The radiation observed without the grids contains also a doubly scattered ingredient which may be calculated from Eq. (7) by putting $r=L$, $P=1$, and $h/L=3.17$. Correction factors for absorption and recoil losses are obtained by squaring those applied in the single scattering case. This is equivalent to assuming that the effective path in the scatterer is $2L$ and that 90° is a proper effective scattering angle to represent both primary and secondary scattering for the purposes of this correction.

The radiation observed with the grids is calculated as explained in Section III for the case of double scattering by co-axial disks. For each primarily irradiated section as many as six emergence slots pass appreciable doubly scattered radiation. All such calculated contributions, corrected as in the preceding paragraph, are combined to give the total measurable radiation. Traces of higher order scattering will be present in the observed radiation both with and without the grids but no calculation of such intensities has been made.

Results

The calculated ratio of observable intensities without and with the grids, carried through as outlined above, is 47. The ratio as observed was 44 at an x-ray tube potential of 40 kv, 46 to 50 kv, and 44 at 60 kv, the agreement being somewhat closer than might reasonably have been expected.

The methods of calculation outlined in this paper will subsequently be utilized for the correction of conclusions now in print concerning the polarization of primary x-rays, and for the interpretation of experiments in progress. The author is greatly indebted to Mr. Keith Harworth for assistance in the experimental part of this investigation.

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Preliminary Analysis of the First Spark Spectrum of Cerium—Ce II

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By applying the spectral interval sorter and a newly designed interval recorder to new data obtained with the automatic recording spectrum comparator on the M.I.T.-W.P.A. wavelength program, a preliminary term array for Ce II has been set up in which 584 lines have been accounted for as transitions between 31 lower and 51 upper states. The term diagram is found to be the most complex yet observed for a three-electron spectrum. Both configurations $4f5d6s$ and $4f5d^2$ appear to be low in Ce II, contrary to the analysis of Haspas. Most of the differences between observed wave numbers and those computed from the term array are less than 0.02 cm^{-1}, and 60 percent of the lines are found to be consistent to within 0.002A. Several of the term assignments have been checked with partially resolved Zeeman patterns recorded by King and Albertson, and the absolute J values have been determined by this means. An inclusive description of the spectra of the cerium atom is being undertaken in the range 10,000 to 1000A.

THAT the spectra emitted by rare earth atoms would be unusually difficult to analyze has been expected by spectroscopists for some time, but fortunately a number of these atoms whose spectra are so complex emit outstanding groups of lines. By attacking such lines the beginnings of term arrays have been constructed in a number of cases.[1] Cerium (58), the first element of the rare earth group, which is of unusual interest spectroscopically because of its position in the periodic table, presents no such suggestive features for attack. When we made

[1] Sm I, Sm II, W. E. Albertson, Phys. Rev. **47**, 370 (1934); Astrophys. J. **84**, 26 (1936). Eu I, Eu II, H. N. Russell and A. S. King, Phys. Rev. **46**, 1023 (1934); W. E. Albertson, Phys. Rev. **45**, 499 (1934). Gd I, W. E. Albertson, Phys. Rev. **47**, 370 (1934). Yb I, Yb II, W. F. Meggers and H. N. Russell (see C. E. Moore, *Term Designations for Excitation Potentials* (Princeton, N. J., 1934)). Lu I, Lu II, Lu III, W. F. Meggers and B. G. Scribner, Nat. Bur. Stand. J. Research **5**, 73 (1930).

preliminary attempts to analyze Ce I and Ce II several years ago[2] we came to the conclusion that more precise wave-length values, or more highly resolved Zeeman patterns, or both, would be required before the term arrays of these spectra could successfully be unravelled.

A comprehensive resurvey of the cerium spectrum was then undertaken, and with the improved wave-length values so obtained we have developed a quadratic array for Ce II which in its present status accounts for 584 lines, including a majority of the stronger lines, as transitions between 31 lower and 51 upper states. This array is of special interest because it shows a new order of complexity in three-electron spectra. For example, about 700 lines due to Ti II are known, whereas more than 3000 lines have already been ascribed to Ce II on the basis of studies not yet complete. The difficulty of starting a term array is now explained, since we find more than two dozen low energy levels within 6000 cm^{-1} of the lowest, while Fe I, for example, shows only five levels in the same range.

Haspas[3] has published a term array for Ce II with which we can find no point of agreement. He assigns 430 lines to 137 states, and the deviation between his observed and calculated wave numbers $(O-C)$ is sometimes as great as 0.70 cm^{-1}, which he justifies on the basis that the wave-lengths used, as measured by different observers, disagreed among themselves by as much as 0.3A. Haspas' average value of $(O-C)$ for his lines is over 0.2 cm^{-1}, while our average is something under one-tenth this, as discussed below.

We calculate the probability of finding by accident a solid array of even four columns and 10 rows with the tolerance which we have used as being less than one in a million, starting with any random interval and the actual density of Ce II lines. If the tolerance were doubled the probability would increase to 1 in 10. With the use of Haspas' tolerance, ten times ours, such chance arrays become very numerous in a spectrum so complex.

The present note illustrates the application of the spectral interval sorter[4] and the spectral interval recorder[5] to the analysis of a complex term array, where the combination principle has little power for analysis unless precise wave-lengths are available. Our results also show the internal consistency to be expected of wave-length values obtained by means of the automatic recording comparator[6] in the program undertaken in this laboratory, with the assistance of the Works Progress Administration, on a systematic resurvey of atomic spectra.

Procedure

A revised master-list of all known Ce II lines in the range 5500–2850A was prepared, using the M.I.T.-W.P.A. wave-length values. The wave numbers of all lines on this list were then punched on a tape for the interval recorder, using a scale of 7.5 mm per cm^{-1}. A similar tape was then prepared for the interval sorter, containing only the 337 strongest lines, to cut down the probability of accidental coincidences.[4] No quadratic arrays grew from the intervals which were shown by the machine to occur most frequently, so the 700 strongest lines were punched on the tape. From this tape were recorded all intervals in the range 57 to 1000 cm^{-1}, in four settings covering 300 cm^{-1} each. The most probable number of chance occurrences of any specified interval within a tolerance of ± 0.10 cm^{-1} was calculated to be about 10, but many intervals were found occurring on the developed chart from 14 to 20 times. The interval recorder was then set for each of these highly recurrent intervals in turn, and with it all pairs of lines in the master list which gave these intervals to within ± 0.10 cm^{-1} were automatically recorded. With the intervals thus determined a quadratic array was set up which was soon demonstrated to be valid by the ease and precision with which other intervals found from the record fitted into it.

Once a quadratic array has been started, both its validity and the mutual consistency of the wave-length values used can be tested by calculation of the differences $(O-C)$ mentioned

[2] G. R. Harrison and W. E. Albertson, Phys. Rev. **45**, 289 (1934).
[3] K. Haspas, Zeits. f. Physik **96**, 410 (1935).
[4] G. R. Harrison, Rev. Sci. Inst. **3**, 753 (1932); Rev. Sci. Inst. **4**, 581 (1933).
[5] To be described elsewhere shortly.
[6] G. R. Harrison, J. Opt. Soc. Am. **25**, 169 (1935).

TABLE I. *Difference between observed and computed wave numbers for lines measured on M.I.T.-W.P.A. program.*

(O − C) ±cm^{-1}	Percent in Range	Total Percent
0.00	20.7	20.7
.01	28.8	49.5
.02	23.3	73.0
.03	11.9	84.9
.04	6.6	91.5
.05	4.1	95.6
.06	2.5	98.1
.07	.9	99.0
.08	.6	99.6

above. From Table I it will be seen that our average value of (O − C) is somewhat under 0.02 cm^{-1}, and the agreement is such as to indicate that over 60 percent of the wave-length values used are mutually consistent to within 0.002A.

Our wave-length data were supplemented by King's temperature classification of the 337 strongest lines.[7] Partially resolved Zeeman patterns for both the *n* and *p* components in the range 3750–2900A were also made available to us through the kindness of Drs. A. S. and R. B. King. In addition, *n* components for the range 4700–3850A were photographed by A. S. King and one of us (W. A.), who desires to record here his thanks to the National Research Council for the award of a fellowship which made this work possible. These cerium Zeeman effect plates were taken in the physical laboratory of the Mt. Wilson Observatory in Pasadena, using a 15 ft. concave grating and a large Weiss electromagnet.

[7] A. S. King, Astrophys. J. **68**, 194 (1928).

While the Zeeman patterns were not sufficiently resolved to enable this powerful means of starting a term analysis to be used, our application of the combination principle, together with the selection principle for inner quantum numbers, served to determine the relative J values of the terms. Several of the patterns were sufficiently resolved to rule out certain J values, and by this means the absolute scale for J was determined. The partially resolved pattern types served also to check our assignments in a number of cases, with very satisfactory agreement.

Term Analysis of Ce II

Various considerations indicate that the electron configurations $4f5d6s$ and $4f5d^2$ both give rise to low lying terms in Ce II, with the former probably the lower. If $4f5d6s$ is lower the ground

TABLE II. *Energy levels of Ce II.*

Level	Term Value Wave Numbers	J Value	No. of Combinations	Level	Term Value Wave Numbers	J Value	No. of Combinations	Level	Term Value Wave Numbers	J Value	No. of Combinations
1	0.00	3½	19	29	6,638.25	4½	12	125	29,984.08	1½	7
2	1,410.30	4½	20	30	7,259.08	3½	16	126	30,065.19	3½	15
3	1,873.95	3½	23	31	8,280.96	3½	13	127	30,166.08	1½	5
4	2,382.26	4½	22	101	24,663.05	4½	9	128	30,245.89	4½	14
5	2,563.26	5½	11	102	25,359.69	2½	7	129	30,425.37	2½	10
6	2,581.27	4½	27	103	25,681.50	1½	4	130?	30,576.84	4½	7
7	2,595.65	1½	12	104	25,945.40	3½	13	131	30,637.17	4½	12
8	2,634.68	2½	21	105	26,841.40	4½	13	132	30,702.64	4½	16
9	2,641.57	3½	29	106	26,900.37	3½	13	133	30,829.13	3½	15
10	2,879.71	5½	14	107	27,187.06	3½	15	134	31,075.60	5½	8
11	3,363.44	2½	21	108	27,249.69	2½	13	135	31,207.96	4½	14
12	3,593.89	4½	25	109	27,379.95	5½	9	136	31,558.64	3½	13
13	3,703.61	3½	23	110	27,514.68	3½	11	137	31,738.50	5½	8
14	3,995.48	3½	30	111	27,811.52	4½	13	138	31,851.42	2½	9
15	4,266.41	3½	29	112	27,812.41	2½	12	139	32,138.73	2½	12
16	4,322.70	3½	21	113	27,835.23	1½	4	140	32,318.21	3½	14
17	4,459.89	3½	24	114	27,934.66	4½	19	141	32,862.80	3½	16
18	4,511.26	2½	20	115	28,297.49	3½	14	142	33,552.59	2½	11
19	4,523.01	4½	25	116	28,334.77	4½	11	143	33,808.31	2½	12
20	4,844.63	1½	8	117	28,337.82	2½	16	144	33,977.16	3½	16
21	4,910.98	5½	10	118	28,634.51	5½	11	145	34,155.33	3½	19
22	5,010.88	2½	15	119	28,725.16	4½	14	146	34,333.12	2½	11
23	5,118.81	2½	18	120	29,166.61	4½	16	147	34,426.07	2½	11
24	5,437.46	3½	25	121	29,281.37	2½	10	148	34,920.78	3½	11
25	5,716.22	3½	20	122	29,438.83	5½	9	149	34,934.46	2½	10
26	5,819.12	4½	25	123	29,807.09	4½	11	150	35,346.30	3½	14
27	5,942.79	3½	19	124	29,908.92	4½	18	151	35,558.70	3½	12
28	6,389.93	4½	10								

TABLE III. *List of classified Ce II lines.*

Wave-Length	Int.	Wave Number	Comb.
4984.42	1	20,056.94	31–117
4914.938	8 V	20,340.47	16–101
4865.12	1	20,548.76	29–107
4795.22	2	20,848.29	18–102
4755.51	2	21,022.38	26–105
4744.91	3	21,069.34	12–101
4742.22	1	21,081.29	26–106
4739.49	25 V	21,093.44	15–102
4722.31	2	21,170.17	18–103
4705.85	1	21,244.22	27–107
4692.02	2	21,306.84	27–108
4678.61	1	21,367.91	26–107
4670.76	2	21,403.82	24–105
4666.70	1	21,422.44	19–104
4664.11	1	21,434.34	18–104
4657.85	1	21,463.14	24–106
4657.22	1	21,466.05	30–119
4644.22	2	21,526.13	31–123
4636.72	1	21,560.95	26–109
4623.47	1	21,622.74	16–104
4589.37	1	21,783.40	10–101
4571.47	1	21,868.69	27–111
4567.12	1	21,889.52	22–106
4563.35	1	21,907.60	28–115 30–120
4554.54	1	21,949.98	14–104
4545.878	2	21,991.80	27–114
4544.961	5	21,996.25	11–102 29–118
4539.755	200 IV	22,021.46	9–101
4527.354	200 V	22,081.78	6–101
4524.590	1	22,095.27	25–107
4520.410	0	22,115.71	26–114
4508.084	4	22,176.17	22–107
4499.52	1 u	22,218.38	25–114
4495.389	4	22,238.80	22–108
4494.226	4	22,244.55	28–118
4486.909	150 V	22,280.83	4–101
4483.900	100 V	22,295.78	31–130
4479.35	30 V 50 V	22,318.39	11–103 19–105
4472.716	6	22,351.53	12–104
4472.11	1	22,354.56	27–115
4468.023	2 u	22,375.01	24–112
4467.537	5	22,377.44	19–106
4463.87	1 u	22,395.82	23–110
4462.03	1	22,405.06	20–108
4454.984	3	22,440.49	17–106
4449.337	200 V	22,468.97	21–109
4443.752	4	22,497.21	24–114
4442.43	1	22,503.90	22–110
4440.13	1	22,515.56	26–116
4439.50	1	22,518.76	16–105
4437.612	4	22,528.34	29–120
4433.708	2	22,548.18	31–133
4428.437	5	22,575.01	15–105
4427.917	6	22,577.66	16–106
4427.070	5	22,581.98	11–104
4419.89	1	22,618.67	25–116
4419.298	3	22,621.70	25–117
4416.904	4	22,633.96	15–106
4413.805	2	22,649.85	30–124
4400.872	3	22,716.41	23–113
4400.545	3	22,718.09	9–102
4399.204	60 IV	22,725.02	8–102
4398.790	5	22,727.16	17–107
4396.585	3	22,738.56	18–108
4391.663	250 IV	22,764.04	7–102

Wave-Length	Int.	Wave Number	Comb.
4390.59	1	22,769.61	17–108
4384.44	1	22,801.54	22–112
4381.779	4	22,815.39	26–118
4380.057	3	22,824.36	22–113
4375.932	60 V	22,845.88	14–105
4373.820	50 V	22,856.91	19–109
4373.220	3	22,860.04	24–115
4372.401	4	22,864.33	16–107
4365.520	2	22,900.36	24–117
4364.659	125 IV	22,904.88	14–106
4364.502	?	22,905.71	26–119
4361.661	6	22,920.63	15–107
4360.444	3	22,927.02	16–108 31–135
4352.733	75 IV	22,967.64	20–112
4349.790	100 IV	22,983.18	15–108
4348.190	3	22,991.63	19–110
4345.963	5	23,003.42	18–110
4344.920	1	23,008.94	25–119
4342.137	3	23,023.68	21–114
4337.777	125 IV	23,046.83	8–103
4330.444	30 IV	23,085.85	7–103
4320.723	60 IV	23,137.78	13–105
4315.404	3	23,166.31	30–129
4314.939	2	23,168.80	29–128
4313.100	2	23,178.68	23–115
4310.700	5	23,191.59	14–107
4309.740	50 IV	23,196.75	13–106
4305.609	2	23,219.11	23–117
4304.723	4	23,223.79	27–120
4300.331	60 IV	23,247.51	12–105
4299.362	60 IV	23,252.75	2–101
4299.092	3	23,254.21	14–108
4296.069	6	23,270.57	29–124
4294.756	3	23,277.68	31–136
4292.905	1	23,287.72	24–119
4292.767	4	23,288.47	19–111
4290.435	2	23,301.13	18–112
4289.937	300 IV	23,303.84	9–104
4289.453	5	23,306.46	12–106
4288.671	1	23,310.71	8–104
4283.550	2	23,338.58	27–121
4281.914	1	23,347.49	26–120
4281.156	3	23,351.63	17–111
4280.998	3	23,352.49	17–112
4278.865	5	23,364.12	6–104
4270.189	60 IV	23,411.60	19–114
4264.372	3	23,443.54	30–132
4258.699	1	23,474.77	17–114
4257.120	4	23,483.47	13–107
4256.156	5	23,488.79	16–111
4255.992	4	23,489.70	16–112
4255.359	3	23,493.19	20–117
4250.651	1	23,519.21	14–110
4245.976	6	23,545.10	15–111
4242.726	7	23,563.14	4–104
4241.403	2	23,570.49	31–138
4234.726	2	23,607.65	29–128
4233.949	2	23,611.99	16–114
4232.569	4	23,619.68	26–122
4223.882	4	23,668.26	15–114
4214.041	50 IV	23,723.53	21–118
4213.035	3 u	23,729.20	24–120
4202.944	150 IV	23,786.17	12–109 18–115
4198.431	4	23,811.74	19–116
4197.998	5	23,814.19	21–119
4197.668	4	23,816.06	14–111

Wave-Length	Int.	Wave Number	Comb.
4197.511	3	23,816.95	14–112
4196.335	75 V	23,823.63	11–107
4195.819	3	23,826.56	18–117
4193.875	5	23,837.60	17–115
4192.757	2	23,843.96	24–121
4189.176	2	23,864.34	27–123
4187.324	6	23,874.90	17–116
4185.334	5	23,886.25	11–108
4179.291	2	23,920.79	12–110
4176.081	3	23,939.17	14–114
4174.386	2	23,948.89	30–135
4172.152	1	23,961.71	10–105
4171.384	2	23,966.13	27–124
4169.878	30 V	23,974.78	16–115
4162.89	1	24,015.04	16–117
4160.107	2	24,031.09	15–115
4159.033	50 IV	24,037.30	31–140
4153.130	4	24,071.46	3–104 15–117
4149.936	50 V 60 V	24,089.99	26–124 25–123
4146.235	75 IV	24,111.49	19–118
4137.475	4	24,162.54	23–121
4132.633	3	24,190.85	29–133
4131.099	100 V	24,199.82	9–105
4130.705	100 V	24,202.14	19–119
4128.067	4	24,217.60	12–111
4125.776	2	24,231.05	13–114
4123.230	5	24,246.01	26–126
4121.595	1	24,255.63	21–120
4120.829	150 V	24,260.14	6–105
4119.886	5	24,265.70	8–106
4114.141	2	24,299.58	30–136
4113.722	4	24,302.05	14–115 27–128
4111.923	2	24,312.69	28–132
4110.840	3	24,319.09	6–106
4107.426	200 V	24,339.31	14–116
4106.881	5 d	24,342.54	14–117
4092.715	4	24,426.79	26–128
4090.942	4	24,437.37	29–134
4089.006	3	24,448.94	11–112
4087.371	4 d	24,458.72	15–119
4087.297	4	24,459.17	4–105
4085.232	100 V	24,471.53	24–124
4080.435	5	24,500.30	10–109
4077.470	75 V	24,518.11	4–106
4075.853	125 IV	24,527.84	21–122
4074.646	2	24,535.11	2–104
4066.910	1	24,581.78	31–141
4065.164	3	24,592.33	30–138
4064.904	3	24,593.91	13–115
4062.941	3	24,605.79	6–107
4061.421	2	24,615.00	8–108
4059.314	1	24,627.77	24–126
4058.76	4	24,631.13	13–116
4058.245	4	24,634.26	13–117
4054.944	50 IV	24,654.01	7–108
4053.508	100 IV	24,663.05	1–101
4049.80	1	24,685.63	28–134
4048.367	1	24,694.37	27–131
4046.341	100 V	24,706.73	17–120
4045.976	?	24,708.96	25–129
4042.584	200 IV	24,729.69	14–119
4040.758	300 IV	24,740.87	12–116
4037.664	5	24,759.83	27–132
4031.339	150 IV	24,798.67	6–109
4030.343	4	24,804.80	4–107

TABLE III.—*Continued.*

Wave-Length	Int.	Wave Number	Comb.	Wave-Length	Int.	Wave Number	Comb.	Wave-Length	Int.	Wave Number	Comb.
4029.75	1	24,808.45	24–128	3898.949	?	25,640.70	3–110	3769.046	5	26,524.41	2–114
4028.413	150 IV	24,816.68	5–109	3898.674	1	25,642.51	15–124	3766.514	4 u	26,542.23	13–128
4028.198	2	24,818.01	26–131	3896.804	100 IV	25,654.81	18–127	3765.044	4	26,552.60	19–134
			28–135	3896.637	1	25,655.91	9–115	3764.117	150 IV	26,559.14	10–122
4027.633	2	24,821.49	17–121	3895.114	125 IV	25,665.93	21–130	3763.612	3	26,562.70	15–133
4020.542	2	24,865.27	23–125	3890.986	6	25,693.17	9–116	3760.404	2	26,585.36	6–120
4019.274	2	24,873.11	9–110	3890.519	2	25,696.26	9–117	3757.858	4	26,603.37	5–120
4018.213	1	24,879.68	30–139				31–144	3755.425	75 IV	26,620.61	11–125
4017.596	2	24,883.54	26–132	3889.478	3	25,703.13	8–117	3752.453	2	26,641.69	14–131
4014.899	125 V	24,900.22	15–120	3888.388	4 u	25,710.34	23–133	3751.002	1	26,652.00	12–128
4012.389	300 IV	24,915.79	19–122	3886.495	3	25,722.86	19–128	3746.373	2 d	26,684.93	19–135
4011.559	2	24,920.95	25–131	3883.983	1	25,739.50	26–136	3746.260	2	26,685.73	7–121
4003.168	1	24,973.18	22–125	3883.583	4	25,742.15	7–117	3744.05	1	26,701.48	11–126
4002.975	4	24,974.38	11–117	3881 874	4	25,753.48	6–116				24–139
4001.049	4	24,986.41	25–132	3881.675	5	25,754.80	10–118	3741.721	3	26,718.10	30–144
3999.242	500 IV	24,997.69	4–109	3879.313	3	25,770.48	24–135	3739.691	2	26,732.61	23–138
3996.481	4	25,014.97	15–121	3878.372	150 IV	25,776.73	2–107	3737.540	3	26,747.99	17–135
3995.429	2	25,021.55	13–119	3876.975	6	25,786.02	17–128	3729.918	4	26,802.65	11–127
3992.385	125 IV	25,040.63	12–118	3876.129	4	25,791.65	21–132	3726.462	3	26,827.50	21–137
3991.317	3	25,047.33	23–127	3875.036	6 d	25,798.91	15–126	3724.639	5	26,840.63	22–138
3990.105	5	25,054.94	10–114	3873.117	1	25,811.71	14–123	3722.291	4	26,857.56	6–122
3989.444	30 V	25,059.09	30–140	3872.137	1	25,818.24	22–133	3719.797	3	26,875.57	5–122
3982.901	60 V	25,100.25	29–137	3868.516	2	25,842.41	25–136	3719.091	1	26,880.67	24–140
3980.895	100 V	25,112.90	25–133	3868.138	4	25,844.93	12–122	3718.190	150 IV	26,887.19	2–115
3977.807	4	25,132.40	4–110	3863.741	4	25,874.34	31–145	3716.938	4	26,896.24	30–145
3976.67	1	25,139.58	20–125	3857.928	2 u	25,913.33	14–124	3716.365	600 IV	26,900.39	1–106
			24–130	3857.813	2	25,914.10	18–129	3713.648	2	26,920.07	27–141
3974.201	2	25,155.20	22–127	3857.644	5	25,915.24	4–115	3711.783	3	26,933.59	13–131
3972.071	6	25,168.69	28–136	3857.240	4	25,917.95	11–121	3710.684	2	26,941.57	15–135
3971.873	3	25,169.95	9–111	3857.032	5	25,919.35	26–137	3704.979	4	26,983.06	12–130
3971.684	100 V	25,171.14	14–120	3854.322	100 IV	25,937.57	3–111	3702.785	5	26,999.05	13–132
3970.646	5	25,177.72	8–112	3854.187	100 IV	25,938.48	3–112	3701.730	1	27,006.74	20–138
3967.185	4	25,199.68	24–131	3853.158	125 IV	25,945.41	1–104	3699.920	50 V	27,019.95	23–139
3967.048	100 IV	25,200.55	8–113	3852.103	2	25,952.51	4–116	3698.650	5	27,029.23	5–124
3964.503	6	25,216.73	7–112	3849.562	2	25,969.65	2–109	3696.673	2	27,043.68	26–141
3960.914	125 IV	25,239.58	7–113	3848.105	3	25,979.48	15–128	3694.911	60 V	27,056.58	4–122
3958.266	6	25,256.47	26–134	3837.210	3	26,053.24	6–118	3693.720	3	27,065.30	31–150
3956.901	4	25,265.12	24–132	3836.110	6	26,060.69	3–114	3689.165	3	27,098.72	17–136
			27–135	3834.785	3	26,069.71	14–126	3687.802	30 V	27,108.73	12–132
3953.957	4 u	25,283.99	19–123	3834.556	100 IV	26,071.27	5–118	3685.516	2 u	27,125.55	13–133
3953.660	5	25,285.89	14–121	3832.745	4	26,083.59	9–119	3682.660	2	27,146.59	25–141
3952.573	125 V	25,292.84	9–114	3829.946	2	26,102.65	16–129	3680.084	4	27,165.59	9–123
	125 IV			3829.694	4	26,104.37	2–110	3679.92	1	27,166.80	30–147
3950.436	5	25,306.52	23–129	3827.227	3	26,121.19	24–136	3677.176	2	27,187.07	1–107
3949.412	5	25,313.11	3–107	3823.903	50 IV	26,143.90	6–119	3673.739	2	27,212.50	14–135
3944.101	3 u	25,347.11	17–123	3821.702	6	26,158.96	15–129	3672.166	5 d	27,224.16	2–118
3943.888	100 IV	25,348.54	28–137	3821.270	5	26,161.91	5–119	3671.941	4	27,225.83	6–123
3943.141	5	25,353.34	6–114	3820.871	5	26,164.64	21–134	3670.669	2	27,235.26	12–133
3942.151	125 IV	25,359.71	1–102	3819.024	5	26,177.30	17–131	3668.727	4	27,249.68	1–108
3940.338	100 IV	25,371.38	5–114	3818.688	5	26,179.60	19–132	3666.346	2	27,267.38	9–124
3939.662	3	25,375.73	3–108	3814–942	2	26,205.31	13–124	3664.944	1	27,277.81	31–151
3938.086	7	25,385.89	19–124	3808.384	3	26,250.43	14–128	3663.005	2	27,292.25	15–136
3937.643	2	25,388.74	26–135	3808.124	300 IV	26,252.22	4–118	3659.972	6	27,314.86	2–119
3931.369	100 IV	25,429.26	4–111	3803.097	200 IV	26,286.88	10–120	3658.258	3	27,327.66	6–124
3931.088	125 IV	25,431.08	2–105	3800.324	1	26,306.11	19–133	3656.756	3	27,338.88	29–144
3928.312	4	25,449.05	17–124	3799.097	3	26,314.56	16–131	3655.851	500 IV	27,345.65	5–124
3927.383	4	25,455.07	10–116	3799.035	2	26,315.03	12–124	3655.349	2	27,349.40	8–125
3926.163	2	25,462.98	13–120	3792.326	50 IV	26,361.58	13–126	3653.108	125 V	27,366.18	10–128
3924.644	60 IV	25,472.83	18–125	3790.342	3	26,375.38	27–140	3650.134	3	27,388.48	7–125
3921.731	100 V	25,491.75	25–135	3786.632	150 IV	26,401.22	2–111	3649.730	1	27,391.51	17–138
3913.995	2	25,542.14	19–126	3783.569	5	26,422.59	25–139	3645.455	4	27,423.63	9–126
3912.424	300 IV	25,552.39	4–114	3782.524	75 IV	26,429.89	14–129	3645.226	5 u	27,425.36	24–131
3912.191	5	25,553.91	18–126	3781.620	150 IV	26,436.21	15–132	3644.539	1	27,430.53	8–126
3909.313	6	25,572.73	12–120	3781.102	3	26,439.83	23–136	3639.868	1	27,465.73	11–133
3908.543	100 IV	25,577.76	13–121	3777.668	2	26,463.87	3–117	3637.459	2	27,483.98	6–126
3908.094	3	25,580.70	20–129	3776.611	5	26,471.28	12–126	3633.391	3	27,514.68	1–110
3904.582	2	25,603.71	30–141	3772.650	4	26,499.07	26–140	3631.194	125 V	27,531.33	8–127
3904.340	5	25,605.30	17–126	3771.602	6	26,506.43	16–133	3627.001	2	27,563.16	14–136

TABLE III.—*Continued.*

Wave-Length	Int.	Wave Number	Comb.
3623.837	200 V	27,587.22	28–144
3618.576	2	27,627.33	18–139
3613.701	150 V	27,664.60	6–128
3611.331	3 / 2	27,682.75	4–126 / 5–128
3603.355	3	27,744.03	23–141
3600.583	60 V	27,765.39	28–145
3598.196	50 V	27,783.81	9–129
3596.725	2	27,795.17	19–140
3594.61	3	27,811.52	1–111
3594.496	1	27,812.41	1–112
3593.134	2	27,822.95	10–132
3589.390	1	27,851.96	22–141
3587.639	4	27,865.56	27–143
3586.753	2	27,872.45	15–139
3578.738	1	27,934.87	1–114
3574.906	1	27,964.81	12–136
3570.983	3	27,995.53	6–130, 9–131, 16–140
3566.77	1	28,028.60	2–122
3563.823	3	28,051.77	15–140
3559.328	2	28,087.20	30–150
3558.706	3	28,092.11	25–143
3555.788	2	28,115.16	24–142
3554.993	150 V	28,121.45	6–132
3552.727	5	28,139.39	5–132
3552.067	2	28,144.60	12–137
3551.664	4	28,147.80	13–138
3546.651	2	28,187.59	9–133
3546.190	150 V	28,191.25	3–126
3545.781	2	28,194.51	4–130 / 8–133
3545.603	3	28,195.92	10–134
3543.520	4	28,212.49	27–145
3539.086	300 V	28,247.84	6–133
3537.43	?	28,261.06	25–144
3532.878	3	28,297.48	1–115
3532.609	3	28,299.63	30–151
3530.022	5	28,320.37	4–132
3529.043	2	28,328.23	10–135
3528.052	2	28,336.18	26–145
3527.850	4	28,337.80	1–117
3527.607	2	28,339.76	19–141
3520.522	150 V	28,396.79	2–123
3515.776	5	28,435.12	13–139
3509.254	3	28,487.97	11–138
3508.470	4	28,494.33	6–134
3507.945	125 V	28,498.60	2–124
3506.256	5	28,512.32	5–134
3503.978	3	28,530.86	28–148
3502.888	3	28,539.74	24–144
3502.650	3	28,541.68	22–142
3501.453	60 V	28,551.44	3–129
3495.941	4	28,596.45	15–141
3493.728	5	28,614.56	13–140
3492.249	3	28,626.68	6–135
3482.355	6	28,708.01	20–142 / 29–150
3482.139	5	28,709.79	25–147
3481.155	3	28,717.91	24–145
3480.382	4	28,724.29	12–140
3480.279	3	28,725.14	1–119
3475.670	5	28,763.22	3–131
3474.216	6	28,775.26	11–139

Wave-Length	Int.	Wave Number	Comb.
3471.546	1	28,797.39	22–143
3467.776	4	28,828.70	3–132
3466.952	4	28,835.55	2–128
3464.160	6	28,858.79	10–137
3463.138	1	28,867.31	14–141
3457.177	4	28,917.08	9–136
3456.772	3	28,920.47	29–151
3456.340	1 u	28,924.08	8–136
3452.623	3	28,955.22	3–133
3451.617	3	28,963.66	20–143
3449.910	1	28,977.99	27–148
3448.290	3	28,991.60	27–149
3442.955	3	29,036.53	23–145
3442.380	75 V	29,041.38	18–142
3436.304	4	29,092.73	17–142
3428.697	3	29,157.27	6–137
3427.605	2 u	29,166.56	1–120 / 2–130
3426.583	4	29,175.26	5–137
3421.556	2	29,218.12	25–149
3420.534	2	29,226.85	2–131
3420.176	5	29,229.91	16–142
3414.168	2	29,281.34	1–121
3412.334	4	29,297.08	18–143
3409.405	2	29,322.25	22–146
3406.364	2	29,348.43	17–143
3394.138	2	29,454.14	19–144
3392.784	2	29,465.89	18–144
3390.515	5	29,485.61	16–143
3389.212	1	29,496.95	9–139 / 24–149
3388.407	2	29,503.95	8–139
3383.925	1	29,543.03	7–139
3373.729	125 V	29,632.31	19–145
3368.690	5	29,676.64	9–140
3366.554	150 V	29,695.46	17–145
3364.821	4	29,710.76	15–144
3361.853	3	29,736.99	6–140
3361.555	3	29,739.63	26–151
3355.011	7	29,797.63	2–135
3354.520	2	29,802.09	23–148
3352.986	3	29,815.62	23–149
3352.283	4 d	29,821.88	18–146
3351.077	2	29,832.61	16–145
3349.967	5	29,842.49	25–151
3346.517	4	29,873.26	17–146
3344.761	300 V	29,888.94	15–145
3342.531	2	29,908.88	1–124 / 24–150
3341.868	100 V	29,914.82	18–147
3340.886	4	29,923.61	22–149
3339.505	4	29,935.98	4–140
3334.896	1	29,977.35	3–138
3331.224	3	30,010.40	16–146
3324.985	3	30,066.70	15–146
3320.940	2	30,103.32	16–147
3320.781	2	30,104.77	13–143
3318.964	5	30,121.25	24–151
3314.731	100 V	30,159.71	14–141 / 15–147
3311.497	5 d	30,189.16	11–142
3307.233	5	30,228.09	8–141
3303.225	3	30,264.76	3–139
3295.289	80 V	30,337.65	14–146
3290.341	4	30,383.27	12–144

Wave-Length	Int.	Wave Number	Comb.
3286.020	5 d	30,423.22	18–149
3285.224	125 V	30,430.59	14–147
3284.221	4	30,439.88	23–151
3283.680	4	30,444.90	11–143
3280.485	4	30,474.55	17–149
3279.842	125 V	30,480.52	4–141
3271.151	4	30,561.50	12–145
3267.245	2	30,598.08	16–148
3263.884	5	30,629.54	13–146
3263.071	2	30,637.17	1–131
3261.242	1	30,654.36	15–148
3259.784	3	30,668.07	15–149
3254.013	5	30,722.45	13–147
3246.678	60 V	30,791.86	11–145
3243.370	200 V	30,823.27	19–150
3242.135	2	30,835.01	18–150
3236.735	150 V	30,886.45	17–150
3234.165	300 V	30,910.98	9–142
3233.441	3	30,917.91	8–142
3231.236	200 V	30,939.01	14–149
3229.363	4	30,956.95	7–142
3228.024	1	30,969.79	11–146
3226.036	2	30,988.88	3–141
3221.171	250 V	31,135.68	19–151
3218.380	5	31,062.59	11–147
3207.624	3	31,166.75	9–143
3206.921	2	31,173.58	8–143
3202.906	2	31,212.66	7–143
3190.341	3	31,335.58	9–144
3189.638	4	31,342.49	8–144
3188.787	6	31,350.85	14–150
3184.212	4	31,395.84	6–144
3178.485	3	31,452.46	2–141
3172.299	4	31,513.79	9–145
3171.615	200 V	31,520.60	8–145
3167.918	3	31,557.37	11–148
3167.324	3	31,563.29	14–151
3166.243	5	31,574.06	6–145
3164.154	200 V	31,594.91	4–144
3155.793	5	31,678.61	3–142
3154.506	5	31,691.54	9–146
3149.937	2	31,737.50	7–146
3148.458	4	31,752.42	12–150
3146.407	200 V	31,773.11	4–145
3145.282	150 V	31,784.48	9–147
3144.596	5	31,791.41	8–147
3138.296	3 u	31,855.23	13–151
3127.529	80 V	31,964.89	12–151
3125.762	1	31,982.96	11–150
3114.055	1 u	32,103.19	3–144
3097.079	2	32,279.15	9–148
3096.876	3 d	32,281.27	3–145
3095.098	2	32,299.77	8–149
3093.348	3	32,318.09	1–140
3091.292	3 d	32,339.57	6–148
3079.906	1	32,459.12	3–146
3072.391	1	32,538.52	4–148
3071.109	4	32,552.10	3–147
3056.775	200 V	32,704.74	9–150
3051.163	2	32,764.89	6–150
3037.049	2	32,917.15	9–151
3032.727	3	32,964.06	4–150
3025.124	1	33,046.90	3–148
2986.669	2	33,472.39	3–150
2862.787	3	34,920.77	1–148

state should be $^4H_{3\frac{1}{2}}$, whereas if $4f5d^2$ is lower it should be $^4I_{4\frac{1}{2}}$. The J value of the lowest state which we have thus far found is $3\frac{1}{2}$, this possibly being $^4H_{3\frac{1}{2}}$. In any case the spectrum is not like that of La I, which Haspas' analysis purported to show.

Experimental g values have been determined for several of the levels. While these are not very precise they do show large departures from the theoretical g values, evidence of large interactions between the various levels. This perturbation is to be expected, since our term diagram, though far from complete, shows the greatest density of low levels yet observed. The fact that 13 low levels having J values of $3\frac{1}{2}$ have already been found means that at least 13 multiple terms lie within 8300 cm^{-1} of the lowest state. The large number of times this value of J is found shows also that some of the low levels belong to $4f5d^2$, since $4f5d6s$ can account for only eight at the most. The two configurations probably interact so strongly that exact electron configuration assignments will have little meaning.

The energy levels found are presented in Table II. The low levels are numbered from 1 up in order of energy, and the middle levels are numbered from 101 up.

Table III contains a list of the lines which have thus far been classified. Those wave-lengths given to hundredths of an angstrom only are taken from Exner and Haschek;[8] the remainder are M.I.T.-W.P.A. measurements. The second column contains the estimated intensity of the line as given by Klein[9] or by Exner and Haschek,[8] and, where known, King's temperature classification.

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[8] F. Exner and E. Haschek, *Die Spektren der Elemente bei normalen Druck* (Franz Deuticke, Leipzig, 1911).
[9] Ph. Klein, Zeits. f. wiss. Phot. **18**, 45 (1918).

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Pressure Effects of Homogeneous K Vapor in Absorption

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By use of the newly developed corrosion-resistant MgO windows, the K resonance lines in absorption of a homogeneous vapor, were obtained for pressures ranging from 0.001 to 20 mm Hg. The "dispersion" equation was generally adequate to describe the observed contours. The corresponding half-breadths were linear in the density, equal as between components, but of magnitude several times that predicted by the theory of the resonance interaction. The slight asymmetry which appeared at the highest pressure was attributed to van der Waals forces. But it is pointed out that, in contradistinction to the circumstance for Hg, a quantitative verification of the inverse sixth power law is probably not possible. The infrared bands of the K_2 molecule were also observed.

THE strong asymmetries and shifts, characteristic of spectral lines arising from absorption by a metallic vapor in the presence of a foreign gas, have recently been the subject of extended investigation. The pressure effects in a homogeneous absorbing vapor,[1] with the typical marked symmetrical broadenings, are, however, not only less well understood, but their experimental study has been comparatively neglected. It is the purpose of this paper to describe an experimental investigation of the contours of the K resonance lines (λλ7664.9, 7699.0) for the latter case.

In what follows, it will be supposed that foreign gases are present in negligible quantity, so that the interactions among like particles only,

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[1] For a recent review article dealing with the general subject of pressure effects, see H. Margenau and W. W. Watson, Rev. Mod. Phys. 8, 22 (1936).