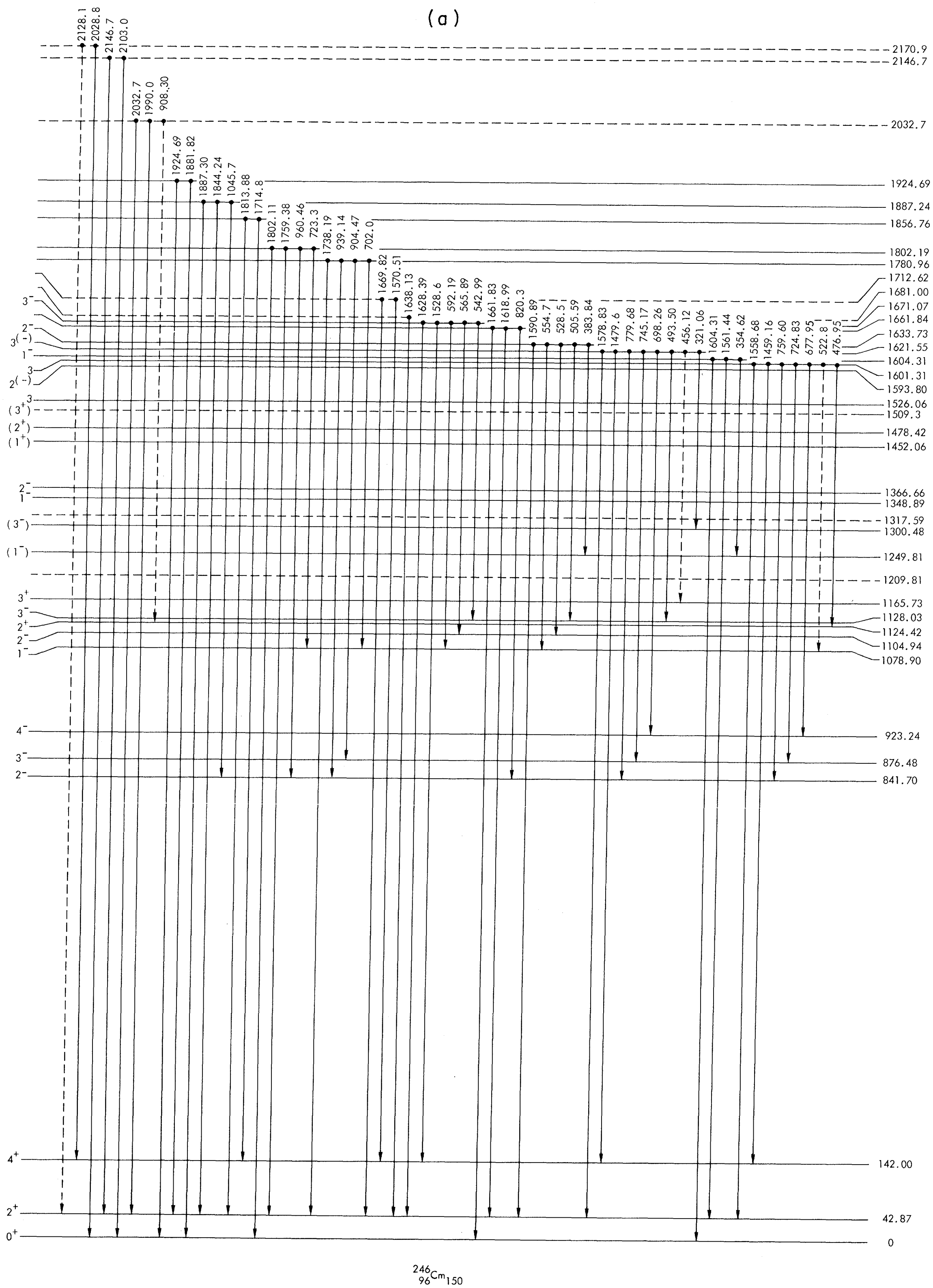

FIG. 3. Decay scheme of ^{246m}Am.

(b)

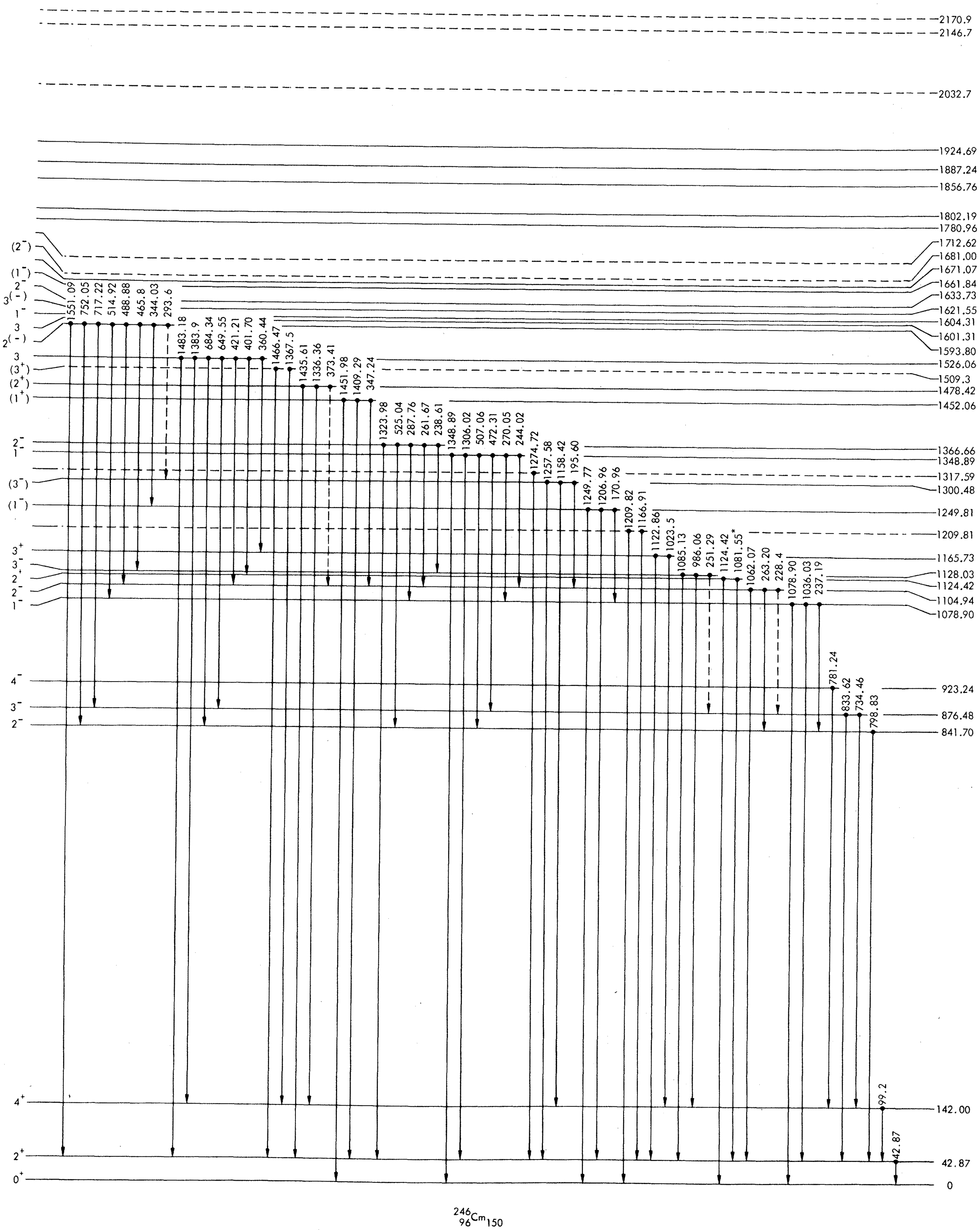

FIG. 3 *(Continued)* Asterisk in (b) denotes 1081.55-keV transition observed by Orth (Ref. 4) which is obscured in ^{246m}Am decay.

TABLE V. Relative transition probabilities from the $K^\pi = 1^-$ bands at 1078.90 and 1348.89 keV.

E_γ	To E_{final}	$I^\pi K_{final}$	$B(E \text{ or } M1)_{rel}$	$B(E \text{ or } M1)_{theor}$ ($K_i = 1$)
		From the 1078.90-keV level (1^-1)		
237.19	841.70	2^-2	1.3 ± 0.2	
1036.03	42.87	2^+0	0.52 ± 0.04	0.50
1078.90	0	0^+0	1.00	1.00
		From the 1104.94-keV level (2^-1)		
228.4	876.48	3^-2	0.5 ± 0.4	
263.20	841.70	2^-2	0.28 ± 0.16	
1062.07	42.87	2^+0	1.00	
		From the 1128.03-keV level (3^-1)		
251.29	876.48	3^-2	0.33 ± 0.10	
986.06	142.00	4^+0	0.83 ± 0.10	0.75
1085.13	42.87	2^+0	1.00	1.00
		From the 1348.89-keV level (1^-1)		
244.02	1104.94	2^-1	1.06 ± 0.10	
270.05	1078.90	1^-1	1.00	
472.31	876.48	3^-2	$(3.4 \pm 1.3) \times 10^{-3}$	
507.06	841.70	2^-2	$(6 \pm 3) \times 10^{-3}$	
1306.02	42.87	2^+0	$(1.9 \pm 0.8) \times 10^{-4}$	2.5×10^{-4}
1348.89	0	0^+0	$(5.6 \pm 0.6) \times 10^{-4}$	5.6×10^{-4}
		From the 1366.66-keV level (2^-1)		
238.61	1128.03	3^-1	1.00	
261.67	1104.94	2^-1	0.68 ± 0.15	
287.76	1078.90	1^-1	0.36 ± 0.06	
525.04	841.70	2^-2	$(2.0 \pm 0.6) \times 10^{-2}$	
1323.98	42.87	2^+0	$(5.8 \pm 1.5) \times 10^{-4}$	

is evidence that the 1526.06- and the 1601.31-keV levels which decay to it have K values of 3. Transitions to a $K = 0$ band would be K hindered, which is not consistent with the measured γ intensity values.

β population of the 1124.42- and 1165.73-keV levels is weak ($\log ft \geq 8.6$), which could be explained by K forbiddenness of decay to a $K^\pi = 0^-$ band. However, the $\log ft$ value of 6.6 measured by Orth[4] for decay from ^{246}Bk($K^\pi = 2^-$) to the 1124.42-keV level is very low for a K-forbidden decay. β decay, therefore, favors a $K^\pi = 2^+$ assignment. Additional evidence for the $K^\pi = 2^+$ value is given by the 41.31-keV separation of the two levels, corresponding to a moment of inertia [where $E_I = E_0 + \frac{1}{2}\hbar^2 \mathcal{I} I(I+1)$] of $\mathcal{I}_{K=2} = 1.04 \mathcal{I}_{g.s.}$.

Calculations by Soloviev and Siklos[8] indicate that $K^\pi = 2^+$ two-quasiparticle states should have energies of 1.7 and 2.0 MeV. The low energy of the 1124.42-keV band suggests a collective γ-vibration description. Soloviev and Siklos construct a collective 2^+ state of the two-neutron configurations $\frac{5}{2}^+[622]\uparrow - \frac{1}{2}^+[620]\uparrow$, $\frac{7}{2}^+[624]\downarrow - \frac{3}{2}^+[622]\downarrow$, and $\frac{3}{2}^+[622]\downarrow + \frac{1}{2}^+[620]\uparrow$. Their calculated energy of 0.8 MeV suggests that the 1124.42-keV band is somewhat less collective. However, if the band is composed of the configurations given by Soloviev and Siklos, the large $\log ft$ value (≥ 8.6) for β population in ^{246}Am decay clearly could be due to quasiparticle forbiddenness. The $\log ft$ of 6.6 for ^{246}Bk decay to the 1124.42-keV state is also in accord with predictions (first forbidden unhindered) for the collective state.

E. Levels at 1209.81 and 1317.59 keV

A level at 1209.81 keV is suggested by γ rays of

TABLE VI. Relative $B(E2)$ values from the $K^\pi = 2^+$ band at 1124.42 keV.

Level	E_γ	Final spin g.s. band	$B(E2)_{rel}$	$B(E2)_{theory}$ ($K=0$)	($K=2$)
1124.42	1081.55	2^+	0.72 [a]	0.50	0.70
	1124.42	0^+	1.00 [a]	1.00	1.00
1165.73	1023.5	4^+	0.39 ± 0.15	1.33	0.40
	1122.86	2^+	1.00	1.00	1.00

[a]Intensity values taken from Ref. 4.

1166.91 and 1209.82 keV, whose energy difference (42.91 keV) corresponds closely to the energy of the first excited state (42.87 keV). The level at 1317.59 keV is hypothesized to explain a relatively strong γ transition which could not be placed elsewhere in the decay scheme. A $0^{\pm}$ or 2^- level at 1317.59 keV would not decay to levels of the ground-state band other than the 2^+ level. Present evidence does not justify strong conclusions regarding either of these levels.

F. Band at 1249.81 keV

A band is proposed at 1249.81 keV with a second member at 1300.48 keV. Both are populated by β decay and fed from levels of $K^\pi = 2^{(-)}$ and 1^- bands proposed at 1593.80 and 1604.31 keV, respectively. Both levels of the 1249.81-keV band decay by transitions to the 1078.90-keV $K^\pi = 1^-$ band and by hindered transitions to the ground-state band. Both also are characterized by an absence of transitions to the $K^\pi = 2^-$ band at 841.70 keV. The 1249.81-keV level is restricted to spin and parity values of $1^{\pm}$ or 2^+ by an observed crossover transition to the ground state. Spin and parity possibilities for the 1300.48-keV level are $3^{\pm}$, as indicated by transitions to the 2^+, 4^+, and 2^- levels at 42.87, 142.00, and 1104.94 keV, respectively. The absence of transitions to levels of spin less than 2 makes an I^π of 2^- improbable. Hence, spin sequences of 1^-, 3^- and 2^+, 3^+ corresponding to bands of $K^\pi = 0^-$ and 2^+, respectively, are possible. Of the two, the absence of transitions to the $K^\pi = 2^-$ band at 841.70 keV favors the $K^\pi = 0^-$ assignment. In addition, the nature of the distortion of the $K^\pi = 1^-$ bands at 1078.90 and 1348.89 keV suggests that both are Coriolis coupled to a $K^\pi = 0^-$ band lying between them. The energy of the band corresponds closely to the 1.2-MeV value calculated by Soloviev and Siklos[8] for a $K^\pi = 0^-$ octupole band and is in reasonable agreement with predictions of Neergaard and Vogel[13] for the first two members of a $K^\pi = 0^-$ band of approximately 1220 (1^-) and 1300 (3^-) keV.

G. $K^\pi = 1^-$ Band at 1348.89 keV

A band at 1348.89 keV has been postulated,[3,4] and its parity has been determined to be negative by conversion-electron measurements[4] of transitions to the $K^\pi = 1^-$ band at 1078.90 keV. The spin sequence, however, has been uncertain. This is clarified by our observation of transitions to the $K^\pi = 2^-$ band at 841.70 keV and to the ground-state band. Levels at 1348.89 and 1366.66 keV have similar logft values (7.0 and 7.4, respectively), and both are characterized by intense transitions to the 1078.90-keV band, weaker transitions to the 841.70-keV band, and greatly hindered transitions to the ground-state band. Relative transition intensities are given in Table V. The observation of a crossover transition to the ground state from the 1348.89-keV level is sufficient to specify its spin and parity as 1^-. The assignment of a 2^- value for the 1366.66-keV level is supported by the absence of transitions to levels of the ground-state band other than the 2^+ level and by the results of Orth,[4] who by conversion-electron measurements determined the multipolarity of the 287.76-keV transition to the 1^- level at 1078.90 keV to be $M1$. The similarity in intensity of the 287.76-, 261.67-, and 238.61-keV lines to 1^-, 2^-, and 3^- levels, respectively (see Table V), is evidence of a common $M1$ multipolarity. These results strongly support a 2^- spin and parity for the 1366.66-keV level. Stevens *et al.*[3] have identified the 1348.89-keV band with the two-proton configuration $\frac{5}{2}^-[523]\downarrow + \frac{7}{2}^+[633]\uparrow$ calculated by Soloviev and Siklos[8] to have a bandhead energy of 1.3 MeV. If this is correct, one would expect transitions to the ground-state band to be forbidden. Weak transitions could be explained by a small amount of configuration mixing. Transitions to the 1078.90-keV band would also be forbidden if the 1078.90-keV configuration were the two-neutron $\frac{7}{2}^+[624]\downarrow + \frac{9}{2}^-[734]\uparrow$. A significant amount of mixing of the n-n and p-p configurations of the 1078.90- and 1348.89-keV bands would be required to explain the intense transitions between them. However, if the 1078.90 keV is identified with the $K^\pi = 1^-$ octupole state, the two-quasiparticle overlap may be sufficient to explain the observed intensity.

H. Band at 1452.06 keV

Levels are proposed at 1452.06 and 1478.42 keV on the basis of γ rays whose energies give a consistent fit for transitions to the ground-state band and the 1104.94-keV level. γ transitions place spin and parity restrictions of $1^{\pm}$, 2^+ and 2^+, $3^{\pm}$ on the 1452.06- and 1478.42-keV levels, respectively. The similar pattern of γ deexcitations and nearly equal logft values of 8.3 and 8.4 suggest that these levels are components of a band. Spin and parity values would allow a K^π of 1^+, 2^+, or 0^-. A third level is tentatively proposed at 1509.3 keV, based on weak γ rays of 1367.5 and 1466.5 keV which could not be placed elsewhere in the decay scheme and whose energies are consistent with transitions to the 2^+ and 4^+ levels of the ground-state band. Possible spin and parity values are 2^+, $3^{\pm}$, and 4^+, with the 2^+ being least likely in the absence of a crossover transition to the ground state. The energy spacing of this level and those at 1452.06 and 1478.42 keV suggest that they form a band with $K^\pi = 1^+$.

I. Levels at 1526.06 and 1601.31 keV

Levels with $I^\pi K = 3^\pm 3$ are proposed at 1526.06 and 1601.31 keV. These are considered together because of the similarity of their decay properties. Both are populated by β decay ($\log ft$ values of 7.0 and 7.3, respectively) with no observed contribution from γ decay of higher-lying levels. Both levels decay by γ transitions to $K^\pi = 0^+$, 2^-, 1^-, and 2^+ bands at 0, 841.70, 1078.90, and 1124.42 keV, respectively. Possible spin and parity values of 2^+ and $3^\pm$ for the 1526.06-keV level are indicated by γ transitions to 2^+, 2^-, and 4^+ levels. The absence of transitions to the ground state and 1^- level at 1078.90 keV argues against the 2^- assignment. In the case of the 1601.31-keV level, γ transitions to levels of $I^\pi = 2^+$, 2^-, 4^+, and 4^- limit the spin and parity possibilities to $3^\pm$.

The similarity of the 1526.06- and 1601.31-keV levels suggests that they are a part of a common band. However, the possible spins (both 3) and energy separation (75.25 keV) argue strongly against this possibility. The absence of other levels which can be associated with either the 1526.06- or 1601.31-keV level suggests that each is the bandhead of a $K = 3$ band. Associated levels with a spin of 4 or higher are expected to be populated very weakly or not at all, as they require first-forbidden-unique or second-forbidden β feeding, or γ population from higher-lying levels. The $K = 3$ assignments are supported by a comparison of relative $B(E \text{ or } M1)$ values of transitions from the 1526.06- and 1601.31-keV levels. (See Table VII.) Transitions of $\Delta K = 2$ have lower relative $B(E \text{ or } M1)$ values than those for any $\Delta K = 1$ transitions. Ground-state transitions are very weak, which is consistent with hindered $\Delta K = 3$ decays.

TABLE VII. Relative transition intensities from levels at 1526.06 and 1601.31 keV.

Level	E_γ	E_{final} $(I^\pi K)$	ΔK $(K_i = 3)$	$B(E \text{ or } M1)_{\text{rel}}$
1526.06	360.44	1165.73 (3^+2)	1	0.32 ± 0.04
	401.70	1124.42 (2^+2)	1	1.00
	421.21	1104.94 (2^-1)	2	0.08 ± 0.03
	649.55	876.48 (3^-2)	1	0.33 ± 0.03
	684.34	841.70 (2^-2)	1	0.46 ± 0.04
	1383.77	142.00 (4^+0)	3	0.00089 ± 0.00028
	1483.18	42.87 (2^+0)	3	0.0031 ± 0.0013
1601.31	476.95	1124.42 (2^+2)	1	0.20 ± 0.06
	522.76	1078.90 (1^-1)	2	0.09 ± 0.03
	677.95	923.24 (4^-2)	1	0.10 ± 0.02
	724.83	876.48 (3^-2)	1	0.41 ± 0.06
	759.60	841.70 (2^-2)	1	1.00
	1459.16	142.00 (4^+0)	3	0.0034 ± 0.0006
	1558.68	42.87 (2^+0)	3	0.0041 ± 0.0012

J. Band at 1593.80 keV

A $K^\pi = 2^{(-)}$ band is proposed with a bandhead at 1593.80 keV and a 3^- member at 1621.55 keV. Both levels are populated by β decay ($\log ft$ values of 6.8 and 7.0) and both decay to levels of bands at 0, 841.70, 1078.90, and 1249.81 keV having K^π values of 0^+, 2^-, 1^-, and (0^-), respectively. The 1593.80-keV level could have spin and parity values of 2^- or 3^- on the basis of the observed γ decay, values of 1^- and 2^+ being less likely because of the absence of a transition to the ground state. Relative $B(E \text{ or } M1)$ values, shown in Table VIII, agree best with a spin assignment of 2. A spin value of 3 is indicated for the 1621.55-keV level by γ transitions to 2^+, 2^-, 4^+, and 4^- levels. Relative $B(E \text{ or } M1)$ values to the 841.70-keV $K^\pi = 2^-$ band (see Table VIII) are consistent with a spin-3 assignment. The small energy separation of the two levels (27.75 keV) suggests that the band is deformed because of significant mixing with other bands.

K. $K^\pi = 1^-$ Band at 1604.31 keV

Levels at 1604.31, 1633.73, and 1671.07 keV have similar properties and appropriate spacing to form a band with $K^\pi = 1^-$. Each level is fed by β decay ($\log ft = 7.8$, 7.2, and 7.5, respectively), and each decays by γ transitions to the ground-state band. The 1633.73- and 1671.07-keV levels also populate the spin-1, -2, and -3 levels of the K^π

TABLE VIII. Relative transition intensities from the $K^\pi = 2^{(-)}$ band at 1593.80 keV.

Level	E_γ	E_{final} $(I^\pi K)$	ΔK $(K_i = 2)$	$B(E \text{ or } M1)_{\text{rel}}$
1593.80	293.6	1300.48 (3^-0)	(2)	0.18 ± 0.09
	344.03	1249.81 (1^-0)	(2)	0.46 ± 0.12
	465.80	1128.03 (3^-1)	1	0.15 ± 0.05
	488.88	1104.94 (2^-1)	1	0.49 ± 0.08
	514.92	1078.90 (1^-1)	1	0.37 ± 0.14
	717.22	876.48 (3^-2)	0	0.33 ± 0.04
	752.05	841.70 (2^-2)	0	1.00
	1551.09	42.87 (2^+0)	2	0.052 ± 0.005
1621.55	321.06	1300.48 (3^-0)	(2)	0.026 ± 0.006
	456.12	1165.73 (3^+2)	0	0.018 ± 0.008
	493.50	1128.03 (3^-1)	1	1.00
	698.26	923.25 (4^-2)	0	0.29 ± 0.07
	745.17	876.48 (3^-2)	0	0.52 ± 0.11
	779.68	841.70 (2^-2)	0	0.14 ± 0.05
	1479.60	142.00 (4^+0)	2	0.067 ± 0.011
	1578.83	42.87 (2^+0)	2	0.020 ± 0.004

$=1^-$ band at 1078.90 keV. Transitions from the 1604.31-keV level to the 1078.90-keV band are not observed, but peaks of appropriate intensity easily could be lost in the Compton background. Levels at 1604.31 and 1633.73 keV do have transitions in common to the 1249.81-keV level. Spin and parity possibilities for the three levels as determined by the pattern of γ decays are $1^{\pm}$, 2^+; 1^-, $2^{\pm}$, 3^-, and 2^+, 3^-, respectively. However, the absence of decays from the 1633.73-keV level to the ground-state band other than to the 2^+ level strongly suggests a 2^- assignment for this level. In addition, the only spin and parity sequence from the above possibilities that could compose a band corresponds to $K^{\pi}=1^-$. The relative $B(E$ or $M1)$ values for transitions from the levels (Table IX) are consistent with this assignment. The moment of inertia for the band computed from level separations is within 4% of the value of the ground-state band.

L. Levels at Higher Energies

Levels are proposed at 1661.84 keV and tentatively at 1681.00 and 1712.62 keV which may be members of a $K^{\pi}=1^-$ band. The 1681.00-keV level is based only on one relatively intense γ ray which could not be placed elsewhere in the decay scheme. A spin of 2^- is proposed to explain the absence of other decays to the ground-state band and the logft of 7.6. Spin and parity values of 1^- and 3^- for the 1661.84- and 1712.62-keV levels are consistent with the observed γ decays. The proposed band has a moment of inertia of $1.49\mathscr{I}_{\text{g.s.}}$, assuming no mixing, and an approximate $I(I+1)$ structure; the 3^- level is at 1712.62 keV compared with a value of 1709.74 keV predicted from the energies of the 1^- and 2^- levels.

Levels at 1780.96 and 1802.19 keV are both observed to decay to the ground-state, 841.70, and 1078.90-keV bands. The similarity of deexcitation suggests that they are part of a common band. However, the spin sequence would have to be inverted, the most probable sequence being 2^-, 1^-.

Levels with energies greater than 1712 keV have been placed at 1856.76, 1887.24, 1924.69, (2032.7), (2146.7), and (2170.9) keV. These levels are weakly populated by β decay and have few observable γ rays by which to be characterized.

M. Decay of the 7^- ^{246}Am Ground State

Fields *et al.*[6] have studied the decay of a spin-7 state in ^{246}Am discovered by Orth *et al.*[5] Two γ rays were assigned to the decay of a level postulated to be the 8^-8 (n-n $\frac{7}{2}^+[624]\downarrow+\frac{9}{2}^-[734]\uparrow$) state. A level was also proposed at 1053 keV, and several γ rays were observed but not assigned.

Having added the 4^- member of the $K^{\pi}=2^-$ octupole band, we have attempted to correlate the higher-lying members of the band with high-spin states populated in the decay of the spin-7 state. Using our energy values for the first three levels, we calculate energies for higher-spin members by means of one- and two-term energy equations (see Table X). We propose that the 1053-keV level observed by Fields is the 6^- member of the band, and that the unassigned γ rays arise from the decay of the 8-8 level to other members of the band and their subsequent decay. Shown in Table XI are the data of Fields *et al.* taken from their published spectra and recalibrated according to our more accurate γ-ray energies. The proposed decay scheme for the spin-7 state is shown in Fig. 5. Good agreement is found between predicted and observed level energies (Table X).

The decay of the 1179-keV 8^- level is observed

TABLE IX. Relative transition intensities from the $K^{\pi}=1^-$ band at 1604.31 keV.

Level	E_{γ}	E_{final} ($I^{\pi}K$)	$B(E \text{ or } M1)_{\text{rel}}$	$B(E \text{ or } M1)_{\text{theory}}$ ($K_i=1$)
1604.31	354.62	1249.81 (1^-0)	7 ± 7	
	1561.44	42.87 (2^+0)	1.2 ± 0.2	2.0
	1604.31	g.s. (0^+0)	1.0	1.0
1633.73	383.84	1249.81 (1^-0)	3.6 ± 1.8	
	505.59	1128.03 (3^-1)	1.0 ± 0.8	1.0
	528.48	1104.94 (2^-1)	1.7 ± 0.8	0.3
	554.71	1078.90 (1^-1)	1.5 ± 0.6	0.6
	1590.89	42.87 (2^+0)	1.0	
1671.07	542.99	1128.03 (3^-1)	14 ± 4	4
	565.89	1104.94 (2^-1)	17 ± 5	17
	592.19	1078.90 (1^-1)	5 ± 4	8
	1528.58	142.00 (4^+0)	2.1 ± 0.4	0.8
	1628.39	42.87 (2^+0)	1.0	1.0

TABLE X. Energy values for levels of the $K^{\pi}=2^-$ octupole band.

Spin	Experimental	One term	Two term
2	841.70	(841.70)	(841.70)
3	876.48	(876.48)	(876.48)
4	923.24	922.85	(923.24)
5	981	980.82	982.31
6	1051	1050.38	1054.11
7	1129	1131.53	1139.13
8		1224.28	1237.95

to go to the 8^+ member of the ground-state rotational band. The peak at 127.4 keV in the γ-ray spectrum of Fields *et al.* is suggested to be an $E2$ transition to the 6^- member of the 2^- octupole band. The peak may be a doublet, however, since a 128-keV γ ray is required to feed the 4^- member of the 2^- octupole band. Three other transitions are inferred, though not observed. These are the 50-keV (1179 to 1129), 78-keV (1129 to 1051), and the 148-keV (1129 to 981) transitions. It is expected that they would have large conversion coefficients and therefore low γ intensities.

The 1179-keV level should have a measurable lifetime, as the 679-keV $E1$ is a $\Delta K=8$ transition, and the 50- and 127.4-keV transitions represent a K change of 6. With such a degree of K forbiddeness, the $M2$ deexcitation to the ground-state band might be expected to compete in the decay. However, Fields *et al.* do not report an 884-keV γ ray which could correspond to an $M2$ branch between the 1179-keV level and the 6^+ member of the ground-state rotational band. Their data are not sufficient to indicate whether the 39-min half-life is attributable to the 7^- state in ^{246}Am or the 1179-keV level of ^{246}Cm.

TABLE XI. γ rays in ^{246}Am decay.

E_γ [a]	I_γ [b]	Assignment	
99.2 ± 0.2	9 ± 2	142	42
127.4 ± 0.5	~6	1179	1051
153.5 ± 0.5	48 ± 5	295	142
205 ± 1	68 ± 7	500	295
629 ± 1	5 ± 1	1129	295
679 ± 1	100	1179	500
686 ± 2	~4 [a]	981	295
756 ± 1	25 ± 2	1051	295
781 ± 1	7.5 ± 0.8	923	142
834 ± 1	~10	1129	295
839 ± 2	~4 [a]	981	142

[a]Data of Fields *et al.* (Ref. 6) reanalyzed, using energy values from this work.
[b]Taken from Ref. 6.

V. CONCLUSION

Of particular interest in ^{246}Cm are the octupole vibrational states. Soloviev and Siklos (SS)[8] give the more dominant two-quasiparticle terms in the $K^{\pi}=0^-$ and 2^- octupole states calculated by their model. In general, Soloviev's model requires that the lowest-lying octupole state be the most collective, while higher-lying members are predicted to have a more two-quasiparticle nature. Such has been shown to be true in the rare-earth region.[14,15] In the case of ^{246}Cm, the $K^{\pi}=2^-$ solution is expected to be the lowest-lying octupole state. It should be expected that the neutrons contribute less than SS predict, since in their calculations they do not include the more recent evidence for a $N=152$ neutron deformed subshell. Also, the low density of Nilsson states in the vicinity of $N=150$ neutrons may result in the two-proton configurations contributing more strongly than the neutrons to the collectivity of these levels. The more recent calculations of Neergaard and Vogel (NV)[13] differ significantly in predicting bandhead energies of octupole states. However, a detailed comparison of their calculations with experimental values has not been made, as wave functions and state energies are not explicitly presented in Ref. 13.

The 841.70-keV band is identified as the $K^{\pi}=2^-$

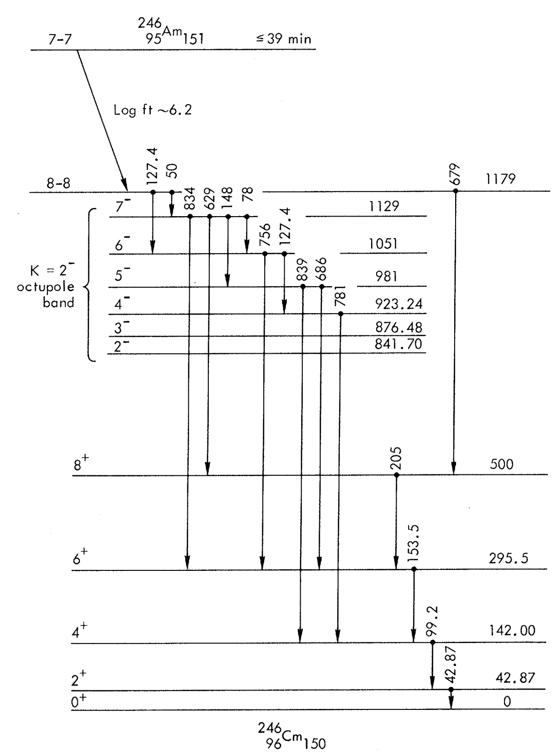

FIG. 5. Decay scheme of ^{246}Am.

octupole state and is the lowest collective band observed, confirming the calculations of both SS and NV. SS calculate a bandhead energy of 1.1 MeV. NV's calculations are in much better agreement with experiment, giving a value of approximately 760 keV.

The $K^\pi = 1^-$ band at 1078.90 keV is suggested to be the 1^- member of the octupole multiplet. NV's calculations yield an energy value here (830 keV) which is 250 keV below the experimental bandhead energy. One possible explanation for the discrepancy is that the $K^\pi = 1^-$ octupole state is fragmented. This might account for the low energy and decay properties of the 1348.89-keV $K^\pi = 1^-$ band.

NV also calculate $K^\pi = 0^-$ and 3^- octupole states at about 1220 and 1275 keV, respectively. The 0^- state is tentatively identified with the 1249.81-keV band, in good agreement with both NV and SS. However, a 3^- state at 1275 keV has not been identified. The 3^- member of the octupole multiplet may be associated with a level at 1526.06 ($3^\pm$) or 1601.31 ($3^\pm$).

SS also calculate the bandhead energies of collective 0^+ and 2^+ bands and find both to be 0.8 MeV. This is significantly lower in the case of the $K^\pi = 2^+$ γ vibrational band than the 1124.42-keV value experimentally determined. Observation of the γ band raises the possibility of a state which is due to a two-phonon octupole-γ vibration. The identification of this type of excitation may be more straightforward than the identification of pure two-phonon octupole bands. However, states of ^{246}Cm at high energy (>1.6 MeV) are too poorly characterized to be identified as collective.

The lowest $\log ft$ values in the decay of 25-min ^{246}Am are to negative-parity bands. The $\log ft$ values to the known $K^\pi = 2^+$ γ-vibrational band are at least 8.6 and may be fed entirely from higher-lying levels. The only other band assigned a positive parity (1452.06 keV) is populated by β decay with $\log ft$ values of 8.3 to 9.0. This tends to support the assignment of an $I^\pi K$ value of 2^-2 for the 25-min isomer of ^{246}Am. The 39-min activity reported by Orth *et al.*[5] and Fields *et al.*[6] is assigned an $I^\pi K$ value of 7^-7. Both of these ^{246}Am levels presumably are from the $\frac{5}{2}^+[624]\uparrow p \pm \frac{9}{2}^-[734]\downarrow n$ configuration. This would require the 39-min 7^- level to be the ground state and the 25-min 2^- level to be the first excited state. Since a separation of ~100 keV is expected, an $M5$ transition between them should be very weak.

Further study of the 2^- ^{246m}Am decay with more intense sources seems warranted, to identify high-energy levels. Conversion-electron data would be useful in assigning parity values. Also, the study of the 7^- ^{246}Am decay with greater source intensity may reveal additional states with large K values.

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