Title
ISOTOPE SHIFT AMD WAVELENGTHS OF THE CURIUM SPECTRUM

Authors
Conway, John G.
McLaughlin, Ralph D.

Publication Date
1955-06-15

UCRL 3037

UNCLASSIFIED

UNIVERSITY OF CALIFORNIA

Radiation Laboratory

ISOTOPE SHIFT AND WAVELENGTHS OF THE CURIUM SPECTRUM

UCRL-3037

UNIVERSITY OF CALIFORNIA

Radiation Laboratory
Berkeley, California

Contract No. W-7405-eng-48

ISOTOPE SHIFT AND WAVELENGTHS OF THE CURIUM SPECTRUM

John G. Conway and Ralph D. McLaughlin

June 15, 1955

Printed for the U. S. Atomic Energy Commission

Isotope Shift and Wavelengths of the Curium Spectrum

John G. Conway and Ralph D. McLaughlin
Radiation Laboratory
University of California, Berkeley, California

June 15, 1955

ABSTRACT

One hundred and eighty-two lines of curium were recorded, 148 of which had isotope shift. Both positive and negative shifts were found. The magnitude of the shift ranged up to 0.131 cm^{-1}.

Isotope Shift and Wavelengths of the Curium Spectrum

John G. Conway and Ralph D. McLaughlin
Radiation Laboratory
University of California, Berkeley, California

June 15, 1955

INTRODUCTION

Unusually large isotope shifts have been observed in many of the actinide elements.[1] These large shifts are attributed to the $5f^m6d^n7s^2$ and $5f^m6d^n7s'$ electron configurations. The size and shape of the nucleus also influence the magnitude of the isotope shift. The grouping of lines according to the magnitude of the isotope shift will be as great an aid in the term analysis of the spectra of these elements as are hyperfine splittings, intensities of lines as a function of excitation conditions and Zeeman effects.

EXPERIMENTAL

The two isotopes of curium which were available were Cm^{242}, a 162.5-day alpha emitter, and Cm^{244}, a 19-year alpha emitter.[2] The isotopes were in separate HCl solutions and were better than 90 percent isotopically pure. Thirty-nine micrograms of each isotope was available.

The spectrograph was a 21-foot Paschen-Runge mount with a 30,000 line per inch grating. The spectra were photographed in the second and third order using Eastman I-O plates. Many of the more intense lines appeared in both the second and third order. The wavelength range covered was 3050 to 5250 A (second order).

The adjustable mask in front of the plate holder was modified so that the spectra of the curium isotopes could be partially overlapped. This aided in the search for shifts.

The solutions were evaporated to dryness on 1/4-inch diameter flat ended graphite electrodes which were used as the anode. The cathodes were pointed graphite electrodes. All the graphite electrodes were baked at 800° F for four hours in a vacuum of better than 10^{-3} mm of mercury. The vacuum was turned off and oxygen admitted to a pressure of 1 pound per square inch and the electrodes cooled to room temperature. This treatment together with arcing in an oxygen atmosphere served to reduce the cyanogen band intensities.

Because of the radioactive hazard involved the samples were arced in separate air-tight chambers of lucite, brass and quartz which were mounted in a well-ventilated gloved box. The ventilating air was well filtered before being discharged outside the building. Each container was loaded with the electrodes then flushed with oxygen, sealed and arced at 15 amperes dc for 30 seconds. The containers were not opened until sometime later when recovery of the sample was attempted. The wavelengths were measured on a 200 cm measuring comparator.

RESULTS

Table I contains the wavelengths and the shifts of the curium lines. Lines with an "O" in the shift column exhibited no shift. These lines are included because they have not all been previously reported or because of the more accurate wavelength determination.[3]

Wavelengths of the same lines in the second and third order indicate the wavelengths to be accurate to ±0.01 A, except as noted. The accuracy of the wavelength determination of lines which appear in only one order was determined by the scatter of the points of the dispersion curve and was found to be ±0.01 A except as noted. Because of the small distances involved the shifts are felt to be accurate to less than ±0.005 A.

ACKNOWLEDGMENTS

We wish to thank J. C. Wallmann and W. W. T. Crane who supplied the curium isotopes and Professor F. A. Jenkins of the Department of Physics of the University of California who kindly permitted us to use the spectrograph and comparator. We also wish to acknowledge the assistance of J. O. Ward and the Health Chemistry Division.

This work was performed under the auspices of the U.S. Atomic Energy Commission.

REFERENCES

1. Thorium: G. L. Stukenbroeker and J. R. McNally, Jr., J. Opt. Soc. Am. 43, 36 (1953).

   Uranium: D. D. Smith, Oak Ridge National Laboratory Report ORNL-1412 (1952).

   Plutonium: J. G. Conway and M. Fred, J. Opt. Soc. Am. 43, 216 (1953).

   Americium: J. G. Conway and R. D. McLaughlin, Phys. Rev. 94, 498 (1954).

2. J. M. Hollander, I. Perlman, and G. T. Seaborg, Revs. Modern Phys. 25, 469 (1953).

3. J. G. Conway, M. F. Moore, and W. W. T. Crane, J. Am. Chem. Soc. 73, 1308 (1951).

Table I

Wavelengths and Isotope Shifts
of the Curium Spectrum

λ Cm^{244} (A)	Shift (A x 10^{-3}) $\lambda^{242} - \lambda^{244}$	Shift (cm^{-1} x 10^{-2}) $\nu^{242} - \nu^{244}$	Intensity	Remarks
3045.059	0	0	4	-
3059.916	-25	+27	3	-
3096.329	-a	+a	4	-
3105.342	+a	-a	2	-
3105.953	+28	-29	4	1
3112.607	-a	+a	2	-
3123.609	+a	-a	3	-
3125.298	-39	+40	3	-
3135.089	-a	+a	2	-
3138.334	+a	-a	3	-
3143.871	-a	+a	5	-
3147.318	-a	+a	1	-
3158.590	-44	+44	2	1
3160.654	+a	-a	4	-
3160.868	+a	-a	3	-
3170.002	0	0	4	1
3177.563	-43	+43	2	1
3178.812	0	0	2	1
3179.110	-40	+40	3	1
3180.757	-61	+60	3	-
3181.037	+49	-49	3	1
3186.409	-a	+a	3	1
3188.101	-a	+a	2	-
3190.455	-34	+33	3	-
3191.673	+63	-62	5	2
3193.890	0	0	3	-
3195.511	0	0	3	-

λ Cm^{244} (A)	Shift (A x 10^{-3}) $\lambda^{242} - \lambda^{244}$	Shift (cm^{-1} x 10^{-2}) $\nu^{242} - \nu^{244}$	Intensity	Remarks
3197.024	-30	+29	6	-
3198.057	+a	-a	3	-
3198.466	0	0	1	-
3207.123	-a	+a	4	1
3209.896	-22	+21	4	1
3210.054	-48	+47	7	1
3217.385	0	0	2	-
3220.766	-49	+47	8	1
3225.119	-a	+a	1	1
3225.342	0	0	2	-
3226.419	0	0	5	2
3228.362	0	0	2	-
3230.360	0	0	5	2
3233.063	-116	+111	3	1
3238.556	-30	+29	4	1
3242.640	-27	+25	3	1
3252.644	0	0	5	3
3254.603	-44	+42	1	-
3255.266	-63	+59	1	-
3265.802	-43	+40	4	-
3271.200	+a	-a	4	1
3278.775	0	0	3	1
3279.003	-37	+35	5	1
3280.447	-36	+34	4	1
3283.291	0	0	2	-
3285.762	-27	+25	3	1
3289.484	-57	+53	2	-
3289.710	-55	+51	3	1
3294.298	-29	+27	1	-
3296.127	-a	+a	3	1
3296.702	-39	+36	7	1

λ Cm^{244} (A)	Shift (A x 10^{-3}) $\lambda^{242} - \lambda^{244}$	Shift (cm^{-1} x 10^{-2}) $\nu^{242} - \nu^{244}$	Intensity	Remarks
3298.235	-63	+58	3	1
3304.851	+a	-a	4	-
3311.907	-29	+26	3	1
3317.147	-53	+48	3	1
3323.272	-48	+44	1	-
3325.154	+42	-38	1	-
3367.952	+28	-25	3	3
3374.714	-45	+39	4	1
3375.073	0	0	2	-
3382.897	0	0	3	1
3391.467	-85	+74	1	-
3391.965	0	0	2	-
3395.640	-55	+48	3	1
3417.287	-71	+61	5	1
3422.653	+85	-73	3	-
3424.223	0	0	2	1
3426.496	-62	+53	5	1
3438.232	0	0	1	-
3446.157	+102	-86	4	1
3452.931	-44	+37	2	-
3458.342	0	0	1	-
3473.078	-56	+46	7	1
3482.519	+26	-21	2	-
3487.790	-49	+40	1	-
3498.777	-54	+44	4	-
3510.284	+56	-46	3	-
3518.422	-62	+50	1	-
3520.034	-57	+46	4	-
3546.145	-62	+49	5	-
3547.014	-51	+40	3	-
3550.295	-37	+29	2	-
3561.427	-47	+37	2	-

λ Cm^{244} (A)	Shift (A x 10^{-3}) $\lambda^{242}-\lambda^{244}$	Shift (cm^{-1} x 10^{-2}) $\nu^{242}-\nu^{244}$	Intensity	Remarks
3562.028	-53	+42	1	-
3567.377	-58	+46	5	-
3570.433	-56	+44	4	-
3572.943	-71	+56	4	-
3573.668	0	0	4	-
3581.022	-62	+48	2	-
3591.485	+18	-14	2	-
3600.646	-52	+40	1	-
3615.605	-69	+53	3	-
3639.965	-69	+52	2	-
3648.438	-31	+23	3	-
3664.338	-42	+31	2	-
3670.382	0	0	3	-
3672.014	0	0	2	-
3691.521	-22	+16	2	-
3691.610	-17	+12	3	-
3692.301	+24	-18	4	-
3709.428	0	0	2	-
3738.261	-67	+48	2	-
3739.270	-24	+17	2	-
3747.796	-33	+23	2	-
3750.438	-55	+39	2	-
3761.737	-35	+25	1	-
3765.153	-53	+38	2	-
3775.776	-56	+39	2	-
3777.944	+a	-a	3	-
3784.803	-187	+131	2	-
3847.197	0	0	4	4
3900.262	-49	+32	2	-
3903.893	-60	+39	8	-
3904.073	-66	+43	3	-
3908.234	-84	+55	7	-

λ Cm^{244} (A)	Shift (A x 10^{-3}) $\lambda^{242} - \lambda^{244}$	Shift (cm^{-1} x 10^{-2}) $\nu^{242} - \nu^{244}$	Intensity	Remarks
3919.353	-51	+33	2	-
3929.666	+22	-14	2	-
3935.322	0	0	4	4
3942.054	-49	+32	2	4
3947.996	-81	+52	4	-
3948.685	-a	+a	3	-
3953.370	-70	+45	2	-
3954.433	-52	+33	2	-
3960.287	-80	+51	5	-
3962.289	0	0	2	-
3962.712	+30	-19	2	-
3964.834	-a	+a	3	-
3970.165	0	0	1	-
3974.729	0	0	5	-
3976.762	+76	-66	2	-
3980.715	-61	+39	2	-
3983.975	-69	+44	1	-
3995.117	-56	+35	1	4
4003.484	-45	+28	7	4
4006.482	+a	-a	1	4
4016.145	+a	-a	2	-
4018.396	+19	-12	2	-
4024.576	-64	+40	5	4
4028.031	0	0	4	4
4042.755	-a	+a	2	4
4061.539	+31	-19	3	-
4078.787	-64	+39	4	-
4105.338	-101	+60	3	-
4106.550	0	0	5	-
4129.112	-73	+43	4	-
4145.847	-219	+127	4	-
4149.516	0	0	3	-

λ Cm^{244} (A)	Shift (A x 10^{-3}) $\lambda^{242}-\lambda^{244}$	Shift (cm^{-1} x 10^{-2}) $\nu^{242}-\nu^{244}$	Intensity	Remarks
4156.581	-51	+29	2	-
4157.471	-84	+49	6	-
4164.448	-35	+20	2	-
4177.492	-159	+91	3	-
4194.402	-66	+38	2	-
4202.356	+a	-a	2	-
4207.660	-67	+38	10	-
4218.463	-48	+27	5	-
4236.302	-60	+33	2	-
4240.145	-47	+26	4	-
4243.335	-66	+37	2	-
4266.422	0	0	2	4
4272.544	-76	+41	3	-
4292.979	-a	+a	2	5
4345.695	-79	+42	2	-
4357.102	0	0	2	-
4369.469	+52	-27	2	-
4402.522	-43	+22	2	-
4402.946	+a	-a	2	-
4407.417	-37	+19	2	-
4416.885	-47	+24	2	-
4429.509	0	0	2	-
4433.082	-39	+20	4	-
4443.253	-58	+30	1	4
4446.166	+a	-a	3	4
4448.749	+a	-a	2	4
4494.270	-60	+30	3	-
4547.268	-41	+20	4	6
4717.651	-120	+54	1h	6

1. Value reported represents mean of second order an third order lines whose standard deviation is less than ±0.015 A.

2. These lines were observed in both the second and third orders but were measured only in the second order.
3. Value reported represents mean of second and third order line whose standard deviation is less than ± 0.025 A.
4. Scatter of points from dispersion curve indicate error in this line to be ± 0.03 A.
5. This line was observed in the second order but was measured with respect to third order iron lines. Hence the error is unknown.

a--too small to measure

o--no shift

h--hazy, diffuse