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New Classifications in the Spectra of Au I and Au II‡

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Measurements have been made on the spectrum of gold excited in a hollow cathode discharge in helium. In the region investigated (600A-10,000A) some 2000 new gold lines were found, of which 237 have been newly classified in the gold arc spectrum and 83 have been newly classified in the first spark spectrum of gold. The new classifications involve 32 new terms in Au I and 12 new terms in Au II. In the arc spectrum, the *ns* and *nd* series have been extended to $n=14$, and new values of the $5f\,^2F$ levels are suggested. The series limit, $5d^{10}\,^1S_0$ of Au II, is calculated to be 74,410 cm^{-1} above the ground state, $5d^{10}6s\,^2S_{\frac{1}{2}}$, of Au I. Several new terms above the series limit have been located. In the first spark spectrum of gold, the resonance triplet discovered by Sawyer and Thomson has been confirmed. The lowest six members of the $5d^97p$ group have been found, and the $5d^86s^2$ configuration has been completed.

Introduction

Early classifications in the arc spectrum of gold were made by Thorsen,[1] who found the sharp and diffuse series, and by McLennan and McLay,[2] who studied extensively the $5d^96snx$ configurations. These early assignments were largely confirmed by the Zeeman effect studies of Symons and Daley,[3] although few of their Zeeman patterns were completely resolved.

The first spark spectrum of gold was partially analyzed by McLennan and McLay,[4] who located the low $5d^9nx$ groups as well as some terms of the $5d^86s^2$ structure; Rao[5] has proposed some additional levels of these configurations. The discovery of the ground state of Au II was announced by Sawyer and Thomson,[6] but the validity of their choice of resonance lines has been questioned by Mack and Fromer in a paper on the Pt I isoelectronic series.[7]

In these previous studies of the gold spectrum, the hollow cathode has been used only once[8] as a source—by Sawyer and Thomson, who limited their measurements to the vacuum ultraviolet. The hollow cathode, however, has well-known advantages in spectral analysis, and therefore it was employed in the present work; measurements of the radiation were made throughout the photographic region in an attempt to extend the classification of Au I and Au II.

Apparatus

The electrodes were enclosed in a Pyrex tube (with a quartz window over one end) through which purified helium was continuously circulated at a pressure of some ten millimeters of mercury. The cathode itself consisted of a hollow tungsten cylinder, one centimeter in diameter, in which gold foil was placed; the cylindrical aluminum anode surrounded the cathode and was concentric with it. The discharge was maintained at a current of about 0.3 ampere supplied by a d.c. generator of range up to 1500 volts.

The light from this source was photographed with four different spectrographs: a glass instrument of the Hilger E1 type (used in the region 4000A–10,000A); a quartz spectrograph of the same design (2000A–4500A); a Zeiss Qu-24 quartz spectrograph (1975A–2400A); and the University of Michigan one-meter vacuum grating spectrograph (600A–2500A), which has been described elsewhere.[9] The dispersions of the

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[1] V. Thorsen, Naturwiss. **11**, 500 (1923).

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[3] A. S. M. Symons and J. Daley, Proc. Phys. Soc. **41**, 431 (1929).

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[5] B. V. R. Rao, Proc. Roy. Soc. **A142**, 118 (1933).

[6] R. A. Sawyer and K. Thomson, Phys. Rev. **38**, 2293 (1931).

[7] J. E. Mack and M. Fromer, Phys. Rev. **48**, 357 (1935).

[8] The hollow cathode was also used by Richard G. Stoner in a series of measurements on the gold spectrum for his undergraduate thesis, Princeton University, 1941. Mr. Stoner has very kindly loaned us a copy of his wavelength list for comparison with our own.

[9] R. A. Sawyer, J. Opt. Soc. Am. **15**, 305 (1927).

TABLE I. *Energy levels in* Au I.

TERM SYMBOL		J VALUE	n^*	ENERGY	REFERENCES
$5d^{10}6s\ ^2S$		$\frac{1}{2}$	1.215	74,410.0	T
$5d^9(^2D_{2\frac{1}{2}})6s^2\ ^2D$		$2\frac{1}{2}$		65,248.7	M-M
$5d^9(^2D_{1\frac{1}{2}})6s^2\ ^2D$		$1\frac{1}{2}$		52,974.7	M-M
$5d^{10}6p\ ^2P^\circ$		$\frac{1}{2}$	1.722	37,051.1	T
		$1\frac{1}{2}$	1.818	33,235.7	T
$5d^9(^2D_{2\frac{1}{2}})6s6p$	1°	$2\frac{1}{2}$		32,246.5	M-M
	2°	$3\frac{1}{2}$		28,872.6	M-M
	3°	$2\frac{1}{2}$		28,235.5	M-M
	4°	$2\frac{1}{2}$		28,031.0	New
	5°	$1\frac{1}{2}$		27,402.6	M-M
	6°	$4\frac{1}{2}$		25,712.6	M-M
	7°	$3\frac{1}{2}$		23,380.9	M-M
	8°	$1\frac{1}{2}$		23,178.6	M-M
	9°	$1\frac{1}{2}$		22,925.0	New
	10°	$2\frac{1}{2}$		22,756.1	M-M
	11°	$3\frac{1}{2}$		21,607.9	New
	12°	$\frac{1}{2}$		21,212.5	M-M
$5d^{10}7s\ ^2S$		$\frac{1}{2}$	2.347	19,925.1	T
$5d^9(^2D_{1\frac{1}{2}})6s6p$	13°	$\frac{1}{2}$		18,677.5	New
	14°	$1\frac{1}{2}$		18,304.0	M-M
	15°	$2\frac{1}{2}$		15,793.5	M-M
	16°	$1\frac{1}{2}$		15,564.9	M-M
	17°	$2\frac{1}{2}$		14,696.8	M-M
$5d^{10}7p\ ^2P^\circ$		$\frac{1}{2}$	2.763	14,377.0	M-M
		$1\frac{1}{2}$	2.832	13,681.1	M-M
$5d^9(^2D_{1\frac{1}{2}})6s6p$	18°	$2\frac{1}{2}$		13,154.9	M-M
	19°	$1\frac{1}{2}$		12,846.7	M-M
$5d^{10}6d\ ^2D$		$1\frac{1}{2}$	2.968	12,458.4	T
		$2\frac{1}{2}$	2.978	12,376.3	T
$5d^9(^2D_{1\frac{1}{2}})6s6p$	20°	$1\frac{1}{2}$		11,404.9	M-M
$5d^{10}8s\ ^2S$		$\frac{1}{2}$	3.369	9667.6	T
$5d^{10}8p\ ^2P^\circ$		$\frac{1}{2}$	3.750	7804.7	New
		$1\frac{1}{2}$	3.825	7499.7	New
$5d^{10}7d\ ^2D$		$1\frac{1}{2}$	3.977	6940.6	T
$5d^{10}5f\ ^2F^\circ$		$3\frac{1}{2}$	3.981	6924.7	New
		$2\frac{1}{2}$	3.982	6920.0	New
$5d^{10}7d\ ^2D$		$2\frac{1}{2}$	3.988	6899.3	T
$5d^9(^2D_{2\frac{1}{2}})6s7s$	1	$3\frac{1}{2}$		6598.5	M-M
$5d^{10}9s\ ^2S$		$\frac{1}{2}$	4.377	5729.5	T
$5d^9(^2D_{2\frac{1}{2}})6s7s$	2	$2\frac{1}{2}$		5704.9	M-M
$5d^{10}8d\ ^2D$		$1\frac{1}{2}$	4.972	4438.7	T
		$2\frac{1}{2}$	4.993	4402.4	T
$5d^{10}10s\ ^2S$		$\frac{1}{2}$	5.379	3792.7	T
$5d^9(^2D_{2\frac{1}{2}})6s7s$	3	$1\frac{1}{2}$		3756.7	M-M
	4	$2\frac{1}{2}$		3188.0	New
$5d^{10}9d\ ^2D$		$1\frac{1}{2}$	5.993	3055.6	T
		$2\frac{1}{2}$	6.018	3029.6	New
$5d^{10}11s\ ^2S$		$\frac{1}{2}$	6.380	2696.2	New
$5d^{10}10d\ ^2D$		$1\frac{1}{2}$	6.990	2246.2	T
		$2\frac{1}{2}$	7.000	2239.2	New
$5d^{10}12s\ ^2S$		$\frac{1}{2}$	7.381	2014.1	New
$5d^{10}11d\ ^2D$		$1\frac{1}{2}$	7.988	1719.9	New
		$2\frac{1}{2}$	7.999	1715.2	New
$5d^{10}13s\ ^2S$		$\frac{1}{2}$	8.38	1562.5	New
$5d^{10}12d\ ^2D$		$1\frac{1}{2}$	8.986	1359.0	New
		$2\frac{1}{2}$	8.999	1355.2	New
$5d^{10}14s\ ^2S$		$\frac{1}{2}$	9.38	1247.9	New
$5d^{10}13d\ ^2D$		$1\frac{1}{2}$	9.983	1101.9	New
		$2\frac{1}{2}$	10.000	1097.4	New
$5d^{10}14d\ ^2D$		$1\frac{1}{2}$	10.98	909.6	New
		$2\frac{1}{2}$	11.00	907.5	New
($5d^{10}\ ^1S_0$ of Au II)…………………				0.0	
$5d^9(^2D_{2\frac{1}{2}})6s6d$	5	$1\frac{1}{2}$		−1868.0	New
	6	$2\frac{1}{2}$		−2156.7	M-M
	7	$5\frac{1}{2}$		−2159.8	M-M
	8	$3\frac{1}{2}$		−2321.9	M-M
	9	$4\frac{1}{2}$		−2419.9	M-M
	10	$1\frac{1}{2}$		−2496.4	New
	11	$2\frac{1}{2}$		−2545.0	New
	12	$2\frac{1}{2}$		−4257.8	New
	13	$1\frac{1}{2}$		−4409.9	New
	14	$1\frac{1}{2}$		−4600.2	New
?	15	$2\frac{1}{2}$		−6362.7	New
?	16	$2\frac{1}{2}$		−6666.8	New
?	17	$1\frac{1}{2}$		−7273.7	New

instruments used make possible an accuracy of about 0.3 cm^{-1} in frequency determinations outside of the vacuum region, although temperature shifts during the long exposures in the infra-red produced uncertainties in the measurements in that region amounting to 1.0 cm^{-1}. In the vacuum region, the uncertainties of wave-length measurement were less than 0.1A, which is equivalent to about 4 cm^{-1} at a wave-length of 1600A.

At least two plates were taken in every wave-length region, and the wave-lengths of the same line as determined from different plates were averaged. The plates were measured on a Gaertner comparator (with a least count of 0.001 mm) and the readings were reduced with the help of a ten-place electrically operated Monroe calculator, which was also used in the search for frequency differences.

RESULTS

Au I

Table I lists the energy levels of Au I as now known, with their energies referred to the newly determined series limit. All of the levels have been newly evaluated from the present measurements. Table II gives all of the classified wave-lengths of Au I.

Some of the assignments deserve further comment.

$5d^{10}ns\ ^2S_{\frac{1}{2}}$.—The first five states of this series were confirmed as classified by Thorsen. The one line on which he based the $5d^{10}11s$ term could not be found, and the present value for this term is supported by two transitions with the expected frequencies and intensities. The present values of the $5d^{10}13s$ and $5d^{10}14s$ terms are each based on one line, as in each case the second possible transition seems to be masked

TABLE II. *Classified lines in* Au I.

λ(air)	ν	INT.	CLASSIFICATION
10,109.0	9889.4	15	$10s\,^2S_{\frac{1}{2}}-7p\,^2P_{1\frac{1}{2}}$
10,066.5	9931.3	7	$8d\,^2D_{1\frac{1}{2}}-7p\,^2P_{\frac{1}{2}}$
9898.1	10,100.2	5	$9d\,^2D_{1\frac{1}{2}}-18^\circ_{2\frac{1}{2}}$
9708.7	10,297.2	7	$6d\,^2D_{1\frac{1}{2}}-10^\circ_{2\frac{1}{2}}$
9552.5	10,465.6	3	$6d\,^2D_{1\frac{1}{2}}-9^\circ_{1\frac{1}{2}}$
9529.3	10,491.1	7	$4_{2\frac{1}{2}}-7p\,^2P_{1\frac{1}{2}}$
9442.4	10,587.6	7	$10s\,^2S_{\frac{1}{2}}-7p\,^2P_{\frac{1}{2}}$
9408.7	10,625.5	7	$9d\,^2D_{1\frac{1}{2}}-7p\,^2P_{1\frac{1}{2}}$
9391.7	10,644.8	30*u*	$9d\,^2D_{2\frac{1}{2}}-7p\,^2P_{1\frac{1}{2}}$
9164.8	10,908.3	3	$10d\,^2D_{1\frac{1}{2}}-18^\circ_{2\frac{1}{2}}$
9098.8	10,987.4	3	$11s\,^2S_{\frac{1}{2}}-7p\,^2P_{1\frac{1}{2}}$
9085.1	11,004.0	7	$6d\,^2D_{2\frac{1}{2}}-7^\circ_{3\frac{1}{2}}$
8984.7	11,127.0	3	$8d\,^2D_{1\frac{1}{2}}-16^\circ_{1\frac{1}{2}}$ $11d\,^2D_{1\frac{1}{2}}-19^\circ_{1\frac{1}{2}}$
8943.1	11,178.7	7	$12_{2\frac{1}{2}}-5f\,^2F_{2\frac{1}{2}}$
8828.3	11,324.1	7	$9d\,^2D_{1\frac{1}{2}}-7p\,^2P_{\frac{1}{2}}$
8824.1	11,329.5	5	$13_{1\frac{1}{2}}-5f\,^2F_{2\frac{1}{2}}$
8777.0	11,390.3	5	$8d\,^2D_{2\frac{1}{2}}-15^\circ_{2\frac{1}{2}}$
8741.4	11,436.7	15	$10d\,^2D_{1\frac{1}{2}}-7p\,^2P_{1\frac{1}{2}}$
8736.3	11,443.3	3	$10d\,^2D_{2\frac{1}{2}}-7p\,^2P_{1\frac{1}{2}}$
8677.8	11,520.5	4	$14_{1\frac{1}{2}}-5f\,^2F_{2\frac{1}{2}}$
8570.2	11,665.1	3	$12s\,^2S_{\frac{1}{2}}-7p\,^2P_{1\frac{1}{2}}$
8556.9	11,683.3	3	$11s\,^2S_{\frac{1}{2}}-7p\,^2P_{\frac{1}{2}}$
8356.7	11,963.1	5	$11d\,^2D_{1\frac{1}{2}}-7p\,^2P_{\frac{1}{2}}$ $11d\,^2D_{2\frac{1}{2}}-7p\,^2P_{\frac{1}{2}}$
8248.2	12,120.5	3	$7s\,^2S_{\frac{1}{2}}-8p\,^2P_{\frac{1}{2}}$ $13s\,^2S_{\frac{1}{2}}-7p\,^2P_{1\frac{1}{2}}$?
8078.2	12,375.5	10	$4_{2\frac{1}{2}}-16^\circ_{1\frac{1}{2}}$
8045.5	12,425.9	5	$7s\,^2S_{\frac{1}{2}}-8p\,^2P_{1\frac{1}{2}}$
8029.5	12,450.7	5	$10d\,^2D_{1\frac{1}{2}}-17^\circ_{2\frac{1}{2}}$
7931.2	12,605.0	5	$4_{2\frac{1}{2}}-15^\circ_{2\frac{1}{2}}$
7704.6	12,975.7	5	$11d\,^2D_{1\frac{1}{2}}-17^\circ_{2\frac{1}{2}}$
7612.8	13,132.1	5	$10d\,^2D_{1\frac{1}{2}}-7p\,^2P_{\frac{1}{2}}$
7510.74	13,310.61	200	$7s\,^2S_{\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$
7495.57	13,337.55	9	$12d\,^2D_{1\frac{1}{2}}-17^\circ_{2\frac{1}{2}}$
7191.61	13,901.26	5	$10_{1\frac{1}{2}}-20^\circ_{1\frac{1}{2}}$ $8d\,^2D_{2\frac{1}{2}}-14^\circ_{1\frac{1}{2}}$
6794.54	14,713.64	70	$5_{1\frac{1}{2}}-19^\circ_{1\frac{1}{2}}$?
6700.32	14,920.55	9	$3_{1\frac{1}{2}}-13^\circ_{\frac{1}{2}}$
6663.20	15,003.67	40	$6_{2\frac{1}{2}}-19^\circ_{1\frac{1}{2}}$
6660.52	15,009.71	20	$1_{3\frac{1}{2}}-11^\circ_{3\frac{1}{2}}$
6654.73	15,022.76	9	$5_{1\frac{1}{2}}-18^\circ_{2\frac{1}{2}}$
6652.33	15,028.18	9*u*	$6d\,^2D_{2\frac{1}{2}}-5^\circ_{1\frac{1}{2}}$
6495.22	15,391.69	7	$11_{2\frac{1}{2}}-19^\circ_{1\frac{1}{2}}$
6387.68	15,650.82	1	$10_{1\frac{1}{2}}-18^\circ_{2\frac{1}{2}}$
6336.66	15,776.83	9	$6d\,^2D_{1\frac{1}{2}}-3^\circ_{2\frac{1}{2}}$
6321.15	15,815.54	9?	$13_{1\frac{1}{2}}-20^\circ_{1\frac{1}{2}}$ $7d\,^2D_{1\frac{1}{2}}-10^\circ_{2\frac{1}{2}}$
6305.00	15,856.05	5	$7d\,^2D_{2\frac{1}{2}}-10^\circ_{2\frac{1}{2}}$
6286.80	15,901.95	1	$2_{2\frac{1}{2}}-11^\circ_{3\frac{1}{2}}$
6278.30	15,923.48	35*u*	$6s^2\,^2D_{1\frac{1}{2}}-6p\,^2P_{\frac{1}{2}}$
6254.96	15,982.90	15	$7d\,^2D_{1\frac{1}{2}}-9^\circ_{1\frac{1}{2}}$
6246.50	16,004.55	15	$14_{1\frac{1}{2}}-20^\circ_{1\frac{1}{2}}$
6186.69	16,159.27	1	$13_{\frac{1}{2}}-10^\circ_{2\frac{1}{2}}$
6156.44	16,238.67	9	$7d\,^2D_{1\frac{1}{2}}-8^\circ_{1\frac{1}{2}}$
6065.57	16,482.21	9	$7d\,^2D_{2\frac{1}{2}}-7^\circ_{3\frac{1}{2}}$
6059.61	16,498.15	1	$6d\,^2D_{2\frac{1}{2}}-2^\circ_{3\frac{1}{2}}$
5957.02	16,782.28	1	$1_{3\frac{1}{2}}-7^\circ_{3\frac{1}{2}}$
5932.32	16,852.15	9	$6_{2\frac{1}{2}}-17^\circ_{2\frac{1}{2}}$
5863.17	17,030.90	5	$2_{2\frac{1}{2}}-10^\circ_{2\frac{1}{2}}$
5837.29	17,125.94	40	$7s\,^2S_{\frac{1}{2}}-6p\,^2P_{\frac{1}{2}}$
5810.32	17,206.00	1	$8d\,^2D_{2\frac{1}{2}}-11^\circ_{3\frac{1}{2}}$
5793.16	17,256.96	5	$13_{1\frac{1}{2}}-19^\circ_{1\frac{1}{2}}$
5741.24	17,413.02	25	$12_{2\frac{1}{2}}-18^\circ_{2\frac{1}{2}}$
5734.69	17,432.91	5	$5_{1\frac{1}{2}}-16^\circ_{1\frac{1}{2}}$
5726.75	17,457.08	45	$3_{1\frac{1}{2}}-12^\circ_{\frac{1}{2}}$
5721.51	17,473.07	5	$2_{2\frac{1}{2}}-8^\circ_{1\frac{1}{2}}$
5691.47	17,565.29	(25)	$13_{1\frac{1}{2}}-18^\circ_{2\frac{1}{2}}$
5660.18	17,662.36	5	$5_{1\frac{1}{2}}-15^\circ_{2\frac{1}{2}}$
5655.72	17,676.35	60*u*	$2_{2\frac{1}{2}}-7^\circ_{3\frac{1}{2}}$
5641.32	17,721.44	5	$6_{2\frac{1}{2}}-16^\circ_{1\frac{1}{2}}$
5636.82	17,735.59	1	$8s\,^2S_{\frac{1}{2}}-5^\circ_{1\frac{1}{2}}$
5630.82	17,754.49	1	$14_{1\frac{1}{2}}-18^\circ_{2\frac{1}{2}}$
5569.67	17,949.41	9	$6_{2\frac{1}{2}}-15^\circ_{2\frac{1}{2}}$
5534.82	18,062.43	3	$10_{1\frac{1}{2}}-16^\circ_{1\frac{1}{2}}$?
5531.90	18,071.96	35	$16_{2\frac{1}{2}}-20^\circ_{1\frac{1}{2}}$
5520.24	18,110.17	3	$11_{2\frac{1}{2}}-16^\circ_{1\frac{1}{2}}$
5465.87	18,289.64	35	$10_{1\frac{1}{2}}-15^\circ_{2\frac{1}{2}}$
5457.73	18,317.56	5	$8d\,^2D_{1\frac{1}{2}}-10^\circ_{2\frac{1}{2}}$
5452.18	18,336.25	1	$11_{2\frac{1}{2}}-15^\circ_{2\frac{1}{2}}$?
5446.96	18,353.78	70	$8d\,^2D_{2\frac{1}{2}}-10^\circ_{2\frac{1}{2}}$?
5427.22	18,420.53	(15)	$4_{2\frac{1}{2}}-11^\circ_{3\frac{1}{2}}$?
5408.39	18,484.67	1	$8d\,^2D_{1\frac{1}{2}}-9^\circ_{1\frac{1}{2}}$
5334.78	18,739.75	6	$8d\,^2D_{1\frac{1}{2}}-8^\circ_{1\frac{1}{2}}$
5324.20	18,776.95	15	$8d\,^2D_{2\frac{1}{2}}-8^\circ_{1\frac{1}{2}}$
5261.80	18,999.63	25	$3_{1\frac{1}{2}}-10^\circ_{2\frac{1}{2}}$
5230.29	19,114.10	30	$1_{3\frac{1}{2}}-6^\circ_{4\frac{1}{2}}$
5225.26	19,132.49	7	$10s\,^2S_{\frac{1}{2}}-9^\circ_{1\frac{1}{2}}$
5215.28	19,169.10	6	$3_{1\frac{1}{2}}-9^\circ_{1\frac{1}{2}}$
5204.57	19,208.53	7	$15_{2\frac{1}{2}}-19^\circ_{1\frac{1}{2}}$?
5180.29	19,298.58	7	$14_{1\frac{1}{2}}-17^\circ_{2\frac{1}{2}}$
5161.13	19,370.22	1	$10d\,^2D_{2\frac{1}{2}}-11^\circ_{3\frac{1}{2}}$
5147.46	19,421.70	40	$3_{1\frac{1}{2}}-8^\circ_{1\frac{1}{2}}$
5123.50	19,512.49	6	$16_{2\frac{1}{2}}-19^\circ_{1\frac{1}{2}}$
5122.01	19,517.44	4	$15_{2\frac{1}{2}}-18^\circ_{2\frac{1}{2}}$
5108.86	19,568.40	10	$4_{2\frac{1}{2}}-10^\circ_{2\frac{1}{2}}$
5074.57	19,700.63	6	$9d\,^2D_{1\frac{1}{2}}-10^\circ_{2\frac{1}{2}}$
5067.62	19,727.64	6	$9d\,^2D_{2\frac{1}{2}}-10^\circ_{2\frac{1}{2}}$
5064.69	19,739.06	15	$6s^2\,^2D_{1\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$ $4_{2\frac{1}{2}}-9^\circ_{1\frac{1}{2}}$
5051.69	19,789.58	6	$6d\,^2D_{1\frac{1}{2}}-1^\circ_{2\frac{1}{2}}$
5043.44	19,822.22	1	$12_{2\frac{1}{2}}-16^\circ_{1\frac{1}{2}}$ $16_{2\frac{1}{2}}-18^\circ_{2\frac{1}{2}}$
5030.61	19,872.82	7	$6d\,^2D_{2\frac{1}{2}}-1^\circ_{2\frac{1}{2}}$
4985.42	20,052.91	1	$12_{2\frac{1}{2}}-15^\circ_{2\frac{1}{2}}$?
4967.86	20,123.79	4	$9d\,^2D_{1\frac{1}{2}}-8^\circ_{1\frac{1}{2}}$
4961.64	20,149.02	1	$9d\,^2D_{2\frac{1}{2}}-8^\circ_{1\frac{1}{2}}$
4957.54	20,165.68	25	$14_{1\frac{1}{2}}-16^\circ_{1\frac{1}{2}}$?
4950.77	20,193.26	15	$4_{2\frac{1}{2}}-7^\circ_{3\frac{1}{2}}$
4948.11	20,204.11	4	$13_{1\frac{1}{2}}-15^\circ_{2\frac{1}{2}}$
4942.40	20,227.46	2	$11s\,^2S_{\frac{1}{2}}-9^\circ_{1\frac{1}{2}}$
4902.25	20,393.12	20	$14_{1\frac{1}{2}}-15^\circ_{2\frac{1}{2}}$
4886.32	20,459.60	4	$6_{2\frac{1}{2}}-14^\circ_{1\frac{1}{2}}$
4885.41	20,463.41	4	$7d\,^2D_{1\frac{1}{2}}-5^\circ_{1\frac{1}{2}}$
4875.24	20,506.02	20	$7d\,^2D_{2\frac{1}{2}}-5^\circ_{1\frac{1}{2}}$
4873.99	20,511.36	4	$10d\,^2D_{1\frac{1}{2}}-10^\circ_{2\frac{1}{2}}$
4872.20	20,518.90	8	$10d\,^2D_{2\frac{1}{2}}-10^\circ_{2\frac{1}{2}}$?
4866.22	20,544.11	4	$5_{1\frac{1}{2}}-13^\circ_{\frac{1}{2}}$
4822.97	20,728.34	7	$6s^2\,^2D_{1\frac{1}{2}}-1^\circ_{2\frac{1}{2}}$
4811.61	20,777.23	60	$6d\,^2D_{1\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$
4806.17	20,800.79	4	$10_{1\frac{1}{2}}-14^\circ_{1\frac{1}{2}}$
4795.01	20,849.20	1	$11_{2\frac{1}{2}}-14^\circ_{1\frac{1}{2}}$
4792.63	20,859.43	100	$6d\,^2D_{2\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$
4775.98	20,932.28	4	$10d\,^2D_{1\frac{1}{2}}-8^\circ_{1\frac{1}{2}}$
4752.43	21,036.00	1	$11d\,^2D_{1\frac{1}{2}}-10^\circ_{2\frac{1}{2}}$
4749.30	21,049.89	2	$11d\,^2D_{2\frac{1}{2}}-10^\circ_{2\frac{1}{2}}$?
4747.08	21,059.71	1	$15_{2\frac{1}{2}}-17^\circ_{2\frac{1}{2}}$
4731.06	21,131.02	10	$7d\,^2D_{2\frac{1}{2}}-4^\circ_{2\frac{1}{2}}$
4721.61	21,173.31	2	$10_{1\frac{1}{2}}-13^\circ_{\frac{1}{2}}$?
4694.69	21,294.72	7	$7d\,^2D_{1\frac{1}{2}}-3^\circ_{2\frac{1}{2}}$
4679.24	21,362.70	6	$16_{2\frac{1}{2}}-17^\circ_{2\frac{1}{2}}$
4672.45	21,396.07	1	$12d\,^2D_{1\frac{1}{2}}-10^\circ_{2\frac{1}{2}}$?
4671.47	21,400.57	1	$12d\,^2D_{2\frac{1}{2}}-10^\circ_{2\frac{1}{2}}$
4664.43	21,432.77	25	$1_{3\frac{1}{2}}-4^\circ_{2\frac{1}{2}}$
4658.75	21,459.00	15	$11d\,^2D_{1\frac{1}{2}}-8^\circ_{1\frac{1}{2}}$
4620.50	21,636.64	7	$1_{3\frac{1}{2}}-3^\circ_{2\frac{1}{2}}$
4612.47	21,674.31	3	$9s\,^2S_{\frac{1}{2}}-5^\circ_{1\frac{1}{2}}$
4607.48	21,697.88	30	$2_{2\frac{1}{2}}-5^\circ_{1\frac{1}{2}}$

TABLE II.—*Continued.*

$\lambda_{\text{(air)}}$	ν	INT.	CLASSIFICATION
4549.33	21,975.06	10	$7d\,^2D_{2\frac{1}{2}}-2^{\circ}_{3\frac{1}{2}}$?
4488.28	22,274.12	20	$1_{3\frac{1}{2}}-2^{\circ}_{3\frac{1}{2}}$
4477.73	22,326.50	6	$2_{2\frac{1}{2}}-4^{\circ}_{2\frac{1}{2}}$
4451.25	22,459.32	3	$16_{2\frac{1}{2}}-15^{\circ}_{2\frac{1}{2}}$?
4437.42	22,529.46	30	$2_{2\frac{1}{2}}-4^{\circ}_{2\frac{1}{2}}$
4430.89	22,562.46	15	$12_{2\frac{1}{2}}-14^{\circ}_{1\frac{1}{2}}$
4401.48	22,713.22	9	$13_{1\frac{1}{2}}-14^{\circ}_{1\frac{1}{2}}$
4353.37	22,964.28	3	$8d\,^2D_{1\frac{1}{2}}-5^{\circ}_{1\frac{1}{2}}$
4346.52	23,000.46	3	$8d\,^2D_{1\frac{1}{2}}-5^{\circ}_{1\frac{1}{2}}$
4333.81	23,067.87	3	$17_{1\frac{1}{2}}-15^{\circ}_{2\frac{1}{2}}$?
4315.12	23,167.83	35	$2_{2\frac{1}{2}}-2^{\circ}_{3\frac{1}{2}}$
4294.66	23,278.20	30	$14_{1\frac{1}{2}}-13^{\circ}_{\frac{1}{2}}$
4241.80	23,368.22	30	$8s\,^2S_{\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$
4227.86	23,645.82	15	$3_{1\frac{1}{2}}-5^{\circ}_{1\frac{1}{2}}$
4206.75	23,764.65	3	$6_{2\frac{1}{2}}-11^{\circ}_{3\frac{1}{2}}$
4201.09	23,796.67	15	$8d\,^2D_{1\frac{1}{2}}-3^{\circ}_{2\frac{1}{2}}$
4194.39	23,834.89	6	$8d\,^2D_{2\frac{1}{2}}-3^{\circ}_{2\frac{1}{2}}$
4177.73	23,929.72	7	$8_{3\frac{1}{2}}-11^{\circ}_{3\frac{1}{2}}$
4160.69	24,027.83	4	$9_{4\frac{1}{2}}-11^{\circ}_{3\frac{1}{2}}$
4128.60	24,214.47	35	$4_{2\frac{1}{2}}-5^{\circ}_{1\frac{1}{2}}$
4118.43	24,274.27	3	$3_{1\frac{1}{2}}-4^{\circ}_{2\frac{1}{2}}$
4084.09	24,478.31	40	$3_{1\frac{1}{2}}-3^{\circ}_{2\frac{1}{2}}$
4065.09	24,592.78	45	$6d\,^2D_{1\frac{1}{2}}-6p^2P_{1\frac{1}{2}}$
4059.85	24,624.52	6	$5_{1\frac{1}{2}}-10^{\circ}_{2\frac{1}{2}}$
4052.76	24,667.53	(9)	$15_{2\frac{1}{2}}-14^{\circ}_{1\frac{1}{2}}$
4040.95	24,739.70	25	$6s^2\,^2D_{1\frac{1}{2}}-3^{\circ}_{2\frac{1}{2}}$
4032.21	24,793.32	6	$5_{1\frac{1}{2}}-9^{\circ}_{1\frac{1}{2}}$
4024.02	24,843.75	3	$4_{2\frac{1}{2}}-4^{\circ}_{2\frac{1}{2}}$
4012.71	24,913.80	3	$6_{2\frac{1}{2}}-10^{\circ}_{2\frac{1}{2}}$
4003.67	24,970.05	3	$16_{2\frac{1}{2}}-14^{\circ}_{1\frac{1}{2}}$?
3991.39	25,046.87	20	$5_{1\frac{1}{2}}-8^{\circ}_{1\frac{1}{2}}$ $4_{2\frac{1}{2}}-3^{\circ}_{2\frac{1}{2}}$
3986.45	25,077.90	6	$8_{3\frac{1}{2}}-10^{\circ}_{2\frac{1}{2}}$
3985.82	25,081.87	6	$6_{2\frac{1}{2}}-9^{\circ}_{1\frac{1}{2}}$
3973.04	25,162.55	3	$10d\,^2D_{2\frac{1}{2}}-5^{\circ}_{1\frac{1}{2}}$
3970.21	25,180.49	8	$9d\,^2D_{1\frac{1}{2}}-3^{\circ}_{2\frac{1}{2}}$
3966.19	25,206.00	6	$9d\,^2D_{2\frac{1}{2}}-3^{\circ}_{2\frac{1}{2}}$
3958.82	25,252.93	9	$10_{1\frac{1}{2}}-10^{\circ}_{2\frac{1}{2}}$
3951.60	25,299.07	6	$11_{2\frac{1}{2}}-10^{\circ}_{2\frac{1}{2}}$?
3950.43	25,306.56	9	$7d\,^2D_{1\frac{1}{2}}-1^{\circ}_{2\frac{1}{2}}$
3945.88	25,335.75	6	$6_{2\frac{1}{2}}-8^{\circ}_{1\frac{1}{2}}$
3943.73	25,349.56	5	$7d\,^2D_{2\frac{1}{2}}-1^{\circ}_{2\frac{1}{2}}$
3930.81	25,422.34	6	$10_{1\frac{1}{2}}-9^{\circ}_{1\frac{1}{2}}$
3914.72	25,537.40	6	$6_{2\frac{1}{2}}-7^{\circ}_{3\frac{1}{2}}$
3909.51	25,572.09	9	$6s^2\,^2D_{1\frac{1}{2}}-5^{\circ}_{1\frac{1}{2}}$
3897.84	25,648.00	12	$1_{3\frac{1}{2}}-1^{\circ}_{2\frac{1}{2}}$
3893.83	25,674.40	6	$10_{1\frac{1}{2}}-8^{\circ}_{1\frac{1}{2}}$?
3892.14	25,685.55	9	$4_{2\frac{1}{2}}-2^{\circ}_{3\frac{1}{2}}$
3886.38	25,723.62	6	$11_{2\frac{1}{2}}-8^{\circ}_{1\frac{1}{2}}$
3874.75	25,800.83	9	$9_{4\frac{1}{2}}-7^{\circ}_{3\frac{1}{2}}$
3864.84	25,866.98	9	$12_{2\frac{1}{2}}-11^{\circ}_{3\frac{1}{2}}$
3853.21	25,945.06	4	$6s^2\,^2D_{1\frac{1}{2}}-4^{\circ}_{2\frac{1}{2}}$
3801.88	26,295.34	30	$7d\,^2D_{1\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$
3799.55	26,311.46	1	$6p\,^2P^{\circ}_{1\frac{1}{2}}-5f\,^2F_{3\frac{1}{2}}$?
3795.95	26,336.38	90	$7d\,^2D_{2\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$
3700.69	27,014.25	25	$12_{2\frac{1}{2}}-10^{\circ}_{2\frac{1}{2}}$
3679.92	27,166.80	30	$13_{1\frac{1}{2}}-10^{\circ}_{2\frac{1}{2}}$
3657.37	27,334.29	2	$13_{1\frac{1}{2}}-9^{\circ}_{1\frac{1}{2}}$
3654.27	27,357.48	1	$14_{1\frac{1}{2}}-10^{\circ}_{2\frac{1}{2}}$
3650.79	27,383.48	30	$8s\,^2S_{\frac{1}{2}}-6p\,^2P_{\frac{1}{2}}$
3643.95	27,434.95	4	$12_{2\frac{1}{2}}-8^{\circ}_{1\frac{1}{2}}$
3634.32	27,507.65	(50)	$9s\,^2S_{\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$
3623.78	27,587.65	9	$13_{1\frac{1}{2}}-8^{\circ}_{1\frac{1}{2}}$
3598.75	27,779.53	3	$14_{1\frac{1}{2}}-8^{\circ}_{1\frac{1}{2}}$
3594.81	27,809.97	4	$8d\,^2D_{1\frac{1}{2}}-1^{\circ}_{2\frac{1}{2}}$
3590.34	27,844.60	2	$8d\,^2D_{2\frac{1}{2}}-1^{\circ}_{2\frac{1}{2}}$
3586.76	27,872.39	45	$7_{5\frac{1}{2}}-6^{\circ}_{4\frac{1}{2}}$
3574.06	27,971.42	2	$15_{2\frac{1}{2}}-11^{\circ}_{3\frac{1}{2}}$?
3566.07	28,034.18	5	$8_{3\frac{1}{2}}-6^{\circ}_{4\frac{1}{2}}$
3553.66	28,132.00	12	$9_{4\frac{1}{2}}-6^{\circ}_{4\frac{1}{2}}$
3535.86	28,273.61	1	$16_{2\frac{1}{2}}-11^{\circ}_{3\frac{1}{2}}$?
3509.04	28,489.70	7	$3_{1\frac{1}{2}}-1^{\circ}_{2\frac{1}{2}}$
3471.60	28,796.95	20	$8d\,^2D_{1\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$
3467.23	28,833.32	70	$8d\,^2D_{2\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$
3440.60	29,056.43	12	$4_{2\frac{1}{2}}-4^{\circ}_{2\frac{1}{2}}$?
3424.62	29,191.95	2	$9d\,^2D_{1\frac{1}{2}}-1^{\circ}_{2\frac{1}{2}}$
3421.50	29,218.63	4	$9d\,^2D_{2\frac{1}{2}}-5^{\circ}_{1\frac{1}{2}}$
3395.43	29,442.90	12	$10s\,^2S_{\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$
3391.34	29,478.43	7	$3_{1\frac{1}{2}}-6p\,^2P_{\frac{1}{2}}$
3384.21	29,540.55	2	$15_{2\frac{1}{2}}-8^{\circ}_{1\frac{1}{2}}$
3382.04	29,559.50	5	$6_{2\frac{1}{2}}-5^{\circ}_{1\frac{1}{2}}$
3378.48	29,590.68	1	$16_{2\frac{1}{2}}-9^{\circ}_{1\frac{1}{2}}$
3361.19	29,742.87	12	$15_{2\frac{1}{2}}-7^{\circ}_{3\frac{1}{2}}$
3355.19	29,796.06	12	$6s^2\,^2D_{1\frac{1}{2}}-8^{\circ}_{1\frac{1}{2}}$
3349.54	29,846.24	9	$16_{2\frac{1}{2}}-8^{\circ}_{1\frac{1}{2}}$
3343.68	29,898.55	2	$10_{1\frac{1}{2}}-5^{\circ}_{1\frac{1}{2}}$ $5_{1\frac{1}{2}}-4^{\circ}_{2\frac{1}{2}}$
3327.15	30,047.16	45	$16_{2\frac{1}{2}}-7^{\circ}_{3\frac{1}{2}}$ $4_{2\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$ $6s^2\,^2D_{1\frac{1}{2}}-9^{\circ}_{1\frac{1}{2}}$
3321.22	30,100.82	3	$5_{1\frac{1}{2}}-3^{\circ}_{2\frac{1}{2}}$?
3320.17	30,110.36	100	$7d\,^2D_{1\frac{1}{2}}-6p\,^2P_{\frac{1}{2}}$
3318.35	30,126.85	5	$5f\,^2F^{\circ}_{3\frac{1}{2}}-6p\,^2P^{\circ}_{\frac{1}{2}}$
3312.46	30,180.35	9	$9d\,^2D_{2\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$
3309.64	30,206.07	30	$9d\,^2D_{2\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$
3308.32	30,218.18	25	$6s^2\,^2D_{1\frac{1}{2}}-10^{\circ}_{2\frac{1}{2}}$
3289.36	30,392.32	2	$6_{2\frac{1}{2}}-3^{\circ}_{2\frac{1}{2}}$
3282.93	30,451.80	50	$17_{1\frac{1}{2}}-8^{\circ}_{1\frac{1}{2}}$
3273.51	30,539.45	7	$11s\,^2S_{\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$
3271.60	30,557.31	1	$8_{3\frac{1}{2}}-3^{\circ}_{2\frac{1}{2}}$
3269.56	30,576.40	8	$11_{2\frac{1}{2}}-4^{\circ}_{2\frac{1}{2}}$
3252.91	30,732.88	1	$10_{1\frac{1}{2}}-3^{\circ}_{2\frac{1}{2}}$?
3226.01	30,989.54	6	$10d\,^2D_{1\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$
3225.25	30,996.48	25	$10d\,^2D_{2\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$
3221.85	31,029.19	7	$6_{2\frac{1}{2}}-2^{\circ}_{3\frac{1}{2}}$
3204.73	31,194.88	9	$8_{3\frac{1}{2}}-2^{\circ}_{3\frac{1}{2}}$
3202.99	31,221.56	5	$12s\,^2S_{\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$
3194.72	31,292.65	7	$9_{4\frac{1}{2}}-2^{\circ}_{3\frac{1}{2}}$
3191.76	31,321.61	12	$9s\,^2S_{\frac{1}{2}}-6p\,^2P_{\frac{1}{2}}$
3181.99	31,417.45	(4)	$11_{2\frac{1}{2}}-2^{\circ}_{3\frac{1}{2}}$
3172.10	31,515.8	6*d*?	$11d\,^2D_{1\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$
3171.63	31,520.47	20	$11d\,^2D_{2\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$
3157.72	31,659.25	1	$12_{2\frac{1}{2}}-5^{\circ}_{1\frac{1}{2}}$?
3156.31	31,673.47	6	$13s\,^2S_{\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$
3142.55	31,812.06	(2)	$13_{1\frac{1}{2}}-5^{\circ}_{1\frac{1}{2}}$
3136.18	31,876.69	5	$12d\,^2D_{1\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$
3135.80	31,880.52	10	$12d\,^2D_{2\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$
3125.66	31,983.92	20	$14s\,^2S_{\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$
3123.84	32,002.60	2	$14_{1\frac{1}{2}}-5^{\circ}_{1\frac{1}{2}}$?
3122.82	32,013.08	(150)	$6s^2\,^2D_{2\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$
3110.66	32,138.28	9	$13d\,^2D_{2\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$
3096.14	32,288.88	3	$12_{2\frac{1}{2}}-4^{\circ}_{2\frac{1}{2}}$
3092.38	32,328.24	5	$14d\,^2D_{2\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$
3081.62	32,441.07	6	$13_{1\frac{1}{2}}-4^{\circ}_{2\frac{1}{2}}$
3065.43	32,612.37	40	$8d\,^2D_{1\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$
3063.61	32,631.78	1	$14_{1\frac{1}{2}}-4^{\circ}_{2\frac{1}{2}}$
3029.23	33,002.09	40	$6s^2\,^2D_{2\frac{1}{2}}-1^{\circ}_{2\frac{1}{2}}$
3017.46	33,130.85	8	$12_{2\frac{1}{2}}-2^{\circ}_{3\frac{1}{2}}$
3005.86	33,258.57	12	$10s\,^2S_{\frac{1}{2}}-6p\,^2P_{\frac{1}{2}}$
3002.64	33,294.35	10	$3_{1\frac{1}{2}}-6p\,^2P_{\frac{1}{2}}$
2940.68	33,995.85	25	$9d\,^2D_{1\frac{1}{2}}-6p\,^2P_{\frac{1}{2}}$
2930.61	34,112.66	3	$5_{1\frac{1}{2}}-1^{\circ}_{2\frac{1}{2}}$
2914.84	34,297.23	30	$6s^2\,^2D_{1\frac{1}{2}}-13^{\circ}_{\frac{1}{2}}$
2909.93	34,355.01	9	$11s\,^2S_{\frac{1}{2}}-6p\,^2P_{\frac{1}{2}}$
2905.91	34,402.51	20	$6_{2\frac{1}{2}}-1^{\circ}_{2\frac{1}{2}}$
2891.99	34,568.15	10	$8_{3\frac{1}{2}}-1^{\circ}_{2\frac{1}{2}}$
2883.45	34,670.43	25	$6s^2\,^2D_{1\frac{1}{2}}-14^{\circ}_{1\frac{1}{2}}$
2873.42	34,791.50	20	$11_{2\frac{1}{2}}-1^{\circ}_{2\frac{1}{2}}$

TABLE II.—*Continued.*

$\lambda_{(\text{air})}$	ν	INT.	CLASSIFICATION
2872.38	34,804.19	20	$10d\,^2D_{1\frac{1}{2}}-6p\,^2P_{\frac{1}{2}}$
2864.33	34,901.94	8	$16_{2\frac{1}{2}}-3^\circ_{2\frac{1}{2}}$
2853.29	35,036.99	8	$12s\,^2S_{\frac{1}{2}}-6p\,^2P_{\frac{1}{2}}$
2831.51	35,306.45	3	$17_{1\frac{1}{2}}-4^\circ_{2\frac{1}{2}}$?
2829.53	35,331.20	12	$11d\,^2D_{1\frac{1}{2}}-6p\,^2P_{\frac{1}{2}}$
2816.99	35,488.38	3	$13s\,^2S_{\frac{1}{2}}-6p\,^2P_{\frac{1}{2}}$
2815.34	35,509.26	15	$17_{1\frac{1}{2}}-3^\circ_{2\frac{1}{2}}$
2800.91	35,692.14	7	$12d\,^2D_{1\frac{1}{2}}-6p\,^2P_{\frac{1}{2}}$
2792.23	35,803.16	3	$14s\,^2S_{\frac{1}{2}}-6p\,^2P_{\frac{1}{2}}$
2780.82	35,949.93	25	$13d\,^2D_{1\frac{1}{2}}-6p\,^2P_{\frac{1}{2}}$
2766.09	36,141.48	3	$14d\,^2D_{1\frac{1}{2}}-6p\,^2P_{\frac{1}{2}}$
2748.24	36,376.11	50	$6s^2\,^2D_{2\frac{1}{2}}-2^\circ_{3\frac{1}{2}}$
2700.90	37,013.77	30	$6s^2\,^2D_{2\frac{1}{2}}-3^\circ_{2\frac{1}{2}}$
2688.72	37,181.37	20	$6s^2\,^2D_{1\frac{1}{2}}-15^\circ_{2\frac{1}{2}}$
2686.08	37,217.95	3	$6s^2\,^2D_{2\frac{1}{2}}-4^\circ_{2\frac{1}{2}}$
2675.95	37,358.68	50	$6s\,^2S_{\frac{1}{2}}-6p\,^2P_{\frac{1}{2}}$
2641.49	37,846.11	30	$6s^2\,^2D_{2\frac{1}{2}}-5^\circ_{1\frac{1}{2}}$
2590.04	38,597.92	15	$6s^2\,^2D_{1\frac{1}{2}}-7p\,^2P_{\frac{1}{2}}$
2589.25	38,609.71	20	$15_{2\frac{1}{2}}-1^\circ_{2\frac{1}{2}}$?
2544.18	39,293.54	12	$6s^2\,^2D_{1\frac{1}{2}}-7p\,^2P_{1\frac{1}{2}}$
2529.56	39,520.70	3	$17_{1\frac{1}{2}}-1^\circ_{2\frac{1}{2}}$
2510.52	39,820.35	7	$6s^2\,^2D_{1\frac{1}{2}}-18^\circ_{2\frac{1}{2}}$
2491.20	40,129.30	6	$6s^2\,^2D_{1\frac{1}{2}}-19^\circ_{1\frac{1}{2}}$
2427.95	41,174.5	(125)	$6s\,^2S_{\frac{1}{2}}-6p\,^2P_{1\frac{1}{2}}$
2404.88	41,569.8	5	$6s^2\,^2D_{1\frac{1}{2}}-20^\circ_{1\frac{1}{2}}$
2387.75	41,867.8	40	$6s^2\,^2D_{2\frac{1}{2}}-7^\circ_{3\frac{1}{2}}$
2376.28	42,070.1	20	$6s^2\,^2D_{2\frac{1}{2}}-8^\circ_{1\frac{1}{2}}$
2362.04	42,323.1	6	$6s^2\,^2D_{2\frac{1}{2}}-9^\circ_{1\frac{1}{2}}$
2352.58	42,493.0	50	$6s^2\,^2D_{2\frac{1}{2}}-10^\circ_{2\frac{1}{2}}$
2213.18	45,169.7	7	$6s^2\,^2D_{1\frac{1}{2}}-8p\,^2P_{\frac{1}{2}}$
2198.32	45,475.0	1	$6s^2\,^2D_{1\frac{1}{2}}-8p\,^2P_{1\frac{1}{2}}$
2170.75	46,054.7	20	$6s^2\,^2D_{1\frac{1}{2}}-5f\,^2F_{2\frac{1}{2}}$
2129.47	46,945.1	6	$6s^2\,^2D_{2\frac{1}{2}}-14^\circ_{1\frac{1}{2}}$
2126.63	47,007.8	15	$6s\,^2S_{\frac{1}{2}}-5^\circ_{1\frac{1}{2}}$
2021.39	49,454.9	2	$6s^2\,^2D_{2\frac{1}{2}}-15^\circ_{2\frac{1}{2}}$
2012.05	49,684.2	15	$6s^2\,^2D_{2\frac{1}{2}}-16^\circ_{1\frac{1}{2}}$
$\lambda_{(\text{vacuum})}$			
1978.19	50,551.2	30	$6s^2\,^2D_{2\frac{1}{2}}-17^\circ_{2\frac{1}{2}}$
1951.93	51,231.6	25	$6s\,^2S_{\frac{1}{2}}-8^\circ_{1\frac{1}{2}}$
1942.31	51,485.0	45	$6s\,^2S_{\frac{1}{2}}-9^\circ_{1\frac{1}{2}}$
1939.21	51,567.6	2	$6s^2\,^2D_{2\frac{1}{2}}-7p\,^2P_{1\frac{1}{2}}$
1919.64	52,093.1	20	$6s^2\,^2D_{2\frac{1}{2}}-18^\circ_{2\frac{1}{2}}$
1857.21	53,844.4	10	$6s^2\,^2D_{2\frac{1}{2}}-20^\circ_{1\frac{1}{2}}$
1714.57	58,324.0	10	$6s^2\,^2D_{2\frac{1}{2}}-5f\,^2D_{3\frac{1}{2}}$
1699.38	58,844.9	4	$6s\,^2S_{\frac{1}{2}}-16^\circ_{1\frac{1}{2}}$
1665.78	60,031.9	12	$6s\,^2S_{\frac{1}{2}}-7p\,^2P_{\frac{1}{2}}$
1646.59	60,729.3	20	$6s\,^2S_{\frac{1}{2}}-7p\,^2P_{1\frac{1}{2}}$
1624.36	61,562.7	8	$6s\,^2S_{\frac{1}{2}}-19^\circ_{1\frac{1}{2}}$
1587.24	63,002.4	20	$6s\,^2S_{\frac{1}{2}}-20^\circ_{1\frac{1}{2}}$
1501.35	66,606.7	1	$6s\,^2S_{\frac{1}{2}}-8p\,^2P_{\frac{1}{2}}$
1494.57	66,909	7	$6s\,^2S_{\frac{1}{2}}-8p\,^2P_{1\frac{1}{2}}$

by an impurity line. The positions of these latter levels are predicted by the series formula with an accuracy of about 2 cm^{-1}.

To determine the series limit, the four terms of the $5d^{10}ns$ series with $n=7$, 8, 9, 10, the four terms of the same series with $n=9$, 10, 11, 12, and the four terms of the $5d^{10}nd$ series with $n=10$, 11, 12, 13, were fitted to an extended Ritz formula of the type given by Shenstone.[10] These three determinations give the series limit, $5d^{10}\,^1S_0$, of Au II, as 74410 cm^{-1} above the ground level, $5d^{10}6s\,^2S_{\frac{1}{2}}$, of Au I, with an average deviation of 3 cm^{-1}.

$5d^{10}np\,^2P_{\frac{1}{2},1\frac{1}{2}}$.—The intensities in the combinations given for $5d^{10}8p$ are irregular, but these are the only combinations with satisfactory frequency differences in the expected region, and the separation of the ^2P terms is of the right order of magnitude. The irregularity in the progression of the Rydberg numbers may perhaps be attributed to the perturbation of the $5d^{10}7p$ terms by the $5d^96s6p$ group. In Ag I, Shenstone[11] observed the same phenomena exhibited here—fewer members of the p series were found than of the s or d series, and the intensities of some combinations involving the p series were highly anomalous.

$5d^{10}nd\,^2D_{1\frac{1}{2},2\frac{1}{2}}$.—The terms $5d^{10}6d$, $-7d$, and $-8d$ were confirmed as classified by Thorsen, as were also the single levels $5d^{10}9d\,^2D_{1\frac{1}{2}}$ and $5d^{10}10d\,^2D_{1\frac{1}{2}}$. However, new choices have been made for the transitions $5d^{10}9d\,^2D_{2\frac{1}{2}}-5d^{10}6p\,^2P_{1\frac{1}{2}}$ and $5d^{10}10d\,^2D_{2\frac{1}{2}}-5d^{10}6p\,^2P_{1\frac{1}{2}}$, which fit better the trends of intensity and separation in the series than do Thorsen's choices, as shown in Table III. The lines Thorsen assigned to these transitions have been newly classified elsewhere.

The d series is slightly perturbed by the low $5d^96s7s$ terms.

$5d^{10}5f\,^2F_{2\frac{1}{2},3\frac{1}{2}}$.—The levels assigned to this structure are based on single transitions, but these transitions are the strongest lines in the

TABLE III. *Intensity of* $^2D_{2\frac{1}{2}}-{}^2P_{1\frac{1}{2}}$ *and* ^2D *separation in the diffuse series of* Au I. (*The data given are from the present study.*)

	THORSEN		PRESENT WORK	
	INT.	SEP.	INT.	SEP.
7*d*	90	41.04	90	41.04
8*d*	70	36.37	70	36.37
9*d*	25	37.83	30	25.72
10*d*	7	39.65	25	6.94
11*d*	—	—	20	4.7
12*d*	—	—	10	3.83

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[10] A. G. Shenstone, Phil. Trans. Roy. Soc. **A235**, 195 (1936).

[11] A. G. Shenstone, Phys. Rev. **57**, 894 (1940).

TABLE IV. *Energy levels in* Au II.

TERM SYMBOL		J VALUE	ENERGY	REFERENCES
$5d^{10}\,{}^1S_0$	1	0	0.0	S-T
$5d^96s(2\frac{1}{2}, \frac{1}{2})$	2	3	15,039.0	M-M
	3	2	17,639.4	M-M
$5d^96s(1\frac{1}{2}, \frac{1}{2})$	4	1	27,764.5	M-M
	5	2	29,620.8	M-M
$5d^86s^2$	6	4	40,478.3	M-M
	7	2	48,510.4	M-M
	8	3	52,176.0	M-M
	9	0	55,436.6	New
	10	2	58,191.2	M-M
	11	1	59,101.0	New
	12	4	61,384.5	New
$5d^96p(2\frac{1}{2}, \frac{1}{2})$	1°	2	63,052.5	M-M
	2°	3	65,002.9	M-M
$5d^86s^2$	13	2	68,145.1	New
$5d^96p(2\frac{1}{2}, 1\frac{1}{2})$	3°	4	72,494.8	M-M
	4°	2	73,177.8	M-M
	5°	1	73,403.1	M-M
	6°	3	74,790.9	M-M
$5d^96p(1\frac{1}{2}, \frac{1}{2})$	7°	2	76,658.7	M-M
	8°	1	81,659.1	M-M
$5d^96p(1\frac{1}{2}, 1\frac{1}{2})$	9°	0	82,613.0	M-M
	10°	3	85,699.2	M-M
$5d^96p(1\frac{1}{2}, 1\frac{1}{2})$	11°	1	85,707.0	M-M
	12°	2	86,565.1	M-M
$5d^86s^2$	14	0	91,114.4	New
$5d^97s(2\frac{1}{2}, \frac{1}{2})$	15	3	108,172.2	M-M
	16	2	108,630.8	M-M
$5d^9(2\frac{1}{2})6d$	17	1	116,049.8	M-M
	18	4	116,945.8	M-M
	19	2	117,065.2	M-M
	20	1	117,296.9	M-M
	21	3	117,511.4	M-M
	22	3	117,982.8	M-M
	23	2	118,028.9	M-M
	24	4	118,167.6	M-M
$5d^97p(2\frac{1}{2}, \frac{1}{2})$	13°	2	119,446.1	New
	14°	3	120,256.5	New
$5d^97s(1\frac{1}{2}, \frac{1}{2})$	25	1	120,822.1	M-M
$5d^86s6p$	15°	2	120,952.0	New
$5d^97s(1\frac{1}{2}, \frac{1}{2})$	26	2	121,117.8	M-M
$5d^97p(2\frac{1}{2}, 1\frac{1}{2})$	16°	2	121,784.2	New
	17°	1	121,862.0	New
	18°	4	123,061.8	New
	19°	3	123,343.8	New

expected region, and the separation is of the expected order of magnitude. The transitions assigned to this configuration by McLennan and McLay were not found. The present assignments are further confirmed by discovery of two weak (forbidden) lines from $5d^{10}5f$ to the ground state, similar to the forbidden lines found by Shenstone in his studies on Ag I with a hollow cathode.

$5d^96s7s$.—It is a little surprising that the new term of this configuration, $4_{2\frac{1}{2}}$, has not been previously found, as the lines involved are fairly intense. The low levels of this group show clearly the near-*jj*-coupling of the $7s$ electron with the $5d^96s$ group of Au II. The four high levels should lie near -7500 cm^{-1}.

$5d^96s6p$.—This structure should give rise to twenty-three levels. Of the eighteen previously proposed, two have been eliminated, while four new levels are here presented. Three high terms, with J values of $\frac{1}{2}$, $\frac{1}{2}$, and $3\frac{1}{2}$, are yet to be located.

The discarded levels were based only on one and two transitions, respectively. The four new states suggested account for several strong lines. The J value of the term 19° has been changed from $\frac{1}{2}$ to $1\frac{1}{2}$ to account for a transition to the term $6_{2\frac{1}{2}}$. The level 17° has been changed from $J=3\frac{1}{2}$ to $J=2\frac{1}{2}$ because of the apparent combinations of this term with $-10d$, $-11d$, and $-12d\,{}^2D_{1\frac{1}{2}}$. The J value of the state 16° has been revised from $3\frac{1}{2}$ to $1\frac{1}{2}$, because of discovery of the resonance line 1699.37A; it is not clear why the transition to $6s^2\,{}^2D_{1\frac{1}{2}}$ does not appear. Since all of the expected $2\frac{1}{2}$ levels of this configuration are now known, the term 14° cannot have a J value of $2\frac{1}{2}$, and therefore the value $1\frac{1}{2}$ has been assigned to it.

A number of newly-found weak lines have been classified in Table I as $5d^9\,6s6p$—$5d^{10}nd$ transitions. Some of the identifications may be spurious, as the intensities are somewhat irregular; but most of these transitions are believed to be real.

The $5d^96s6p$ group shows a general similarity to $5d^96p$ of Au II. Both configurations have an over-all separation of about 24,000 cm^{-1}, divided into two groups 12,000 cm^{-1} wide based, respectively, on $5d^9\,{}^2D_{2\frac{1}{2}}$ and $5d^9\,{}^2D_{1\frac{1}{2}}$ of Au III.

$5d^96s6d$.—This configuration should contain thirty-four levels, all above the series limit. Of the six terms previously announced, one has been discarded because the measured frequency differences were at variance with the expected values; and another has been eliminated because two of the three transitions previously assigned to it were not found. The term $6_{2\frac{1}{2}}$ is well established, but the states $7_{5\frac{1}{2}}$, $8_{3\frac{1}{2}}$, and $9_{4\frac{1}{2}}$ are dubious as they are based on a very small number of

Table V. *Classified lines in* Au II.

$\lambda_{\text{(air)}}$	ν	Int.	Classification
8999.7	11,108.5	7	$12_4-3^\circ_4$
8867.6	11,273.9	25	$15_3-13^\circ_2$
8599.1	11,625.9	35	$16_2-14^\circ_3$
8272.9	12,084.3	40	$15_3-14^\circ_3$
8114.6	12,320.2	4	$16_2-15^\circ_2$
7600.49	13,153.43	125	$16_2-16^\circ_2$
7555.81	13,231.20	70	$16_2-17^\circ_1$
7457.05	13,406.44	40	$12_4-6^\circ_3$
7344.43	13,612.01	70	$15_3-16^\circ_2$
7101.60	14,077.46	20	$11_1-4^\circ_2$
6794.84	14,713.00	50	$16_2-19^\circ_3$
6714.26	14,889.59	90	$15_3-18^\circ_4$
6671.02	14,986.08	20	$10_2-4^\circ_2$
6589.54	15,171.58	30	$15_3-19^\circ_3$
6571.34	15,213.42	7	$10_2-5^\circ_1$
6061.90	16,491.92	15	$7_2-2^\circ_3$
5695.73	17,552.15	25	$13_2-10^\circ_3$?
5691.47	17,565.29	(20)	$13_2-11^\circ_1$
5644.94	17,710.08	35	$14_0-5^\circ_1$
5564.41	17,966.41	12	$9_0-5^\circ_1$
5427.22	18,420.53	(15)	$13_2-12^\circ_2$?
5413.28	18,467.97	3	$10_2-7^\circ_2$
4760.10	21,002.02	8	$8_3-4^\circ_2$
4626.80	21,607.26	5	$15_3-12^\circ_2$
4448.61	22,472.64	7	$15_3-10^\circ_3$
4431.80	22,557.78	15	$11_1-8^\circ_1$
4420.81	22,613.91	10	$8_3-6^\circ_3$
4361.06	22,923.83	12	$16_2-11^\circ_1$
4359.45	22,932.24	3	$16_2-10^\circ_3$
4259.90	23,468.15	9	$10_2-8^\circ_1$
4111.42	24,315.86	3	$12_4-10^\circ_3$
4076.34	24,524.79	4	$6_4-2^\circ_3$
4052.76	24,667.53	9	$7_2-4^\circ_2$
4016.04	24,893.14	9	$7_2-5^\circ_1$
3812.31	26,223.40	4	$9_0-8^\circ_1$
3804.05	26,280.33	9	$7_2-6^\circ_3$
3706.56	26,971.55	9	$16_2-8^\circ_1$
3634.32	27,507.65	(50)	$10_2-10^\circ_3$
3633.24	27,515.83	7	$10_2-11^\circ_1$
3551.57	28,148.55	7	$7_2-7^\circ_2$
3523.35	28,374.08	9	$10_2-12^\circ_2$
3391.34	29,478.43	(7)	$17_1-12^\circ_2$
3302.72	30,269.39	(1)	$9_0-11^\circ_1$
3294.61	30,343.89	4	$17_1-11^\circ_1$
3251.35	30,747.62	80	$14_0-17^\circ_1$
3230.63	30,944.76	25	$21_3-12^\circ_2$
3182.00	31,417.45	(4)	$22_3-12^\circ_2$
3172.31	31,513.68	6?	$15_3-7^\circ_2$?
3164.79	31,589.49	30	$20_1-11^\circ_1$
3142.55	31,812.06	2	$21_3-10^\circ_3$
3126.82	31,972.07	12	$16_2-7^\circ_2$
3122.82	32,013.08	(150)	$6_4-3^\circ_4$
3093.004	32,321.68	20	$23_2-11^\circ_1$
3015.840	33,148.66	12	$7_2-8^\circ_1$
2994.820	33,381.33	35	$15_2-6^\circ_3$
2990.276	33,432.00	20	$\left\{\begin{array}{l}17_1-9^\circ_0\\5_2-1^\circ_2\end{array}\right.$
2982.102	33,523.68	15	$8_3-10^\circ_3$
2954.224	33,839.98	30	$16_2-6^\circ_3$
2918.250	34,257.11	60	$25_1-12^\circ_2$
2913.536	34,312.63	25	$6_4-6^\circ_3$
2907.056	34,389.02	30	$\left\{\begin{array}{l}17_1-8^\circ_1\\8_3-12^\circ_2\end{array}\right.$
2893.299	34,552.53	80	$26_2-12^\circ_2$
2856.752	34,994.53	20	$15_3-4^\circ_2$
2846.962	35,114.87	80	$25_1-11^\circ_1$
2837.870	35,227.36	25	$16_2-5^\circ_1$
2833.022	33,287.62	9	$4_2-1^\circ_2$
2825.453	35,382.10	20	$5_2-2^\circ_3$
2823.170	35,410.85	25	$26_2-11^\circ_1$
2822.550	35,418.56	250	$26_2-10^\circ_3$
2819.800	35,453.12	30	$16_2-4^\circ_2$
2805.214	35,637.47	25	$20_1-8^\circ_1$
2802.064	35,677.49	40	$15_3-3^\circ_4$
2748.708	36,370.00	20	$23_2-8^\circ_1$
2688.161	37,189.10	20	$7_2-10^\circ_3$
2687.628	37,196.50	20	$7_2-11^\circ_1$
2627.016	38,054.67	20	$7_2-12^\circ_2$
2616.401	38,209.05	50	$25_1-9^\circ_1$
2552.666	39,162.99	45	$25_1-8^\circ_1$
2537.889	39,391.00	10	$17_1-7^\circ_2$
2533.519	39,458.92	60	$26_2-8^\circ_1$
2460.159	40,635.6	8	$20_1-7^\circ_2$
2419.418	41,319.7	3	$22_3-7^\circ_2$?
2416.503	41,369.6	9	$23_2-7^\circ_2$
2371.475	42,155.0	9	$18_4-6^\circ_3$
2364.781	42,274.3	12	$19_2-6^\circ_3$
2344.146	42,648.3	4	$17_1-5^\circ_1$
2340.063	42,720.8	25	$21_3-6^\circ_3$
2331.800	42,872.2	7	$17_1-4^\circ_2$
2315.746	43,169.4	20	$15_3-2^\circ_3$
2314.551	43,191.8	25	$22_3-6^\circ_3$
2312.08	43,237.8	7	$23_2-6^\circ_3$
2304.689	43,376.6	45	$24_4-6^\circ_3$
2295.13	43,557.1	4	$5_2-4^\circ_2$
2291.400	43,628.0	25	$16_2-2^\circ_3$
2289.59	43,662.4	2	$19_2-5^\circ_1$
2283.300	43,782.7	25	$5_2-5^\circ_1$
2277.87	43,887.1	4	$19_2-4^\circ_2$
2277.518	43,894.0	25	$20_1-5^\circ_1$
2263.88	44,119.6	18	$20_1-4^\circ_2$
2263.620	44,163.3	80	$25_1-7^\circ_2$
2254.928	44,333.5	6	$21_3-4^\circ_2$
2248.97	44,451.0	7	$18_4-3^\circ_4$
2248.560	44,459.1	70	$26_2-7^\circ_2$
2240.164	44,625.8	25	$23_2-5^\circ_1$
2231.18	44,805.2	30	$22_3-4^\circ_2$
2228.880	44,851.6	45	$23_2-4^\circ_2$
2220.714	45,016.6	10	$21_3-3^\circ_4$
2215.626	45,119.8	35	$15_3-1^\circ_2$
2213.167	45,169.7	7	$5_2-6^\circ_3$
2210.66	45,221.4	9	$6_4-10^\circ_3$
2201.32	45,413.1	25	$\left\{\begin{array}{l}3_2-1^\circ_2\\4_1-4^\circ_2\end{array}\right.$
2197.71	45,488.5	4	$22_3-3^\circ_4$
2193.34	45,578.3	4	$16_2-1^\circ_2$
2190.44	45,638.6	2	$4_1-5^\circ_1$
2188.81	45,672.8	35	$24_4-3^\circ_4$
2125.29	47,037.7	30	$5_2-7^\circ_2$
2110.68	47,363.2	60	$3_2-2^\circ_3$
2108.17	47,419.4	½	$25_1-5^\circ_1$
2098.14	47,646.1	20	$25_1-4^\circ_2$
2095.13	47,715.0	35	$26_2-5^\circ_1$
2085.31	47,939.6	6	$26_2-4^\circ_2$
2082.09	48,013.5	150	$2_3-1^\circ_2$
2044.54	48,894.7	50	$4_1-7^\circ_2$
2000.81	49,963.0	25	$2_3-2^\circ_3$

TABLE V.—*Continued.*

λ(vacuum)	ν	INT.	CLASSIFICATION
1949.24	51,302.0	4	$13_2-13^\circ_2$
1925.23	51,941.8	10	$18_4-\ 2^\circ_3$
1921.64	52,038.8	20	$5_2-\ 8^\circ_1$
1920.73	52,063.8	1	$19_2-\ 2^\circ_3$
1918.93	52,112.3	7	$13_2-14^\circ_3$
1904.43	52,509.1	10	$21_3-\ 2^\circ_3$
1887.44	52,981.8	7	$22_3-\ 2^\circ_3$
1886.96	53,000.9	7	$17_1-\ 1^\circ_2$
1885.72	53,025.9	2	$23_2-\ 2^\circ_3$
1880.79	53,169.1	1	$24_4-\ 2^\circ_3$
1861.61	53,716.9	1	$13_2-17^\circ_1$
1855.46	53,894.9	7	$4_1-\ 8^\circ_1$
1851.49	54,012.0	7	$19_2-\ 1^\circ_2$
1843.50	54,244.6	4	$20_1-\ 1^\circ_2$
1836.28	54,457.9	10	$21_3-\ 1^\circ_2$
1823.24	54,847.4	25	$4_1-\ 9^\circ_0$
1819.05	54,973.7	1	$23_2-\ 1^\circ_2$
1811.71	55,196.7	4	$13_2-19^\circ_3$
1800.58	55,537.6	35	$3_2-\ 4^\circ_2$
1793.31	55,762.8	35	$3_2-\ 5^\circ_1$
1783.22	56,078.3	60	$5_2-11^\circ_1$ $5_2-10^\circ_3$
1756.10	56,944.3	35	$5_2-12^\circ_2$
1749.71	57,152.3	10	$3_2-\ 6^\circ_3$
1740.47	57,456.0	45	$2_3-\ 3^\circ_4$
1731.01	57,769.7	1	$25_1-\ 1^\circ_2$
1725.89	57,941.4	25	$4_1-11^\circ_1$
1721.98	58,072.7	1	$26_2-\ 1^\circ_2?$
1719.97	58,140.8	10	$2_3-\ 4^\circ_2$
1700.69	58,799.6	30	$4_1-12^\circ_2$
1698.59	58,872.3	2	$12_4-14^\circ_3$
1694.29	59,024.9	7	$3_2-\ 7^\circ_2$
1673.61	59,751.4	25	$2_3-\ 6^\circ_3$
1657.09	60,346.7	10	$11_1-13^\circ_2?$
1632.54	61,254.2	2	$10_2-13^\circ_2$
1622.87	61,619.6	2	$2_3-\ 7^\circ_2$
1611.18	62,066.3	12	$10_2-14^\circ_3$
1595.48	62,683.3	7	$11_1-16^\circ_2$
1593.39	62,759.6	12	$10_2-15^\circ_2$ $11_1-17^\circ_1$
1562.09	64,016.8	10	$3_2-\ 8^\circ_1$
1534.88	65,151.6	1	$10_2-19^\circ_3$
1505.44	66,425.7	2	$9_0-17^\circ_1$
1486.49	67,273	25	$8_3-13^\circ_2$
1468.97	68,075	30	$8_3-14^\circ_3$ $3_2-11^\circ_1$ $3_2-10^\circ_3$
1453.88	68,781	1	$8_3-15^\circ_2$
1450.81	68,925	3	$3_2-12^\circ_2$
1436.61	69,608	20	$8_3-16^\circ_2$
1410.98	70,862	7 *w*	$8_3-18^\circ_4$
1409.67	70,939	1	$7_2-13^\circ_2$
1405.17	71,166	30	$8_3-19^\circ_3$
1398.06	71,529	8	$2_3-12^\circ_2$
1393.75	71,747	6	$7_2-14^\circ_3$
1380.43	72,442	8	$7_2-15^\circ_2$
1364.78	73,272	10	$7_2-16^\circ_2$
1363.20	73,357	8	$7_2-17^\circ_1$
1362.36	73,402	6	$1_0-\ 5^\circ_1$
1336.23	74,837	3	$7_2-19^\circ_3$
1253.38	79,784	2	$6_4-14^\circ_3$
1224.57	81,661	20	$1_0-\ 8^\circ_1$
1210.80	82,587	5	$6_4-18^\circ_4$
1206.71	82,869	2	$6_4-19^\circ_3$
1166.76	85,707	3	$1_0-11^\circ_1$
1103.32	90,636	20	$5_2-14^\circ_3$
1094.86	91,336	5	$5_2-15^\circ_2$
1090.68	91,685	8	$4_1-13^\circ_2$
	(92,163)		$5_2-16^\circ_2$
	(92,241)		$5_2-17^\circ_1$
1073.09	93,192	40	$4_1-15^\circ_2$
1066.96	93,724	8	$5_2-19^\circ_3$
	(94,020)		$4_1-16^\circ_2$
	(94,097)		$4_1-17^\circ_1$
982.21	101,811	2	$3_2-13^\circ_2$
974.44	102,611	3	$3_2-14^\circ_3$
967.90	103,309	3	$3_2-15^\circ_2$
959.48	104,210	20	$3_2-17^\circ_1$
957.73	104,411	20	$2_3-13^\circ_2$
	(105,217)		$2_3-14^\circ_3$
	(105,704)		$3_2-19^\circ_3$
944.19	105,910	3	$2_3-15^\circ_2$
	(106,745)		$2_3-16^\circ_2$
	(108,022)		$2_3-18^\circ_4$
	(108,304)		$2_3-19^\circ_3$
820.42	121,888	7 *w*	$1_0-17^\circ_1?$

lines. The unresolved Zeeman patterns of Symons and Daley do not contradict these latter classifications, but neither do they establish them.

Six new terms are proposed for $5d^96s6d$, and three more terms are added near -6700 cm^{-1} which may belong to $5d^96s6d$ or to $5d^96s7s$ or $5d^96s8s$. Each of the newly suggested levels is supported by three or more transitions of at least moderate intensity, except for the states $10_{1\frac{1}{2}}$, $14_{1\frac{1}{2}}$, and $17_{1\frac{1}{2}}$. The latter states are each based on only two transitions to previously established levels, although the transitions in question are intense.

In the spectrum of Au I, thirty-two new terms have been found, and nine previously suggested terms have been discarded, bringing the total to forty-six known even levels and twenty-seven known odd levels in the gold arc spectrum. Of the 318 lines involved in these assignments, eighty-five had been previously classified.

Au II

The levels of Au II are listed in Table IV with respect to $5d^{10}\ {}^1S_0$, the ground state. Table V lists all of the classified wave-lengths of the Au II spectrum.

$5d^{10}\ {}^1S_0$.—This level, the ground state of Au II, is determined from the previously discovered resonance lines of the $5d^96p$ configuration, 73,402 cm^{-1}, 81,661 cm^{-1}, and 85,707 cm^{-1}, which have been confirmed. This resonance triplet was first proposed by Sawyer and Thomson from measurements with the same type of source and the same vacuum spectrograph as in the present work. An alternative resonance triad has been suggested by Mack and Fromer, but it is not supported by the present measurements. The intensities given by various investigators for these two proposed resonance groups are shown in Table VI. Mack and Fromer say of the Sawyer-Thomson triplet: "this disparity in intensities is contrary to the behavior of almost all other known $d^{10}-d^9p$ line triads"; but the paper of Goble[12] lists the following observed intensities for such resonance groups in the Pt I isoelectronic series:

Pt I	Hg III	Tl IV	Pb V	Bi VI
1	8	4	1	7
6	8	10	10	10
2	6	7	7	8

which seem to be in fair accord with the intensities found in the triplet chosen.

A search was made to see if any other combinations of lines within 5000 cm^{-1} of the expected position could possibly be the resonance triad, but no other group was found with the proper frequency differences. The levels of Au II in Table IV have therefore been evaluated with respect to the ground state given by Sawyer and Thomson.

$5d^9ns$.—The $5d^96s$ and $5d^97s$ groups were confirmed as given by McLennan and McLay. Higher members of the series could not be found in the source used since the excitation energy was limited by the ionization energy of helium to 123,900 cm^{-1} above the ground state of Au II. Transitions from $5d^97s$ are seen to be enhanced because of the nearness of the upper levels to this excitation limit.

TABLE VI. *Intensities in proposed resonance triplets of* Au II.

ν	$\Delta\nu$	B-B* (spark)	B-B-F†	S-T	New
SAWYER-THOMSON TRIPLET					
73,402	(+1)	—		4	3
81,661	(−2)		4	7	20
85,707	(0)		0	5	6
MACK-FROMER TRIPLET					
72,388	(−1)	2		—‡	—
80,647	(−4)		3	1	2[80652(−9)]
84,674	(+17)		3	—	1[84668(+23)]

* L. Bloch and E. Bloch, J. de phys. et rad. **6**, 160 (1925).
† L. Bloch, E. Bloch, and J. Farineau, J. de phys. et rad. **3**, 437 (1932).
‡ From unpublished data.

From the known terms of the $5d^9ns$ and $5d^9np$ series, the limit $5d^9\ ^2D_{2\frac{1}{2}}$ of Au III is estimated, with the help of Rydberg term tables, to be 165,000 cm^{-1} above the ground state of Au II.

$5d^9np$.—This group of twelve levels was first classified by McLennan and McLay. Mack and Fromer proposed a new value for the term $J=0$, based on three lines, but the success of their assignment depended on a numerical error of 100 cm^{-1} in one of the transitions, and therefore their proposed term must be rejected. The level given by McLennan and McLay for $J=0$ is regarded as established, since it makes strong combinations with $5d^96s$, $5d^97s$, and $5d^96d$.

The six members of $5d^97p$ based on $^2D_{2\frac{1}{2}}$ of the ion lie below the excitation limit of the discharge, and have been found from the intense combinations they make in the infra-red with $5d^97s$. The higher members of $5d^97p$, based on $5d^9\ ^2D_{1\frac{1}{2}}$, lie above the excitation limit of the discharge, and were not found.

The calculated frequencies of several expected combinations of $5d^97p$ with $5d^9ns$ below 1100A are listed in brackets in Table V, because the lines, if present, lie so near strong known impurity lines that they cannot be measured.

$5d^96d$.—Of the ten levels given by McLennan and McLay for this configuration, two have been discarded. The term with $J=5$ can make only one combination with terms so far established, and so is considered too doubtful. Transitions involving the term with $J=0$ had frequency differences at variance with those expected, and this term was also eliminated. Of the remaining states, the levels 18_4, 19_2, and 24_4 probably should be classed as tentative because they are based on a small number of lines or on rather weak lines.

Rao has proposed some forty terms for $5d^96d$, $5d^86s^2$, $5d^86s7s$. Many of these levels are based on frequency differences which do not agree with the expected values, and in the rest, the intentensities are so low as to suggest that the

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[12] A. T. Goble, Phys. Rev. **48**, 346 (1935).

apparent levels are only a chance coincidence of frequency values. Since also, the location of levels suggested by Rao is often in violent disagreement with theory, none of his classifications is included here.

$5d^86s^2$.—McLennan and McLay listed five states of this configuration. The transitions they assigned to the level with $J=1$ have frequencies which differ from the calculated values, and this term has therefore been omitted here. From the four other previously given terms, it has been possible to predict roughly the location of the remaining five states of the configuration, by analogy with the isoelectronic spectra, Pt I and Hg III. A prediction of the unknown levels was also obtained from the theoretical formulae of Johnson[13] for the general d^2 configuration, after the constants in the formulae had been adjusted to fit the known levels.

With this aid, the missing five terms of this configuration were located. The high level, 14°, is established by two transitions which are unusually strong, because for one of them the upper term is near the helium ionization energy; and for the other, the upper level is near a metastable state of helium.

The relative energies of the states of d^8s^2 measured from the level with $J=3$, are given theoretically by solution of the following equations:

$$
\begin{aligned}
J=4;&\quad E^2-E(bX-5)-4aX=0,\\
J=3;&\quad E=0,\\
J=2;&\quad E^3-E^2(b+c)X+E[bcX^2+(b+2c)X-25]\\
&\qquad -3bcX^2+\tfrac{3}{5}X(10+21c)=0,\\
J=1;&\quad E-cX=0,\\
J=0;&\quad E^2-EX(c+d)+cdX^2-X(c-d)-25=0,
\end{aligned}
$$

where

$$
\begin{aligned}
a&=12+2t,\\
b&=5+9t,\\
c&=15-15t,\\
d&=22+27t.
\end{aligned}
$$

Energy, E, is given by these formulae in units of a parameter, A; to find the energy, W, in wave numbers,

$$W=EA.$$

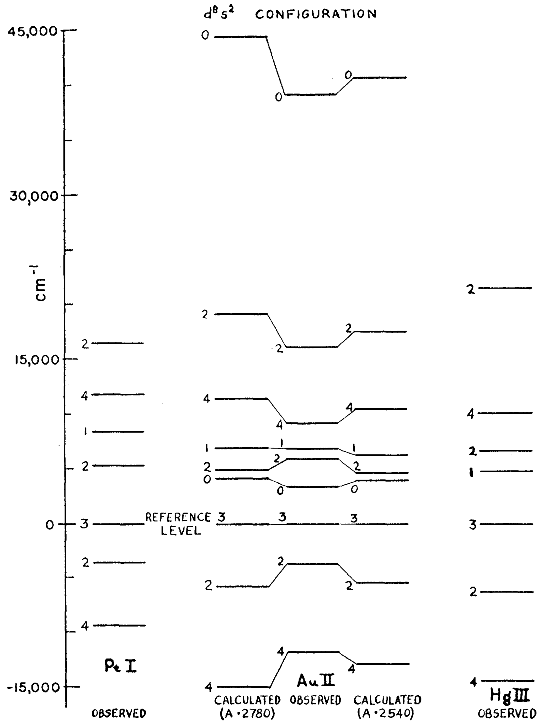

FIG. 1. Observed and calculated structure of d^8s^2 group.

The parameter t depends on the ratio of the radial integrals referred to in discussions of the Slater method:

$$t=5F_4/F_2.$$

X is the coupling parameter.

When an attempt was made to fit the experimental values for d^8s^2 in Pt I, Au II and Hg III to these formulae, the most satisfactory values found for the parameters were:

	Pt I	Au II	Hg III
A	2280 cm⁻¹	2780 (d^8s^2)* 2540 (d^9s)	3150
t	0.48	0.58	0.7
X	0.47	0.40	0.31

The agreement between theoretical predictions for the structure of d^8s^2 and the observed structure of this group in Au II is shown in Fig. 1.

$5d^86s6p$.—The term, $15°_2$, appears as an

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[13] M. H. Johnson, Jr., Phys. Rev. **38**, 1628 (1931).

* Derived from d^8s^2, from a calculation on the centers of gravity of groups of levels with common J values.

interloper among the $5d^96p$ levels, but is distinguished from them by intensity anomalies as well as by its failure to fit into the theoretical structure of the latter group. This term has therefore been assigned to $5d^86s6p$, as this configuration should be the only other group of odd levels in the neighborhood. None of the other states of $5d^86s6p$ has yet been identified.

In the spectrum of Au II, twelve new terms have been found, and four previously suggested terms have been eliminated (not including the states proposed by Rao). This brings the total number of known terms in Au II to twenty-six even and nineteen odd, and it brings the total number of lines assigned in Au to 203, of which 120 had been previously classified.

Some 1500 of the lines measured in this work remain unclassified. It is hoped that it will be possible in the near future, by use of these lines, to extend further the analysis of Au I and Au II.

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A Statistical Analysis of the Earth's Internal Magnetic Field

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The earth's internal magnetic field consists of the field of a large dipole and an irregular part which is of the order of a few percent of the main dipole field. The field may be represented by a series of spherical harmonics and 42 coefficients are numerically known. The coefficients which characterize the irregular part of the field are here statistically compared with a simple model for this field. It is assumed that an arbitrary number of dipoles are thrown at random inside a spherical shell and mean values are calculated for the probabilities with which the various spherical harmonics appear in the field produced. It is shown that a statistical agreement between the observed and calculated coefficients can be obtained only if the outer radius of the spherical shell is approximately $0.50R$ and is definitely not in excess of the radius of the earth's core, $0.55R$ (R, earth's radius). The result is independent of the number of dipoles producing the field. It seems that if the latter number is not very large, the result does not depend too critically upon the assumption of completely random distribution of the dipoles.

THE gradually increasing evidence[1] for the existence inside the earth, of a liquid core, (radius 3500 km $=0.55R$), presumably made up of molten metals, mainly iron, gives a new stimulus to investigations into the origin and causes of the earth's magnetic field. On the basis of this evidence one may gain a better understanding of the secular variations of the field. These variations, when considered from the point of view of a geological time scale, are exceedingly rapid, so rapid indeed that in the course of a few centuries the non-dipole part of the field will have completely changed its aspect. Changes of this magnitude are hardly conceivable inside a solid body. Now it is found that if the electric conductivity of the core is of an order comparable to that of ordinary metals, the interaction between the field and any fluid masses moving in the core must be intense. Induction currents must be set up and their field will superpose itself upon any field originally present. For various reasons we are inclined to think that the entire field originates inside the core, while the relative importance of the currents set up by the dynamo action of moving masses and of the primary currents caused by electromotive forces of a still unidentified nature is perhaps difficult to estimate.

In the present paper we shall not deal with these dynamical problems of a rather intricate nature, but shall confine ourselves to a question of a much more simple character. It is well known that by a potential analysis of the earth's magnetic field one can divide it into an internal and an external field, the former of which has its

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* Part of this investigation was carried out at the California Institute of Technology.

[1] B. Gutenberg, ed. *Internal Constitution of the Earth*, (McGraw-Hill Company, 1939).