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Spectrum and Energy Levels of Four-Times Ionized Yttrium (Y V)

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Abstract: The analysis of the spectrum of four-times-ionized yttrium, Y V, was extended to provide a large number of new spectrum lines and energy levels. The new analysis is based on spectrograms made with sliding-spark discharges on 10.7 m normal- and grazing-incidence spectrographs. The measurements cover the region 184–2549 Å. The results revise levels for this spectrum by Zahid-Ali et al. (1975) and by Ateqad et al. (1984). Five hundred and seventy lines were classified as transitions between 23 odd-parity and 90 even-parity levels. The $4s^24p^5$, $4s4p^6$, $4s^24p^44d$, 5s, 5p, 5d, 6s configurations are now complete. Results for the $4s^24p^46d$ and 7s configurations are tentative. Ritz-type wavelengths were determined from the optimized energy levels, with uncertainties as low as ±0.0004 Å. The observed configurations were interpreted with Hartree-Fock calculations and least-squares fits of the energy parameters to the observed levels. Oscillator strengths for all classified lines were calculated with the fitted parameters. The results are compared with values for the level energies, percentage compositions, and transition probabilities from recent ab initio theoretical calculations. The ionization energy was revised to 607,760 ± 300 cm^{-1} (75.353 ± 0.037 eV).

Keywords: yttrium; ionic spectrum; vacuum ultraviolet; wavelengths; energy levels; transition probabilities; parametric calculations; ionization energy

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1. Introduction

The four-times ionized yttrium atom, Y V, has a Br-like electronic structure with ground configuration $4s^24p^5$ and excited states $4s4p^6$ and $4s^24p^4nl$. The spectrum has a somewhat checkered past. It was first analyzed in 1939 by Paul and Rense [1], who, from a set of transitions to the $4s^24p^5$ ^2P ground term, determined levels of the $4s4p^6$ $^2S_{1/2}$, $4s^24p^44d$, and $4s^24p^45s$ configurations. Unfortunately, an isoelectronic plot published by Edlén [2] in 1964 showed that the $4s^24p^5$ $^2P_{3/2}$-$^2P_{1/2}$ interval of Paul and Rense [1] (12,068 cm^{-1}) was inconsistent with the known intervals for the rest of the isoelectronic sequence. From his plot, Edlén predicted an interval of 12,470 ± 20 cm^{-1}. Since essentially all of their levels were based on transitions to the $4s^24p^5$ ^2P term, Edlén concluded that the analysis would have to be completely revised. A start on this revision came in 1970, when Reader and Epstein [3] observed the true $4s^24p^5$ $^2P_{1/2,3/2}$-$4s4p^6$ $^2S_{1/2}$ transitions, thus obtaining the position of $4s4p^6$ $^2S_{1/2}$ and a revised value for the ^2P term splitting. Their splitting of 12,459.9 ± 3.0 cm^{-1} was indeed close to the value predicted by Edlén. In 1972 Reader and Epstein [4] observed further transitions to the $4s^24p^5$ ^2P ground term and established nearly all levels of the $4s^24p^44d$ and 5s configurations. Only the levels of $4p^44d$ with $J = 7/2$ and $9/2$, which do not combine with $4p^5$ $^2P_{1/2,3/2}$, and the $4p^44d$ $(^3P)^4D_{1/2}$ level could not be located.

In 1975, Zahid-Ali et al. [5] observed the spectrum at lower wavelengths and reported levels of the $4s^24p^45d$, 6s, 6d, and 7s configurations. Since all lines terminated on the $4s^24p^5$ ^2P term, again only levels with $J = 1/2$, $3/2$, and $5/2$ could be found. Finally, in 1984 Ateqad and Chaghtai [6] reported levels of the $4s^24p^44f$ and 5p configurations. From transitions to these new configurations they were able to report levels of $4s^24p^44d$ and 5d having $J = 7/2$ and 9/2.

In the present work we observed the spectrum of Y V in the ultraviolet and determined a new set of energy levels. About half the $4s^24p^45d$ levels of [5] were found to be spurious. Several of the $4s^24p^46s$ levels in this paper had incorrect *J*-values and in fact belong to $4s^24p^45d$. Nearly all of the $4s^24p^45p$ levels of [6] were spurious, as were all of the reported $J = 7/2, 9/2$ levels of $4s^24p^44d$ and 5d.

2. Experiment

The observations were the same as used for earlier work in our laboratory on yttrium [4,7,8]. Briefly, the light source was a low-voltage sliding-spark with metallic yttrium electrodes. The source was operated as described by Reader et al. [9]. From 500 to 2549 Å we used the NIST 10.7-m normal-incidence vacuum spectrograph; from 184 to 500 Å we used the NIST 10.7-m grazing-incidence spectrograph. Both instruments had gratings with 1200 lines/mm. The plate factor for the normal-incidence spectrograph was about 0.78 Å/mm. The plate factor for the grazing-incidence spectrograph at 350 Å was 0.25 Å/mm. From 600 to 2549 Å the spectra were calibrated by spectra of Cu II excited in a hollow cathode discharge. Below 600 Å calibration was obtained from lines of Y in various stages of ionization. Shifts between the reference spectra and the yttrium spectra were removed by use of impurity lines of oxygen, nitrogen, carbon, and silicon. Complete references for the calibration spectra are given in Reference [8].

Ionization stages were distinguished by comparing the intensities of the lines at various peak currents in the spark. The spectra of Y V were relatively enhanced at a peak current of about 2000 A.

The wavelengths, intensities, and classifications of the observed lines of Y V are given in Table 1. All wavelengths are in vacuum. The intensities are estimates of photographic plate blackening. The intensities range from 1 to 5,000,000. The system used to obtain this extensive scale of intensities is described in a recent paper on Mo VI [10]. No attempt was made to account for spectrograph or plate emulsion response. The strongest lines in the spectrum appear as a group of $4p^45p$-5d transitions around 1350 Å.

The general uncertainty of the wavelengths is ±0.007 Å. Hazy lines (h) were given an uncertainty of ±0.010 Å; perturbed (p), complex (c), or asymmetric lines (s, *l*) an uncertainty of ±0.020 Å; unresolved (u) or doubly classified (dc) lines an uncertainty of ±0.030 Å. All uncertainties are reported at the level of one standard deviation.

Table 1. Observed spectral lines of Y V. Wavelengths and wave numbers are in vacuum. Wavelength values in parentheses are Ritz values. General uncertainty of the observed wavelengths is ±0.007 Å. Uncertainties for less certain wavelengths are given in Section 2 of the text. |CF| is the cancellation factor (see text). Unc (Å) is the uncertainty of the Ritz wavelength.

λ_{obs} (Å)	Int [a]		σ_{obs} (cm^{-1})	Even Level [b]	Odd Level [b]	λ_{Ritz} (Å)	Unc (Å)	$g_U A$ (s^{-1})	log($g_L f$)	|CF|
184.144	1		543053	6d83	p5 3	184.1443	0.0049	1.13E+08	−3.25	0.05
187.849	25		532342	7s31	p5 1	187.8490	0.0070	1.99E+09	−1.99	0.69
188.469	3		530591	6d83	p5 1	188.4687	0.0051	3.71E+09	−1.71	0.75
191.571	50		522000	7s25	p5 3	191.5710	0.0070	7.75E+09	−1.38	0.69
193.843	3		515881	6d51	p5 3	193.8426	0.0049	2.45E+08	−2.87	0.03
193.888	3		515762	6d65	p5 3	193.8880	0.0070	2.19E+09	−1.91	0.40
194.165	10		515026	6d73	p5 3	194.1705	0.0061	2.59E+09	−1.84	0.61
194.457	10		514253	6d41	p5 3	194.4567	0.0048	4.97E+09	−1.56	0.54
196.148	30		509819	7s21	p5 3	196.1490	0.0049	4.20E+09	−1.62	0.75
196.206	25		509668	7s33	p5 1	196.2060	0.0070	5.65E+09	−1.49	0.66
196.444	40	u	509051	7s23	p5 3	196.4440	0.0070	3.06E+09	−1.76	0.75
198.495	3		503791	6d53	p5 3	198.4961	0.0049	1.30E+09	−2.12	0.07
198.640	20		503423	6d51	p5 1	198.6404	0.0051	1.42E+10	−1.08	0.65
198.753	60		503137	6d55	p5 3	198.7530	0.0070	4.59E+09	−1.57	0.50
198.990	3		502538	6d73	p5 1	198.9847	0.0064	9.56E+09	−1.25	0.65
199.285	3		501794	6d41	p5 1	199.2853	0.0051	1.89E+09	−1.96	0.48
199.461	2	u	501351	6d43	p5 3	199.4610	0.0300	1.47E+09	−2.07	0.26
200.392	80		499022	7s13	p5 3	200.3926	0.0049	1.25E+10	−1.13	0.74
200.694	1		498271	7s15	p5 3	200.6940	0.0300	4.57E+08	−2.57	0.60
201.064	30		497354	7s21	p5 1	201.0631	0.0051	5.12E+09	−1.51	0.57
202.784	30	u	493136	6d23	p5 3	202.7798	0.0065	1.76E+10	−0.97	0.66
202.792	40	p	493116	6d25	p5 3	202.7920	0.0200	9.35E+09	−1.25	0.64
203.531	10		491326	6d53	p5 1	203.5300	0.0052	9.88E+09	−1.22	0.53
205.525	1		486559	7s13	p5 1	205.5244	0.0051	9.84E+08	−2.21	0.18
205.731	10		486072	6s31	p5 3	205.7327	0.0004	1.48E+09	−2.03	0.14
208.036	2		480686	6d23	p5 1	208.0362	0.0069	1.25E+09	−2.10	0.08
211.144	20		473610	6s31	p5 1	211.1453	0.0005	3.52E+09	−1.63	0.50
212.318	20		470992	5d85	p5 3	212.3188	0.0004	3.67E+09	−1.61	0.30
217.564	100		459635	6s25	p5 3	217.5632	0.0005	1.36E+10	−1.02	0.55
217.853	80		459025	5d83	p5 1	217.8535	0.0005	1.23E+10	−1.06	0.54
222.825	30		448783	6s21	p5 3	222.8289	0.0005	5.90E+08	−2.36	0.02
223.032	70		448366	5d73	p5 3	223.0363	0.0004	5.03E+09	−1.43	0.23

Table 1. *Cont.*

λ_{obs} (Å)	Int [a]		σ_{obs} (cm^{-1})	Even Level [b]	Odd Level [b]	λ_{Ritz} (Å)	Unc (Å)	$g_U A$ (s^{-1})	log($g_L f$)	|CF|
223.561	90	p	447305	6s33	p5 1	223.5630	0.0005	1.04E+10	−1.11	0.54
223.569	80	u	447289	5d51	p5 3	223.5749	0.0004	8.34E+09	−1.20	0.19
223.857	200	dc	446714	6s23	p5 3	223.8547	0.0005	2.27E+09	−1.77	0.12
223.857	200	dc	446714	5d75	p5 3	223.8594	0.0004	2.66E+10	−0.70	0.50
224.107	2		446215	6s11	p5 3	224.1101	0.0005	4.26E+06	−4.49	0.00
224.566	100		445303	5d65	p5 3	224.5678	0.0004	8.77E+09	−1.18	0.34
224.726	150		444986	5d63	p5 3	224.7272	0.0004	2.93E+10	−0.65	0.48
225.159	100		444131	5d41	p5 3	225.1599	0.0004	1.22E+10	−1.03	0.27
228.743	200		437172	6s13	p5 3	228.7434	0.0005	2.18E+10	−0.77	0.56
229.191	3		436317	6s21	p5 1	229.1924	0.0006	8.65E+07	−3.17	0.00
229.411	100		435899	5d73	p5 1	229.4118	0.0006	3.44E+10	−0.57	0.47
229.530	20		435673	6s15	p5 3	229.5312	0.0005	1.52E+08	−2.92	0.03
229.845	70		435076	5d53	p5 3	229.8474	0.0005	4.58E+09	−1.44	0.07
229.981	100	p, x	434819	5d51	p5 1	229.9816	0.0006	2.83E+10	−0.65	0.49
230.071	150		434648	5d55	p5 3	230.0718	0.0005	4.05E+10	−0.49	0.44
230.277	2		434260	6s23	p5 1	230.2778	0.0006	2.09E+08	−2.78	0.04
231.120	20	p, x	432676	5d45	p5 3	231.1214	0.0005	9.45E+08	−2.12	0.27
231.201	50		432524	5d63	p5 1	231.2011	0.0006	7.06E+09	−1.25	0.37
231.659	20		431669	5d41	p5 1	231.6592	0.0006	4.99E+08	−2.40	0.02
231.784	70		431436	5d43	p5 3	231.7843	0.0005	5.06E+09	−1.39	0.27
232.269	20		430535	5d35	p5 3	232.2697	0.0005	1.04E+09	−2.08	0.14
232.370	20		430348	5d33	p5 3	232.3723	0.0005	7.48E+08	−2.22	0.33
232.800	20		429553	5d31	p5 3	232.8009	0.0005	7.21E+08	−2.23	0.15
235.250	200		425080	5d25	p5 3	235.2511	0.0005	3.08E+10	−0.59	0.49
235.386	150	u	424834	5d23	p5 3	235.3880	0.0005	1.72E+10	−0.84	0.46
235.452	25		424715	6s13	p5 1	235.4543	0.0006	8.34E+08	−2.16	0.07
236.208	70	u	423356	5d21	p5 3	236.2106	0.0005	3.24E+09	−1.57	0.25
236.623	80		422613	5d53	p5 1	236.6241	0.0006	1.21E+10	−1.00	0.24
238.675	50		418980	5d43	p5 1	238.6775	0.0006	2.96E+09	−1.60	0.10
238.711	10		418917	5d13	p5 3	238.7123	0.0005	7.10E+07	−3.22	0.02
239.298	2		417889	5d33	p5 1	239.3010	0.0006	2.49E+08	−2.67	0.13
239.754	10		417094	5d31	p5 1	239.7555	0.0006	7.80E+08	−2.17	0.10
242.501	60		412369	5d23	p5 1	242.5005	0.0006	2.55E+09	−1.65	0.05
243.375	3		410889	5d21	p5 1	243.3736	0.0006	4.26E+08	−2.42	0.03
245.389	5		407516	5d11	p5 1	245.3885	0.0006	1.81E+08	−2.79	0.04

Table 1. *Cont.*

λ_{obs} (Å)	Int [a]		σ_{obs} (cm^{-1})	Even Level [b]	Odd Level [b]	λ_{Ritz} (Å)	Unc (Å)	$g_U A$ (s^{-1})	log($g_L f$)	|CF|
289.182	90	H, x	345803	5s31	p5 3	289.1826	0.0008	1.16E+09	−1.84	0.03
(299.992)		A, x	333334	5s31	p5 1	299.9920	0.0010	7.43E+09	−1.00	0.28
312.888	50		319603.2	5s33	p5 3	312.8874	0.0008	2.02E+09	−1.53	0.04
313.349	1000		319133.0	5s25	p5 3	313.3494	0.0008	3.24E+10	−0.32	0.42
320.467	500		312044.6	4d83	p5 3	320.4676	0.0009	9.44E+09	−0.84	0.03
321.691	700		310857.3	5s21	p5 3	321.6905	0.0009	1.57E+10	−0.61	0.42
325.580	2000		307144.2	5s33	p5 1	325.5805	0.0011	1.23E+10	−0.71	0.15
326.567	3000		306215.9	5s23	p5 3	326.5675	0.0009	4.03E+10	−0.19	0.83
(328.337)		A, x	304566.1	5s11	p5 3	328.3372	0.0009	1.06E+08	−2.77	0.00
330.398	300		302665.3	4d51	p5 3	330.3989	0.0009	1.06E+10	−0.76	0.05
333.084	10000		300224.6	4d85	p5 3	333.0844	0.0010	7.88E+11	1.12	0.82
333.796	5000		299584.2	4d83	p5 1	333.7963	0.0012	5.17E+11	0.94	0.83
335.125	200		298396.1	5s21	p5 1	335.1232	0.0012	3.32E+10	−0.25	0.68
335.143	800		298380.1	5s13	p5 3	335.1445	0.0010	1.33E+10	−0.65	0.13
336.621	5000		297070.0	4d73	p5 3	336.6197	0.0010	4.71E+11	0.91	0.88
339.023	3000		294965.2	4d41	p5 3	339.0225	0.0010	2.34E+11	0.61	0.71
340.016	1000		294103.8	5s15	p5 3	340.0176	0.0010	7.67E+09	−0.88	0.92
340.419	75		293755.6	5s23	p5 1	340.4194	0.0012	1.61E+09	−1.55	0.11
342.342	50		292105.6	5s11	p5 1	342.3429	0.0012	5.06E+09	−1.05	0.32
344.583	2000		290205.8	4d51	p5 1	344.5848	0.0013	1.97E+11	0.55	0.82
349.648	800		286001.9	4d75	p5 3	349.6483	0.0011	9.34E+08	−1.77	0.00
349.752	300		285916.9	5s13	p5 1	349.7498	0.0013	4.20E+08	−2.11	0.01
351.355	800		284612.4	4d73	p5 1	351.3567	0.0013	3.58E+09	−1.18	0.02
353.976	1500		282505.0	4d41	p5 1	353.9753	0.0013	1.12E+10	−0.68	0.05
355.564	1500		281243.3	4d63	p5 3	355.5625	0.0011	9.16E+09	−0.76	0.09
372.047	4000		268783.2	4d63	p5 1	372.0454	0.0015	1.22E+10	−0.60	0.06
379.963	1000		263183.5	4d65	p5 3	379.9623	0.0013	2.40E+09	−1.29	0.14
397.767	1000		251403.5	4d55	p5 3	397.7663	0.0015	6.86E+08	−1.79	0.01
403.452	1500		247861.0	4d45	p5 3	403.4517	0.0015	2.13E+09	−1.28	0.01
408.806	10		244614.8	4d53	p5 3	408.8086	0.0015	1.31E+08	−2.49	0.00
409.312	1500		244312.4	4d35	p5 3	409.3134	0.0015	1.28E+09	−1.49	0.02
415.027	1500		240948.2	4d43	p5 3	415.0250	0.0016	1.22E+09	−1.50	0.01
418.179	600		239132.0	4d33	p5 3	418.1776	0.0016	1.66E+09	−1.36	0.02
418.591	1800		238896.7	4d31	p5 3	418.5882	0.0017	1.12E+09	−1.53	0.14
419.792	400		238213.2	4d23	p5 3	419.7887	0.0016	3.12E+08	−2.08	0.01
420.737	1500		237678.2	4d25	p5 3	420.7379	0.0017	8.42E+08	−1.65	0.74

Table 1. *Cont.*

λ_{obs} (Å)	Int [a]		σ_{obs} (cm^{-1})	Even Level [b]	Odd Level [b]	λ_{Ritz} (Å)	Unc (Å)	$g_U A$ (s^{-1})	log($g_L f$)	|CF|
427.875	40		233713.1	4d21	p5 3	427.8764	0.0017	1.41E+07	−3.42	0.00
430.753	500		232151.6	4d53	p5 1	430.7502	0.0020	7.11E+07	−2.71	0.00
437.661	500	p	228487.3	4d43	p5 1	437.6574	0.0021	1.30E+09	−1.43	0.01
441.161	2		226674.6	4d33	p5 1	441.1647	0.0021	1.65E+07	−3.32	0.00
441.622	25		226438.0	4d31	p5 1	441.6217	0.0022	7.60E+07	−2.65	0.01
442.947	300	d, x	225760.6	4d23	p5 1	442.9581	0.0022	3.74E+07	−2.96	0.00
451.974	25		221251.7	4d21	p5 1	451.9728	0.0023	9.54E+07	−2.54	0.00
452.911	5		220793.9	4d11	p5 3	452.9095	0.0024	1.26E+07	−3.41	0.00
455.846	35		219372.3	4d13	p5 3	455.8429	0.0020	2.74E+07	−3.07	0.00
(457.838)		A, x	218417.9	4d15	p5 3	457.8395	0.0021	4.23E+07	−2.88	0.00
479.994	1	x	208335.9	4d11	p5 1	479.9972	0.0030	9.83E+06	−3.47	0.00
481.827	20		207543.4	4p61	5p51	481.8281	0.0022	6.46E+08	−1.65	0.21
491.807	5		203331.8	4p61	5p73	491.8074	0.0023	1.69E+08	−2.21	0.21
498.642	90	*l*	200544.7	4p61	5p63	498.6395	0.0024	1.15E+09	−1.37	0.26
550.483	1	x	181658.7	4p61	5p21	550.4803	0.0029	6.84E+07	−2.51	0.10
573.075	2		174497.2	4p61	5p11	573.0754	0.0031	1.02E+08	−2.30	0.16
584.982	50000		170945.4	4p61	p5 3	584.9815	0.0044	1.66E+09	−1.07	0.03
585.101	5		170910.7	4p61	5p13	585.0990	0.0033	1.09E+08	−2.25	0.19
630.973	30000		158485.4	4p61	p5 1	630.9727	0.0056	7.94E+08	−1.33	0.04
690.718	25		144776.9	4d21	5p51	690.7217	0.0018	7.67E+07	−2.26	0.02
693.434	20		144209.8	6s31	5p13	693.4292	0.0028	2.73E+06	−3.71	0.00
702.063	30		142437.4	4d15	5p53	702.0699	0.0026	6.24E+07	−2.34	0.02
706.816	25		141479.5	4d13	5p53	706.8173	0.0023	5.71E+07	−2.37	0.02
709.527	75		140939.0	4d27	5p55	709.5328	0.0024	1.28E+08	−2.02	0.07
709.676	75		140909.4	4d15	5p43	709.6772	0.0026	3.91E+08	−1.53	0.06
711.410	70		140565.9	4d21	5p73	711.4154	0.0019	4.61E+08	−1.45	0.18
713.977	4	H, x	140060.5	4d11	5p53	713.9878	0.0040	3.35E+07	−2.59	0.04
714.521	5	H, x	139953.9	4d13	5p43	714.5284	0.0023	2.89E+07	−2.66	0.01
715.114	5	H, x	139837.8	4d11	5p41	715.1005	0.0040	3.00E+06	−3.64	0.00
717.580	8		139357.3	4d33	5p51	717.5885	0.0016	2.71E+07	−2.68	0.02
721.365	150		138626.1	4d15	5p35	721.3673	0.0027	3.19E+08	−1.60	0.04
722.091	500		138486.7	4d17	5p35	722.0949	0.0034	1.06E+09	−1.08	0.08
726.376	50		137669.7	4d13	5p35	726.3802	0.0024	1.72E+08	−1.87	0.07
731.760	30		136656.8	4d15	5p33	731.7646	0.0028	9.51E+07	−2.12	0.02
732.991	75		136427.3	4d23	5p55	732.9955	0.0021	1.97E+07	−2.80	0.02
734.949	40		136063.9	4d23	5p73	734.9584	0.0021	2.81E+08	−1.65	0.12

Table 1. *Cont.*

λ_{obs} (Å)	Int [a]		σ_{obs} (cm^{-1})	Even Level [b]	Odd Level [b]	λ_{Ritz} (Å)	Unc (Å)	$g_U A$ (s^{-1})	log($g_L f$)	|CF|
736.921	125		135699.8	4d13	5p33	736.9236	0.0025	3.78E+08	−1.51	0.10
737.953	100		135510.0	4d33	5p55	737.9597	0.0018	3.79E+08	−1.51	0.24
738.669	250	dc	135378.6	4d31	5p73	738.6674	0.0022	8.80E+07	−2.14	0.17
738.669	250	dc	135378.6	4d13	5p31	738.6715	0.0025	6.41E+08	−1.28	0.14
739.566	15		135214.4	4d27	5p27	739.5717	0.0027	2.08E+07	−2.77	0.02
(739.949)		B, x	135144.4	4d33	5p73	739.9494	0.0017	7.27E+07	−2.22	0.04
743.145	400		134563.2	4d15	5p23	743.1465	0.0029	8.96E+08	−1.13	0.12
744.719	50		134278.8	4d11	5p33	744.7212	0.0044	1.76E+08	−1.83	0.13
746.501	25		133958.3	4d11	5p31	746.5064	0.0044	9.33E+07	−2.11	0.03
(747.308)		A, x	133815.4	4d25	5p63	747.3082	0.0022	3.28E+07	−2.56	0.06
747.983	20		133692.9	4d43	5p55	747.9865	0.0020	5.43E+08	−1.34	0.23
(750.032)		C, x	133330.0	4d43	5p73	750.0306	0.0020	6.58E+08	−1.26	0.08
(750.322)		A, x	133276.8	4d23	5p63	750.3217	0.0022	6.03E+07	−2.30	0.02
750.571	150		133231.9	4d13	5p21	750.5742	0.0026	1.12E+08	−2.03	0.02
753.083	20		132787.5	4d27	5p45	753.0857	0.0027	1.13E+08	−2.02	0.02
754.179	30		132594.5	4d31	5p63	754.1877	0.0023	1.14E+08	−2.01	0.09
755.513	10		132360.4	4d33	5p63	755.5242	0.0018	4.84E+07	−2.38	0.01
755.822	150		132306.3	4d37	5p55	755.8279	0.0032	6.53E+08	−1.25	0.11
756.525	30	p	132183.3	4d11	5p23	756.5130	0.0045	4.63E+07	−2.40	0.03
758.670	2000		131809.6	4d11	5p21	758.6650	0.0045	7.25E+08	−1.20	0.17
767.276	800		130331.2	4d35	5p55	767.2829	0.0020	5.58E+08	−1.31	0.28
769.054	600		130029.9	4d53	5p55	769.0631	0.0020	5.91E+08	−1.28	0.23
771.212	1200	p	129666.0	4d53	5p73	771.2243	0.0019	3.31E+08	−1.53	0.07
778.674	2000		128423.4	4d15	5p17	778.6707	0.0033	7.86E+08	−1.15	0.52
779.517	10000		128284.6	4d17	5p17	779.5184	0.0040	5.04E+09	−0.34	0.68
780.633	5000		128101.2	4d17	5p25	780.6328	0.0039	1.92E+09	−0.76	0.29
785.186	50		127358.4	4d33	5p45	785.1885	0.0020	1.60E+07	−2.83	0.06
785.647	40		127283.6	4d13	5p25	785.6435	0.0028	3.18E+07	−2.53	0.03
786.287	1000		127180.0	4d35	5p63	786.2890	0.0020	5.38E+08	−1.30	0.14
787.875	50		126923.7	4d21	5p41	787.8806	0.0023	1.02E+08	−2.02	0.03
788.155	1200		126878.6	4d53	5p63	788.1586	0.0020	1.08E+09	−1.00	0.15
788.759	3000		126781.4	4d45	5p55	788.7654	0.0023	2.47E+09	−0.64	0.31
791.036	50		126416.5	4d45	5p73	791.0389	0.0022	1.35E+08	−1.90	0.03
793.220	3000		126068.4	4d13	5p11	793.2170	0.0029	1.14E+09	−0.97	0.26
796.085	75		125614.7	4d21	5p43	796.0902	0.0024	2.37E+08	−1.64	0.13

Table 1. *Cont.*

λ_{obs} (Å)	Int [a]		σ_{obs} (cm^{-1})	Even Level [b]	Odd Level [b]	λ_{Ritz} (Å)	Unc (Å)	$g_U A$ (s^{-1})	log($g_L f$)	|CF|
796.549	150	p	125541.6	4d43	5p45	796.5496	0.0023	6.33E+08	−1.22	0.34
802.263	4500	s	124647.4	4d11	5p11	802.2588	0.0051	1.84E+09	−0.75	0.56
802.529	35		124606.1	4d35	5p27	802.5321	0.0023	1.11E+08	−1.97	0.14
805.446	3000		124154.8	4d37	5p45	805.4484	0.0036	1.09E+09	−0.97	0.09
807.914	30000		123775.6	4d15	5p15	807.9081	0.0035	5.66E+09	−0.26	0.66
808.825	50000		123636.1	4d17	5p15	808.8207	0.0043	8.06E+09	−0.10	0.43
810.116	10000		123439.1	4d15	5p13	810.1120	0.0034	3.75E+09	−0.43	0.35
810.775	8000		123338.8	4d27	5p35	810.7736	0.0031	3.34E+09	−0.48	0.20
811.434	1000		123238.6	4d55	5p55	811.4400	0.0027	7.59E+08	−1.12	0.23
811.845	10		123176.2	4d25	5p53	811.8503	0.0026	2.02E+07	−2.70	0.02
813.842	700		122874.0	4d55	5p73	813.8463	0.0026	6.21E+08	−1.21	0.16
814.203	8000		122819.5	4d13	5p15	814.2011	0.0032	1.23E+09	−0.91	0.64
815.407	700	p	122638.1	4d23	5p53	815.4080	0.0025	1.05E+07	−2.98	0.01
816.442	30000		122482.7	4d13	5p13	816.4396	0.0031	4.07E+09	−0.39	0.65
816.852	50		122421.2	4d23	5p41	816.8597	0.0025	3.10E+07	−2.51	0.01
819.971	500		121955.5	4d31	5p53	819.9759	0.0028	5.13E+08	−1.29	0.18
820.496	15		121877.5	4d53	5p45	820.4957	0.0022	2.46E+07	−2.60	0.03
821.555	450		121720.4	4d33	5p53	821.5560	0.0021	7.68E+08	−1.11	0.22
822.039	450		121648.7	4d25	5p43	822.0399	0.0026	4.72E+08	−1.32	0.26
823.031	900		121502.1	4d33	5p41	823.0296	0.0021	8.60E+08	−1.06	0.38
823.990	450		121360.7	4d21	5p33	823.9898	0.0026	4.57E+08	−1.33	0.34
825.685	1200		121111.6	4d23	5p43	825.6877	0.0026	7.20E+08	−1.14	0.26
826.035	30000	dc	121060.2	4d11	5p13	826.0217	0.0054	1.08E+09	−0.96	0.67
826.035	30000	dc	121060.2	4d45	5p27	826.0640	0.0026	8.57E+08	−1.06	0.45
826.178	90		121039.3	4d21	5p31	826.1758	0.0026	2.36E+08	−1.61	0.18
830.375	10		120427.5	4d31	5p43	830.3718	0.0028	2.04E+07	−2.68	0.01
831.998	50		120192.6	4d33	5p43	831.9922	0.0022	8.61E+08	−1.05	0.19
837.767	1500		119364.9	4d25	5p35	837.7658	0.0028	1.19E+09	−0.90	0.37
838.455	40		119267.0	4d21	5p23	838.4497	0.0026	2.09E+07	−2.65	0.01
841.095	1800		118892.6	4d21	5p21	841.0940	0.0027	1.82E+09	−0.71	0.65
847.209	1600		118034.6	4d47	5p27	847.2103	0.0035	1.54E+09	−0.78	0.69
848.107	90		117909.7	4d33	5p35	848.1050	0.0023	1.95E+08	−1.67	0.11
848.430	10000		117864.8	4d29	5p27	848.4300	0.0072	1.73E+10	0.27	0.74
850.972	100		117512.7	4d55	5p27	850.9677	0.0030	3.09E+08	−1.47	0.51
851.819	30000		117395.8	4d25	5p33	851.8219	0.0028	3.61E+09	−0.41	0.60

Table 1. *Cont.*

λ_{obs} (Å)	Int [a]		σ_{obs} (cm^{-1})	Even Level [b]	Odd Level [b]	λ_{Ritz} (Å)	Unc (Å)	$g_U A$ (s^{-1})	log($g_L f$)	|CF|
854.303	1000000		117054.5	4d19	5p17	854.3030	0.0072	1.71E+10	0.27	0.79
855.746	30000		116857.1	4d23	5p33	855.7394	0.0028	7.09E+08	−1.11	0.19
856.665	10000		116731.7	5d83	5p31	856.6622	0.0027	2.05E+07	−2.65	0.00
858.081	30000	dc, p	116539.1	4d35	5p53	858.0633	0.0024	2.03E+09	−0.65	0.25
858.081	30000	dc, p	116539.1	4d23	5p31	858.0974	0.0028	3.19E+09	−0.46	0.54
859.152	10000		116393.8	4d63	5p83	859.1583	0.0024	5.20E+08	−1.24	0.30
860.292	1800		116239.6	4d53	5p53	860.2902	0.0024	1.00E+09	−0.95	0.28
860.771	75		116174.9	4d31	5p33	860.7718	0.0030	1.43E+08	−1.80	0.16
861.905	2000		116022.1	4d53	5p41	861.9062	0.0024	2.03E+09	−0.65	0.68
862.511	3000		115940.6	4d33	5p33	862.5132	0.0023	8.94E+08	−1.00	0.22
864.926	2000	p	115616.8	4d33	5p31	864.9086	0.0024	8.39E+07	−2.02	0.02
864.993	5000		115607.9	4d47	5p45	864.9915	0.0035	1.10E+10	0.09	0.66
867.282	10000		115302.8	4d25	5p23	867.2843	0.0029	3.95E+09	−0.35	0.76
868.911	1600		115086.6	4d55	5p45	868.9086	0.0030	8.38E+08	−1.02	0.35
869.451	10000		115015.1	4d35	5p43	869.4541	0.0025	2.86E+09	−0.49	0.33
871.358	25		114763.4	4d23	5p23	871.3457	0.0029	3.53E+07	−2.40	0.01
871.460	2000		114750.0	4d63	5p61	871.4691	0.0030	3.02E+09	−0.46	0.55
871.787	60000		114706.9	4d37	5p35	871.7907	0.0042	8.68E+09	0.00	0.80
872.792	30	c	114574.8	6s31	5p63	872.7799	0.0044	1.07E+08	−1.91	0.15
874.202	4000		114390.0	4d23	5p21	874.2019	0.0029	8.67E+08	−1.01	0.22
874.741	100		114319.6	6s33	5p11	874.7481	0.0022	1.50E+08	−1.76	0.07
876.241	2000		114123.9	4d43	5p33	876.2416	0.0027	9.74E+08	−0.95	0.25
876.565	2500		114081.7	4d31	5p23	876.5639	0.0031	7.29E+08	−1.08	0.39
878.373	600		113846.9	4d33	5p23	878.3698	0.0024	4.76E+08	−1.26	0.13
878.713	3000		113802.8	4d43	5p31	878.7141	0.0027	1.05E+09	−0.92	0.37
879.466	75		113705.4	4d31	5p21	879.4544	0.0032	1.28E+07	−2.83	0.01
881.272	5000		113472.3	4d33	5p21	881.2723	0.0025	6.82E+08	−1.10	0.20
883.887	5000		113136.6	4d27	5p17	883.8812	0.0039	7.24E+08	−1.07	0.26
885.016	5000		112992.3	4d45	5p53	885.0191	0.0027	1.37E+09	−0.80	0.25
885.312	60000		112954.5	4d27	5p25	885.3143	0.0037	7.71E+09	−0.04	0.80
887.067	75		112731.1	4d35	5p35	887.0659	0.0026	1.23E+08	−1.84	0.05
889.448	60		112429.3	4d53	5p35	889.4461	0.0026	1.14E+08	−1.86	0.08
892.613	8000		112030.6	4d43	5p23	892.6118	0.0028	1.53E+09	−0.74	0.42
895.015	3000		111730.0	4d21	5p11	895.0120	0.0030	1.95E+08	−1.63	0.08
895.609	3000		111655.9	4d43	5p21	895.6094	0.0028	3.68E+08	−1.36	0.08
895.769	8000		111635.9	4d75	5p83	895.7698	0.0029	7.97E+09	−0.02	0.77

Table 1. *Cont.*

λ_{obs} (Å)	Int [a]		σ_{obs} (cm^{-1})	Even Level [b]	Odd Level [b]	λ_{Ritz} (Å)	Unc (Å)	$g_U A$ (s^{-1})	log($g_L f$)	|CF|
897.155	5000		111463.5	4d45	5p43	897.1419	0.0028	1.10E+09	−0.88	0.13
900.135	8000		111094.4	4d65	5p73	900.1453	0.0022	3.88E+09	−0.33	0.63
902.141	15	H, x	110847.4	5d83	5p41	902.1284	0.0030	3.83E+07	−2.33	0.01
902.843	4000		110761.2	4d35	5p33	902.8405	0.0027	7.25E+08	−1.05	0.33
905.307	1000		110459.8	4d53	5p33	905.3063	0.0026	4.17E+08	−1.29	0.12
907.946	1000		110138.7	4d53	5p31	907.9457	0.0027	1.65E+08	−1.69	0.10
913.665	8000		109449.3	4d55	5p53	913.6659	0.0033	3.42E+09	−0.36	0.70
915.904	5000		109181.7	4d45	5p35	915.9053	0.0030	6.60E+08	−1.08	0.26
917.601	3000		108979.8	4d25	5p25	917.5967	0.0033	4.78E+08	−1.22	0.51
920.232	3000		108668.2	4d35	5p23	920.2295	0.0027	4.74E+08	−1.22	0.11
921.750	7000		108489.3	4d27	5p15	921.7454	0.0041	1.20E+09	−0.82	0.24
922.118	20000	dc	108446.0	4d57	5p55	922.1279	0.0034	8.24E+09	0.02	0.89
922.118	20000	dc	108446.0	4d23	5p25	922.1442	0.0033	5.10E+06	−3.19	0.02
922.785	700		108367.6	4d53	5p23	922.7913	0.0027	2.08E+08	−1.57	0.06
923.292	3000		108308.1	4d65	5p63	923.2994	0.0023	1.75E+09	−0.65	0.64
924.692	300		108144.1	4d21	5p13	924.6888	0.0033	1.95E+08	−1.59	0.18
925.999	8000		107991.5	4d53	5p21	925.9954	0.0027	7.02E+08	−1.04	0.22
926.587	10000		107922.9	4d55	5p43	926.5919	0.0033	2.82E+09	−0.44	0.59
930.021	25		107524.5	4d33	5p25	930.0148	0.0027	1.44E+08	−1.73	0.16
932.598	3000		107227.3	4d23	5p11	932.5955	0.0033	4.43E+08	−1.24	0.28
932.728	5000		107212.4	4d45	5p33	932.7321	0.0030	1.41E+09	−0.74	0.32
938.575	2000		106544.5	4d31	5p11	938.5756	0.0036	4.74E+08	−1.21	0.75
940.648	1500		106309.7	4d33	5p11	940.6463	0.0028	7.87E+08	−0.98	0.40
941.972	500		106160.3	4d47	5p35	941.9739	0.0042	3.28E+08	−1.36	0.14
946.000	1500		105708.2	4d43	5p25	945.9961	0.0032	1.44E+08	−1.72	0.18
946.619	60		105639.1	4d55	5p35	946.6212	0.0036	7.32E+07	−2.00	0.09
951.300	7000		105119.3	4d45	5p23	951.3034	0.0031	9.14E+08	−0.91	0.19
956.356	15		104563.6	6s25	5p33	956.3568	0.0058	1.12E+09	−0.81	0.78
956.797	75	dc	104515.4	4d25	5p15	956.7919	0.0038	1.26E+08	−1.77	0.11
956.797	75	dc	104515.4	5d75	5p15	956.7967	0.0025	2.17E+07	−2.53	0.00
956.904	75		104503.7	4d37	5p17	956.8938	0.0052	1.06E+08	−1.83	0.08
956.999	5000		104493.3	4d43	5p11	956.9983	0.0032	5.29E+08	−1.14	0.17
958.295	10		104352.0	6s11	5p13	958.2918	0.0030	3.98E+08	−1.26	0.07
958.572	20000		104321.8	4d37	5p25	958.5736	0.0050	2.35E+09	−0.49	0.22
959.888	300		104178.8	4d25	5p13	959.8846	0.0036	1.51E+08	−1.68	0.12
961.737	1500		103978.5	4d23	5p15	961.7373	0.0038	1.31E+08	−1.74	0.23

Table 1. *Cont.*

λ_{obs} (Å)	Int [a]		σ_{obs} (cm^{-1})	Even Level [b]	Odd Level [b]	λ_{Ritz} (Å)	Unc (Å)	$g_U A$ (s^{-1})	log($g_L f$)	|CF|
964.612	75		103668.6	4d55	5p33	964.6066	0.0036	1.07E+07	−2.82	0.01
964.862	1800		103641.8	4d23	5p13	964.8620	0.0036	1.60E+08	−1.66	0.11
970.302	1000		103060.7	4d33	5p15	970.3014	0.0032	3.12E+08	−1.35	0.22
971.262	8000		102958.8	4d31	5p13	971.2645	0.0039	1.10E+09	−0.81	0.47
973.506	8000		102721.5	4d57	5p27	973.5164	0.0039	2.37E+09	−0.47	0.63
987.710	60	s	101244.3	4d43	5p15	987.7102	0.0037	3.38E+06	−3.31	0.01
997.069	200		100294.0	4d57	5p45	997.0683	0.0039	1.91E+08	−1.54	0.08
1001.401	8000	D, x	99860.1	4d37	5p15	1001.4294	0.0056	2.23E+06	−3.47	0.00
1007.459	8	x	99259.62	5s13	5p83	1007.4683	0.0024	1.68E+07	−2.59	0.01
1012.182	300		98796.46	4d45	5p25	1012.1782	0.0036	1.13E+08	−1.76	0.05
1013.316	2	x	98685.90	5d41	5p11	1013.3143	0.0021	8.97E+07	−1.86	0.03
1013.765	2		98642.19	5d65	5p25	1013.7694	0.0023	1.21E+08	−1.73	0.03
1021.642	8000		97881.65	4d35	5p15	1021.6380	0.0037	1.02E+09	−0.80	0.34
1023.866	300		97669.03	4d65	5p53	1023.8658	0.0028	2.65E+08	−1.38	0.25
1024.417	5	x	97616.50	5s13	5p61	1024.4382	0.0033	1.60E+06	−3.60	0.00
1024.800	2000		97580.02	4d53	5p15	1024.7965	0.0036	2.12E+08	−1.47	0.19
1025.165	8000		97545.27	4d35	5p13	1025.1648	0.0035	4.94E+08	−1.11	0.13
1026.554	20		97413.29	4d85	5p83	1026.5538	0.0025	4.97E+08	−1.10	0.18
1028.336	7000	dc	97244.48	4d63	5p51	1028.3415	0.0028	9.37E+08	−0.83	0.64
1028.336	7000	dc	97244.48	4d53	5p13	1028.3452	0.0034	5.34E+07	−2.07	0.02
1040.119	200	p	96142.85	4d65	5p43	1040.1257	0.0029	2.31E+08	−1.43	0.21
1043.889	3		95795.63	6s21	5p23	1043.8995	0.0040	2.43E+08	−1.40	0.07
1044.113	500		95775.07	4d47	5p25	1044.1106	0.0051	3.02E+08	−1.31	0.06
1044.349	3	x	95753.43	5d73	5p21	1044.3602	0.0028	6.83E+07	−1.95	0.01
1049.162	25		95314.17	6s13	5p13	1049.1621	0.0026	7.41E+08	−0.91	0.23
1062.555	500		94112.78	6s23	5p21	1062.5512	0.0035	2.15E+09	−0.44	0.67
1063.881	75		93995.48	4d45	5p13	1063.8787	0.0040	5.32E+07	−2.05	0.02
1065.429	35		93858.91	4d65	5p35	1065.4310	0.0032	8.84E+07	−1.82	0.30
1065.938	200	p, x	93814.09	6s15	5p13	1065.9406	0.0028	3.71E+09	−0.20	0.63
1069.777	8000		93477.43	6s15	5p15	1069.7805	0.0032	7.12E+09	0.09	0.77
1072.143	500	*l*	93271.14	6s33	5p45	1072.1497	0.0034	5.69E+09	−0.01	0.74
1072.627	90		93229.05	6s11	5p23	1072.6265	0.0037	1.19E+09	−0.69	0.41
(1073.586)		A, x	93145.95	6s25	5p45	1073.5858	0.0073	1.50E+09	−0.59	0.95
1074.887	500		93033.04	4d63	5p73	1074.8909	0.0030	5.18E+08	−1.05	0.33
1077.696	3		92790.55	5d55	5p13	1077.7006	0.0022	5.91E+07	−1.99	0.00
1086.914	8		92003.60	5d63	5p23	1086.9113	0.0022	5.29E+08	−1.03	0.13

Table 1. *Cont.*

λ_{obs} (Å)	Int [a]		σ_{obs} (cm^{-1})	Even Level [b]	Odd Level [b]	λ_{Ritz} (Å)	Unc (Å)	$g_U A$ (s^{-1})	log($g_L f$)	|CF|
(1087.355)		A, x	91967.64	6s23	5p31	1087.3552	0.0037	5.74E+07	−1.99	0.03
1088.274	30		91888.62	4d65	5p33	1088.2688	0.0032	8.46E+07	−1.82	0.14
(1090.176)		E, x	91728.48	6s13	5p11	1090.1761	0.0028	1.55E+09	−0.56	0.55
1091.166	500		91645.08	6s23	5p33	1091.1651	0.0036	2.58E+09	−0.34	0.52
1093.406	500		91457.34	6s11	5p31	1093.4074	0.0040	2.09E+09	−0.43	0.89
1097.106	2	H, x	91148.90	5d41	5p23	1097.1087	0.0024	3.23E+08	−1.24	0.31
(1097.260)		A, x	91136.19	6s11	5p33	1097.2599	0.0039	8.52E+08	−0.81	0.43
1100.762	500		90846.16	4d57	5p35	1100.7638	0.0048	2.33E+08	−1.37	0.17
1104.810	8000		90513.30	6s13	5p25	1104.8136	0.0029	6.37E+09	0.07	0.83
1105.225	8		90479.31	5d45	5p15	1105.2225	0.0030	5.86E+08	−0.97	0.05
1112.211	5		89911.00	5d63	5p33	1112.2129	0.0024	4.42E+08	−1.09	0.07
1113.632	500		89796.27	4d65	5p23	1113.6345	0.0033	2.86E+08	−1.27	0.26
1115.130	8000		89675.64	6s23	5p35	1115.1319	0.0039	6.41E+09	0.08	0.88
1115.714	35		89628.70	5d53	5p11	1115.7157	0.0021	5.57E+08	−0.98	0.06
1117.949	5000	H, x	89449.52	6s21	5p43	1117.9617	0.0046	1.22E+09	−0.64	0.30
1122.891	40		89055.84	5d41	5p33	1122.8930	0.0025	1.48E+09	−0.55	0.67
1123.198	15		89031.50	5d73	5p43	1123.2007	0.0032	3.51E+08	−1.18	0.10
1123.432	5	x	89012.95	6s15	5p25	1123.4351	0.0031	4.85E+07	−2.04	0.02
1125.741	8000		88830.38	6s15	5p17	1125.7511	0.0037	8.69E+09	0.22	0.93
(1127.686)		F, x	88676.22	5d35	5p13	1127.6865	0.0027	5.36E+08	−0.99	0.03
(1128.160)		C, x	88640.07	4d75	5p55	1128.1600	0.0041	6.70E+08	−0.89	0.61
1130.833	200		88430.39	6s31	5p83	1130.8356	0.0079	4.02E+09	−0.11	0.98
1131.984	40		88340.47	5d35	5p15	1131.9850	0.0032	2.81E+08	−1.27	0.02
(1133.055)		A, x	88257.20	5d65	5p35	1133.0546	0.0030	1.67E+08	−1.50	0.10
1134.495	75	p	88144.95	6s25	5p63	1134.4903	0.0082	1.51E+09	−0.54	0.38
1134.562	200	p	88139.74	6s21	5p41	1134.5635	0.0048	2.27E+09	−0.35	0.50
1136.509	5		87988.74	5d55	5p25	1136.5057	0.0024	1.55E+08	−1.52	0.01
1136.993	20		87951.29	5d51	5p43	1136.9939	0.0030	4.84E+08	−1.03	0.13
1137.123	3		87941.23	5d63	5p35	1137.1238	0.0027	6.51E+07	−1.90	0.04
1137.375	200		87921.75	6s21	5p53	1137.3759	0.0048	1.31E+09	−0.60	0.49
(1142.799)		E, x	87504.68	5d73	5p53	1142.7989	0.0033	3.50E+08	−1.17	0.17
1150.971	150	p	86883.16	6s11	5p43	1150.9739	0.0043	1.73E+09	−0.46	0.80
1157.079	40		86424.52	5d51	5p53	1157.0806	0.0032	4.32E+08	−1.06	0.24
1161.657	20	p	86083.93	6s23	5p41	1161.6681	0.0041	2.25E+08	−1.34	0.17
1162.889	3		85992.73	5d43	5p11	1162.8868	0.0020	2.63E+08	−1.27	0.02
1163.149	8		85973.51	5d65	5p43	1163.1491	0.0030	1.42E+08	−1.54	0.03

Table 1. *Cont.*

λ_{obs} (Å)	Int [a]		σ_{obs} (cm^{-1})	Even Level [b]	Odd Level [b]	λ_{Ritz} (Å)	Unc (Å)	$g_U A$ (s^{-1})	log($g_L f$)	|CF|
1164.616	200		85865.21	6s23	5p53	1164.6166	0.0042	1.10E+09	−0.65	0.40
1167.437	5		85657.73	5d63	5p43	1167.4378	0.0026	2.34E+08	−1.32	0.04
1168.328	200	p	85592.40	4d83	5p83	1168.3133	0.0031	2.55E+08	−1.28	0.40
1168.565	4	x	85575.04	6s11	5p41	1168.5784	0.0045	7.92E+07	−1.79	0.24
1169.735	150		85489.45	4d75	5p63	1169.7331	0.0042	8.55E+07	−1.76	0.05
1169.818	200		85483.38	6s33	5p73	1169.8078	0.0040	2.78E+09	−0.25	0.65
1176.540	300	p	84994.99	6s25	5p55	1176.5399	0.0089	4.82E+09	0.00	0.81
1177.817	200	u	84902.83	5d33	5p11	1177.8398	0.0027	4.71E+08	−1.01	0.16
1179.214	8		84802.25	5d41	5p43	1179.2104	0.0028	3.64E+08	−1.12	0.11
1185.554	20		84348.75	5d63	5p41	1185.5535	0.0027	3.41E+08	−1.14	0.13
1187.777	200		84190.89	6s13	5p23	1187.7767	0.0033	1.70E+09	−0.45	0.44
1188.940	5		84108.53	5d31	5p11	1188.9343	0.0027	1.23E+08	−1.59	0.02
1191.195	500		83949.31	4d83	5p61	1191.1959	0.0044	1.20E+09	−0.59	0.61
1191.640	20		83917.96	5d37	5p17	1191.6238	0.0100	1.31E+08	−1.55	0.02
1197.981	300		83473.78	4d65	5p25	1197.9782	0.0039	1.40E+08	−1.52	0.25
1201.630	800		83220.29	5d25	5p13	1201.6217	0.0041	1.28E+09	−0.56	0.12
1209.328	100		82690.55	6s15	5p23	1209.3272	0.0035	2.40E+08	−1.28	0.10
1210.115	500		82636.77	5d23	5p15	1210.1135	0.0033	7.42E+08	−0.79	0.28
1213.322	40		82418.35	6s13	5p31	1213.3120	0.0036	1.98E+08	−1.36	0.19
1218.066	3		82097.36	6s13	5p33	1218.0577	0.0035	5.86E+07	−1.89	0.02
1221.502	150		81866.42	5d73	5p45	1221.4970	0.0039	1.45E+09	−0.49	0.64
1227.090	200		81493.61	5d21	5p13	1227.0824	0.0024	1.32E+09	−0.53	0.24
1230.424	150		81272.80	6s33	5p51	1230.4229	0.0045	1.03E+09	−0.63	0.64
1240.739	3	x	80597.13	6s15	5p33	1240.7314	0.0037	3.48E+07	−2.10	0.03
1241.643	50		80538.45	5s15	5p55	1241.6320	0.0027	3.43E+07	−2.10	0.01
1242.844	10000	D, x	80460.62	4d57	5p25	1242.8343	0.0060	1.83E+08	−1.37	0.12
1246.600	15000		80218.19	5d75	5p45	1246.5996	0.0038	5.57E+09	0.11	0.63
1248.301	75	dc	80108.88	5d57	5p45	1248.2886	0.0022	4.67E+07	−1.96	0.01
1248.301	75	dc	80108.88	5s13	5p51	1248.2891	0.0048	2.70E+07	−2.20	0.01
1250.044	200	p	79997.18	5d53	5p33	1250.0283	0.0025	8.30E+08	−0.71	0.12
1254.821	100		79692.64	5d45	5p23	1254.8152	0.0032	5.76E+08	−0.87	0.03
1256.150	60		79608.33	4d63	5p53	1256.1462	0.0041	3.84E+07	−2.04	0.27
1256.701	12000		79573.42	5d55	5p33	1256.6933	0.0028	2.23E+09	−0.28	0.20
1259.640	100000		79387.76	5d23	5p11	1259.6400	0.0029	4.28E+09	0.01	0.59
1260.859	12000		79311.01	4d41	5p73	1260.8507	0.0024	2.93E+08	−1.15	0.67
1262.106	15000		79232.65	5d27	5p15	1262.1007	0.0051	1.69E+09	−0.39	0.28

Table 1. *Cont.*

λ_{obs} (Å)	Int [a]		σ_{obs} (cm^{-1})	Even Level [b]	Odd Level [b]	λ_{Ritz} (Å)	Unc (Å)	$g_U A$ (s^{-1})	log($g_L f$)	|CF|
1265.676	75		79009.16	4d65	5p15	1265.6696	0.0048	1.78E+07	−2.37	0.09
1268.550	300000		78830.16	5d43	5p21	1268.5452	0.0024	5.09E+09	0.09	0.48
1271.817	60		78627.66	6s15	5p35	1271.8124	0.0041	1.91E+08	−1.34	0.06
1273.809	200	p	78504.71	5s25	5p83	1273.8054	0.0038	2.51E+08	−1.21	0.35
1274.001	10	H, x	78492.87	5d63	5p45	1273.9965	0.0034	2.21E+08	−1.27	0.36
(1275.190)		G, x	78419.26	5d25	5p25	1275.1895	0.0046	5.59E+09	0.14	0.70
1278.197	5	x	78235.20	5d25	5p17	1278.1743	0.0053	4.48E+07	−1.96	0.07
1279.227	200		78172.21	5d23	5p25	1279.2227	0.0030	4.74E+08	−0.94	0.25
1280.076	300000		78120.36	5d11	5p13	1280.0759	0.0033	4.17E+09	0.01	0.91
1280.713	50		78081.51	4d63	5p43	1280.7090	0.0043	2.47E+07	−2.22	0.06
1281.503	40		78033.37	5s33	5p83	1281.4978	0.0039	6.24E+07	−1.81	0.29
1283.561	200000		77908.26	5d21	5p11	1283.5609	0.0026	2.83E+09	−0.15	0.88
1284.588	90		77845.97	6s13	5p43	1284.6081	0.0039	1.04E+08	−1.59	0.04
1285.486	400		77791.59	5d75	5p27	1285.4819	0.0045	1.42E+09	−0.46	0.74
1287.278	300000		77683.30	5d57	5p27	1287.2785	0.0055	7.52E+09	0.27	0.77
1288.606	400	p	77603.24	5d55	5p35	1288.5894	0.0033	8.01E+08	−0.70	0.15
1288.660	700	p	77599.99	5d45	5p33	1288.6595	0.0034	1.63E+09	−0.39	0.28
1289.155	200000		77570.19	4d73	5p55	1289.1509	0.0028	3.51E+08	−1.06	0.33
1289.429	250000		77553.71	5d35	5p23	1289.4261	0.0034	3.15E+09	−0.11	0.21
1292.599	700		77363.51	5d33	5p23	1292.5942	0.0031	7.63E+08	−0.72	0.17
1295.238	300000		77205.89	4d73	5p73	1295.2349	0.0022	5.46E+08	−0.87	0.23
1297.729	2000000		77057.69	5d13	5p13	1297.7315	0.0030	8.63E+09	0.34	0.88
1299.606	300000		76946.4	5d31	5p21	1299.6041	0.0032	4.84E+09	0.09	0.92
1303.441	300000	p	76720.00	5d13	5p15	1303.4275	0.0038	3.11E+09	−0.10	0.88
1306.580	25	p	76535.69	6s13	5p41	1306.5769	0.0040	3.93E+08	−0.99	0.21
1306.759	300000		76525.20	4d41	5p63	1306.7526	0.0026	7.33E+08	−0.73	0.53
(1307.988)		G, x	76453.71	5d15	5p13	1307.9875	0.0076	6.73E+09	0.24	0.42
1309.081	10		76389.47	5s33	5p61	1309.0811	0.0055	4.03E+07	−1.98	0.14
1309.538	300000		76362.81	5d43	5p33	1309.5431	0.0024	3.93E+09	0.01	0.58
1309.854	150		76344.39	6s15	5p43	1309.8529	0.0042	5.56E+08	−0.84	0.21
1310.312	15		76317.70	6s13	5p53	1310.3081	0.0041	9.53E+07	−1.61	0.06
1313.774	250		76116.59	5d15	5p15	1313.7740	0.0080	1.12E+10	0.46	0.90
(1314.550)		J, x	76071.89	5d17	5p15	1314.5505	0.0055	1.57E+10	0.61	0.64
1315.851	500000	D, x	75996.45	4d57	5p15	1315.8442	0.0071	2.90E+07	−2.12	0.06

Table 1. *Cont.*

λ_{obs} (Å)	Int [a]		σ_{obs} (cm^{-1})	Even Level [b]	Odd Level [b]	λ_{Ritz} (Å)	Unc (Å)	$g_U A$ (s^{-1})	log($g_L f$)	|CF|
1317.557	90		75898.04	5s13	5p73	1317.5505	0.0022	5.68E+06	−2.83	0.00
1317.946	2000000		75875.64	5d47	5p45	1317.9551	0.0055	2.43E+10	0.80	0.96
1318.842	500000		75824.09	4d51	5p51	1318.8428	0.0028	8.90E+08	−0.64	0.67
1320.219	250		75745.01	5d53	5p43	1320.2188	0.0028	6.57E+08	−0.77	0.14
1322.222	500000		75630.26	5d45	5p35	1322.2205	0.0039	3.42E+09	−0.05	0.58
1322.889	3000000		75592.13	5d33	5p31	1322.8927	0.0034	9.64E+09	0.40	0.94
1324.659	500000		75491.13	5d83	5p61	1324.6640	0.0082	1.01E+10	0.42	0.95
1325.186	3000000		75461.11	5d35	5p33	1325.1898	0.0036	8.78E+09	0.36	0.74
1327.651	3000000		75321.00	5d55	5p43	1327.6556	0.0032	9.45E+09	0.40	0.70
1328.540	50		75270.60	5d33	5p33	1328.5363	0.0033	3.35E+08	−1.05	0.08
1335.958	50	H, x	74852.65	4d75	5p53	1335.9802	0.0054	2.64E+07	−2.15	0.05
1336.587	40		74817.43	6s15	5p53	1336.5834	0.0044	1.68E+08	−1.35	0.08
1336.645	25		74814.18	5s15	5p27	1336.6350	0.0035	2.00E+07	−2.27	0.00
1336.909	25		74799.41	5d31	5p31	1336.9043	0.0035	1.82E+08	−1.32	0.06
1337.456	2000000		74768.81	5d27	5p25	1337.4604	0.0053	2.23E+10	0.78	0.98
1340.744	500		74585.45	5d27	5p17	1340.7443	0.0060	3.68E+08	−1.00	0.22
1341.665	500000		74534.25	5d11	5p11	1341.6604	0.0036	1.85E+09	−0.30	0.46
1342.673	500		74478.3	5d31	5p33	1342.6683	0.0033	6.55E+08	−0.76	0.40
1343.434	1000000		74436.11	5d53	5p41	1343.4334	0.0030	7.36E+09	0.30	0.80
1343.738	1000000	p	74419.27	4d73	5p63	1343.7226	0.0024	1.22E+09	−0.49	0.43
1344.216	50		74392.81	5d43	5p35	1344.2154	0.0029	4.96E+08	−0.87	0.21
1347.381	200		74218.06	5d53	5p53	1347.3784	0.0030	8.35E+08	−0.65	0.31
1349.888	500000		74080.22	5d73	5p73	1349.8860	0.0046	5.01E+09	0.13	0.64
1350.389	900000		74052.74	4d85	5p73	1350.3838	0.0025	6.66E+08	−0.73	0.38
1352.760	2	x	73922.94	5s11	5p51	1352.7493	0.0027	1.50E+07	−2.38	0.11
1354.162	200		73846.41	5d83	5p83	1354.1583	0.0076	1.89E+09	−0.28	0.83
1354.861	500000		73808.31	5d65	5p63	1354.8575	0.0041	7.07E+09	0.29	0.76
1355.128	100000		73793.77	5d55	5p53	1355.1252	0.0034	2.73E+09	−0.12	0.25
1355.245	1800000		73787.40	5d29	5p27	1355.2451	0.0081	3.01E+10	0.92	1.00
1356.518	5000000		73718.15	5d37	5p35	1356.5305	0.0127	2.36E+10	0.81	0.99
1359.388	4500000		73562.51	5d19	5p17	1359.3879	0.0084	2.97E+10	0.91	0.99
1360.408	25		73507.36	4d63	5p31	1360.4060	0.0049	1.84E+07	−2.29	0.04
1360.689	500000	dc	73492.18	5d63	5p63	1360.6799	0.0036	5.35E+09	0.17	0.60
1360.689	500000	dc	73492.18	5d35	5p35	1360.7068	0.0041	8.34E+08	−0.64	0.11
1361.069	150000		73471.66	5d13	5p11	1361.0686	0.0033	1.01E+09	−0.55	0.17

Table 1. *Cont.*

λ_{obs} (Å)	Int [a]		σ_{obs} (cm^{-1})	Even Level [b]	Odd Level [b]	λ_{Ritz} (Å)	Unc (Å)	$g_U A$ (s^{-1})	log($g_L f$)	|CF|
1361.502	300		73448.29	5d47	5p27	1361.4937	0.0063	1.37E+09	−0.42	0.95
1363.284	500000		73352.29	5d85	5p83	1363.2841	0.0090	1.68E+10	0.67	0.98
1367.758	500000		73112.35	5s13	5p63	1367.7557	0.0024	3.08E+08	−1.06	0.09
1369.857	75		73000.32	5d51	5p73	1369.8579	0.0045	1.04E+09	−0.54	0.51
1376.698	100000		72637.57	5d41	5p63	1376.6992	0.0039	2.64E+09	−0.12	0.58
1380.608	500000		72431.86	5d75	5p73	1380.6093	0.0045	6.15E+09	0.25	0.51
1383.652	75		72272.51	5s23	5p51	1383.6407	0.0026	5.21E+07	−1.83	0.06
1383.966	10		72256.11	5d13	5p25	1383.9606	0.0035	3.45E+07	−2.01	0.02
1384.557	8		72225.27	5d23	5p21	1384.5558	0.0035	6.43E+07	−1.73	0.01
1386.785	100		72109.23	5d43	5p43	1386.7829	0.0027	4.73E+08	−0.87	0.07
1387.003	500000		72097.90	5d25	5p23	1387.0083	0.0053	8.83E+09	0.41	0.58
1387.587	100000		72067.55	5d75	5p55	1387.5896	0.0050	3.69E+09	0.03	0.43
1389.683	600000		71958.86	5d57	5p55	1389.6831	0.0062	1.52E+10	0.65	0.97
1391.789	600000		71849.97	5d23	5p23	1391.7813	0.0033	3.99E+09	0.06	0.68
1392.363	600000		71820.35	5d45	5p53	1392.3692	0.0041	1.03E+10	0.48	0.76
1396.402	300		71612.62	4d51	5p73	1396.3986	0.0030	2.01E+08	−1.24	0.33
1396.507	10		71607.23	5d17	5p25	1396.5072	0.0057	1.64E+09	−0.32	0.19
1400.088	500		71424.08	5d17	5p17	1400.0878	0.0064	7.65E+09	0.35	0.99
1403.173	500		71267.05	4d85	5p63	1403.1726	0.0026	1.42E+09	−0.37	0.66
1404.344	400		71207.62	5d35	5p43	1404.3421	0.0041	4.46E+09	0.12	0.60
1408.005	75		71022.48	5d65	5p73	1408.0035	0.0044	3.23E+09	−0.02	0.37
1408.101	60		71017.63	5d33	5p43	1408.1009	0.0037	9.19E+08	−0.56	0.48
1412.421	25		70800.42	5d43	5p41	1412.4202	0.0029	4.78E+07	−1.84	0.01
1414.290	15		70706.86	5d63	5p73	1414.2927	0.0039	4.44E+08	−0.88	0.14
1415.262	800		70658.30	5d65	5p55	1415.2643	0.0049	3.92E+09	0.07	0.38
1416.781	500		70582.54	5d43	5p53	1416.7814	0.0029	1.63E+09	−0.31	0.34
1421.043	400		70370.85	5d21	5p23	1421.0425	0.0030	8.43E+08	−0.60	0.38
1421.641	50	u	70341.25	5d63	5p55	1421.6187	0.0045	2.32E+09	−0.15	0.75
1422.759	3		70285.97	6s21	5p51	1422.7526	0.0077	4.07E+08	−0.91	0.17
1423.983	5		70225.56	5d31	5p43	1423.9864	0.0038	1.40E+08	−1.37	0.09
1426.967	5		70078.71	5d23	5p31	1426.9714	0.0038	9.71E+07	−1.53	0.04
1428.475	2		70004.73	5d25	5p33	1428.4769	0.0057	2.47E+08	−1.12	0.03
1431.245	600		69869.24	5d73	5p51	1431.2485	0.0053	3.38E+09	0.01	0.72
1431.605	60		69851.67	5d41	5p73	1431.6073	0.0042	8.36E+08	−0.59	0.84

Table 1. *Cont.*

λ_{obs} (Å)	Int [a]		σ_{obs} (cm^{-1})	Even Level [b]	Odd Level [b]	λ_{Ritz} (Å)	Unc (Å)	$g_U A$ (s^{-1})	$\log(g_L f)$	|CF|
1433.535	35		69757.63	5d23	5p33	1433.5401	0.0036	5.20E+08	−0.80	0.13
1434.541	3		69708.71	5d33	5p41	1434.5399	0.0039	6.91E+07	−1.67	0.04
1435.114	75		69680.88	5d35	5p53	1435.1135	0.0043	4.03E+08	−0.91	0.09
1439.035	15		69491.01	5d33	5p53	1439.0390	0.0039	9.91E+07	−1.51	0.10
1440.524	60		69419.18	4d73	5p45	1440.5145	0.0030	9.41E+07	−1.54	0.22
1451.028	20		68916.66	5d31	5p41	1451.0311	0.0039	2.33E+08	−1.13	0.10
1453.723	400		68788.90	5d51	5p51	1453.7206	0.0052	2.52E+09	−0.10	0.77
1455.629	15		68698.82	5d31	5p53	1455.6344	0.0040	1.70E+08	−1.27	0.18
1455.759	400		68692.69	4d85	5p27	1455.7530	0.0040	2.37E+08	−1.11	0.70
1457.750	15		68598.87	5d21	5p31	1457.7474	0.0035	1.87E+08	−1.23	0.14
1464.603	8		68277.89	5d21	5p33	1464.6032	0.0032	1.39E+08	−1.35	0.10
1469.257	60		68061.61	5s23	5p73	1469.2521	0.0026	7.48E+07	−1.62	0.05
1476.575	12		67724.29	5d47	5p55	1476.5744	0.0072	2.05E+08	−1.17	0.13
(1478.619)		G, x	67630.67	5s21	5p51	1478.6191	0.0031	6.50E+08	−0.67	0.55
1498.117	800		66750.46	5s15	5p53	1498.1125	0.0032	6.00E+08	−0.69	0.19
1503.863	60		66495.42	5d63	5p51	1503.8621	0.0046	6.82E+08	−0.64	0.38
1505.017	1200		66444.43	4d83	5p51	1505.0166	0.0030	1.10E+09	−0.42	0.61
1508.089	150		66309.08	5d13	5p21	1508.0852	0.0041	3.24E+06	−2.96	0.00
1509.064	40		66266.24	4d85	5p45	1509.0561	0.0034	7.31E+07	−1.59	0.21
1522.539	60		65679.76	6s13	5p63	1522.5393	0.0055	3.29E+08	−0.94	0.29
1523.456	12		65640.23	5d41	5p51	1523.4543	0.0050	1.92E+08	−1.17	0.11
(1526.619)		J, x	65503.71	5d23	5p43	1526.6194	0.0041	3.63E+08	−0.90	0.07
1531.962	1200		65275.77	5s23	5p63	1531.9592	0.0028	1.08E+09	−0.42	0.66
1533.188	700		65223.57	5s15	5p43	1533.1817	0.0032	2.77E+08	−1.01	0.07
1540.731	3		64904.26	5d11	5p33	1540.7340	0.0046	7.53E+07	−1.57	0.07
1557.043	10	*l*	64224.30	5d25	5p53	1557.0348	0.0068	1.45E+08	−1.28	0.02
(1561.446)		L, x	64043.37	5d35	5p45	1561.4460	0.0054	1.29E+05	−4.33	0.00
1561.896	12		64024.75	5d21	5p43	1561.8970	0.0037	1.02E+08	−1.43	0.04
1563.049	150		63977.52	5d23	5p53	1563.0522	0.0043	6.08E+08	−0.65	0.15
1566.381	25		63841.43	5d13	5p33	1566.3841	0.0042	1.34E+08	−1.31	0.05
1573.219	800		63563.94	4d73	5p41	1573.2175	0.0032	3.31E+08	−0.92	0.21
1576.805	400		63419.38	5s21	5p73	1576.8043	0.0032	1.47E+08	−1.26	0.66
1583.386	300		63155.79	5d55	5p63	1583.3874	0.0047	6.74E+08	−0.60	0.24
1588.810	400		62940.19	5s15	5p35	1588.8062	0.0040	1.39E+08	−1.28	0.03
1589.983	75	p	62893.75	6s13	5p73	1589.9818	0.0060	1.46E+07	−2.26	0.02

Table 1. *Cont.*

λ_{obs} (Å)	Int [a]		σ_{obs} (cm^{-1})	Even Level [b]	Odd Level [b]	λ_{Ritz} (Å)	Unc (Å)	$g_U A$ (s^{-1})	log($g_L f$)	|CF|
1594.488	3		62716.06	5d21	5p41	1594.4938	0.0039	8.65E+07	−1.48	0.06
1600.054	300		62497.89	5d21	5p53	1600.0540	0.0040	3.85E+08	−0.83	0.23
1600.662	1200		62474.15	5s13	5p53	1600.6584	0.0032	6.22E+08	−0.62	0.20
1606.264	600	dc	62256.27	5s13	5p41	1606.2619	0.0032	2.53E+08	−1.02	0.12
1606.264	600	dc	62256.27	4d73	5p43	1606.2936	0.0032	2.94E+07	−1.95	0.03
1606.856	200		62233.33	4d83	5p73	1606.8596	0.0030	4.72E+07	−1.73	0.04
1609.689	800		62123.80	6s33	5p83	1609.6880	0.0090	2.84E+06	−2.96	0.08
1616.245	30		61871.81	5d13	5p35	1616.2496	0.0049	7.19E+07	−1.55	0.05
1634.471	60		61181.87	5d45	5p63	1634.4717	0.0056	1.16E+08	−1.33	0.12
(1640.133)		M, x	60970.52	5s15	5p33	1640.1329	0.0037	2.31E+08	−1.03	0.28
1640.759	600		60947.40	5s13	5p43	1640.7572	0.0032	1.09E+08	−1.36	0.03
1643.670	5		60839.46	4d75	5p17	1643.6701	0.0093	9.07E+06	−2.43	0.13
1644.896	150		60794.12	5d53	5p73	1644.8973	0.0046	3.11E+08	−0.90	0.16
1648.776	20		60651.05	5d11	5p43	1648.7785	0.0053	8.11E+07	−1.48	0.05
1649.261	600	p	60633.22	5s21	5p63	1649.2544	0.0035	1.87E+08	−1.12	0.63
1649.378	400	p	60628.92	4d85	5p53	1649.3787	0.0035	1.48E+08	−1.21	0.39
(1656.458)		A, x	60369.56	5d55	5p73	1656.4576	0.0051	1.71E+08	−1.15	0.08
1659.064	5	x	60274.95	5s23	5p45	1659.0513	0.0038	8.14E+06	−2.47	0.01
1663.695	600		60107.17	4d41	5p33	1663.6884	0.0040	9.46E+07	−1.41	0.31
1666.513	50		60005.53	5d55	5p55	1666.5161	0.0059	3.03E+08	−0.90	0.31
1667.463	2		59971.35	4d73	5p35	1667.4554	0.0041	3.71E+07	−1.81	0.10
1668.214	60		59944.35	5d43	5p63	1668.2142	0.0042	2.16E+08	−1.04	0.13
1682.168	8		59447.09	4d83	5p63	1682.1639	0.0033	2.99E+05	−3.90	0.00
1685.140	12	H, x	59342.25	5d11	5p41	1685.1448	0.0056	4.37E+07	−1.72	0.05
1691.351	5	H, x	59124.33	5d11	5p53	1691.3565	0.0057	4.24E+07	−1.74	0.04
1691.986	500		59102.14	4d85	5p43	1691.9881	0.0036	1.68E+08	−1.13	0.20
1698.233	1500		58884.73	5s33	5p51	1698.2352	0.0042	1.51E+09	−0.19	0.69
1698.443	700		58877.45	5s15	5p23	1698.4365	0.0039	3.19E+08	−0.86	0.19
1704.624	400		58663.96	5s13	5p35	1704.6238	0.0041	1.67E+08	−1.13	0.03
1722.320	20	dc	58061.22	5d13	5p53	1722.3173	0.0052	4.20E+07	−1.73	0.02
1722.320	20	dc	58061.22	5d31	5p63	1722.3446	0.0057	3.80E+07	−1.77	0.08
1724.080	60		58001.95	4d73	5p33	1724.0800	0.0037	4.41E+07	−1.71	0.04
1725.009	400		57970.71	4d51	5p41	1725.0088	0.0044	1.44E+08	−1.21	0.22
1734.923	200		57639.45	4d41	5p21	1734.9226	0.0046	7.25E+07	−1.49	0.29
1759.984	500		56818.70	4d85	5p35	1759.9880	0.0046	1.57E+08	−1.13	0.49
1763.854	3	H, x	56694.03	5s13	5p33	1763.8457	0.0037	3.31E+07	−1.81	0.01

Table 1. *Cont.*

λ_{obs} (Å)	Int [a]		σ_{obs} (cm^{-1})	Even Level [b]	Odd Level [b]	λ_{Ritz} (Å)	Unc (Å)	$g_U A$ (s^{-1})	log($g_L f$)	|CF|
1764.854	25		56661.91	4d51	5p43	1764.8562	0.0046	7.38E+07	−1.47	0.18
1767.320	12		56582.85	5d53	5p51	1767.3212	0.0056	9.91E+07	−1.34	0.05
1773.897	400		56373.06	5s13	5p31	1773.8929	0.0042	1.80E+08	−1.07	0.17
1776.577	600		56288.02	5s11	5p53	1776.5732	0.0042	4.41E+08	−0.68	0.37
1783.481	200		56070.12	5s11	5p41	1783.4786	0.0042	1.54E+08	−1.14	0.50
1788.622	50		55908.96	4d73	5p23	1788.6221	0.0039	2.19E+08	−0.98	0.34
1800.697	35		55534.05	4d73	5p21	1800.6987	0.0043	5.29E+07	−1.60	0.08
1801.507	2000		55509.08	5s25	5p55	1801.5093	0.0054	4.44E+09	0.34	0.76
1813.410	1000		55144.73	5s25	5p73	1813.4129	0.0044	9.62E+08	−0.32	0.81
(1816.934)		K, x	55038.23	5s33	5p55	1816.9341	0.0056	1.00E+09	−0.30	0.85
1823.186	200		54849.04	4d85	5p33	1823.1906	0.0042	1.32E+08	−1.18	0.12
1826.103	1800		54761.42	5s11	5p43	1826.1065	0.0043	1.31E+09	−0.18	0.75
1829.037	2000		54673.58	5s33	5p73	1829.0430	0.0045	2.44E+09	0.09	0.64
1830.236	1500		54637.76	5s23	5p53	1830.2378	0.0039	7.41E+08	−0.43	0.35
1831.453	3000		54601.46	5s13	5p23	1831.4579	0.0039	1.94E+09	−0.01	0.57
1836.654	20		54446.84	4d83	5p45	1836.6566	0.0045	1.70E+08	−1.06	0.57
1837.566	300		54419.81	5s23	5p41	1837.5675	0.0039	1.64E+08	−1.09	0.15
1866.128	5	H, x	53586.89	5d25	5p63	1866.1431	0.0098	7.76E+07	−1.39	0.05
1874.773	3	H, x	53339.79	5d23	5p63	1874.7934	0.0063	6.94E+07	−1.44	0.04
1882.840	250		53111.26	5s23	5p43	1882.8530	0.0040	1.61E+08	−1.07	0.07
1888.675	2		52947.17	5d43	5p51	1888.6765	0.0057	4.22E+07	−1.65	0.04
1895.509	300	H, x	52756.28	4d85	5p23	1895.5222	0.0044	7.02E+07	−1.41	0.13
1896.139	30000		52738.75	5s15	5p17	1896.1404	0.0076	6.28E+09	0.53	0.96
1902.748	1		52555.57	5s15	5p25	1902.7475	0.0054	1.79E+07	−2.01	0.01
1909.897	1500		52358.84	5s25	5p63	1909.9026	0.0048	1.24E+09	−0.17	0.42
1919.844	25		52087.57	4d51	5p31	1919.8442	0.0058	9.34E+07	−1.30	0.45
1927.247	1500		51887.49	5s33	5p63	1927.2483	0.0050	8.58E+08	−0.32	0.47
1929.191	1500		51835.20	5s31	5p83	1929.1910	0.0133	2.92E+09	0.21	0.96
1967.435	5000		50827.60	5s23	5p35	1967.4431	0.0053	4.06E+09	0.37	0.96
1979.871	500		50508.34	5s11	5p33	1979.8785	0.0050	5.20E+08	−0.51	0.47
1981.092	20		50477.21	4d41	5p11	1981.0991	0.0060	4.85E+07	−1.55	0.30
1992.386	500	p	50191.08	5d23	5p55	1992.3903	0.0165	2.37E+06	−2.85	0.01
1992.546	1200	p	50187.05	5s11	5p31	1992.5463	0.0056	1.11E+09	−0.18	0.86
2008.655	5000		49784.56	5s25	5p27	2008.6537	0.0075	5.31E+09	0.51	0.97
2008.939	1200		49777.52	5s21	5p41	2008.9462	0.0049	9.32E+08	−0.26	0.92
2016.657	4		49587.01	4d73	5p25	2016.6633	0.0056	3.60E+07	−1.67	0.12

Table 1. *Cont.*

λ_{obs} (Å)	Int [a]		σ_{obs} (cm^{-1})	Even Level [b]	Odd Level [b]	λ_{Ritz} (Å)	Unc (Å)	$g_U A$ (s^{-1})	log($g_L f$)	∣CF∣
2046.757	1500		48857.78	5s23	5p33	2046.7594	0.0047	1.40E+09	−0.06	0.68
2048.791	8		48809.27	4d83	5p53	2048.8000	0.0048	4.94E+07	−1.50	0.20
2057.983	20		48591.27	4d83	5p41	2057.9892	0.0047	4.55E+07	−1.54	0.11
2060.302	12		48536.57	5s23	5p31	2060.3005	0.0054	5.08E+07	−1.49	0.08
2063.186	1500		48468.73	5s21	5p43	2063.1974	0.0051	1.02E+09	−0.19	0.88
2067.325	20		48371.69	4d73	5p11	2067.3300	0.0057	4.43E+05	−3.56	0.00
2071.281	5000		48279.30	5s13	5p25	2071.2849	0.0057	3.56E+09	0.36	0.96
2079.377	8000		48091.33	5s15	5p15	2079.3838	0.0084	3.53E+09	0.36	0.93
2094.038	4000		47754.63	5s15	5p13	2094.0466	0.0064	1.75E+09	0.06	0.89
2111.562	1200		47358.31	5s25	5p45	2111.5663	0.0065	6.65E+08	−0.35	0.95
2112.086	1	x	47346.56	5d63	5p83	2112.0917	0.0124	6.57E+07	−1.36	0.22
2114.962	8		47282.17	4d83	5p43	2114.9590	0.0049	2.42E+07	−1.79	0.07
2124.761	3000		47064.12	5s13	5p11	2124.7699	0.0057	1.02E+09	−0.17	0.88
2132.594	20		46891.25	4d41	5p13	2132.5977	0.0071	2.17E+07	−1.83	0.18
2132.785	1200		46887.05	5s33	5p45	2132.7887	0.0068	2.62E+09	0.26	0.77
2138.358	15		46764.85	5s23	5p23	2138.3637	0.0050	4.77E+06	−2.49	0.00
2153.595	1200		46433.99	4d85	5p25	2153.6032	0.0064	1.63E+08	−0.93	0.55
2155.636	2400		46390.02	5s23	5p21	2155.6477	0.0057	9.32E+08	−0.19	0.92
2222.293	1	x	44998.57	4d83	5p35	2222.2844	0.0066	6.15E+06	−2.33	0.15
2261.667	100		44215.17	5s21	5p33	2261.6611	0.0061	1.91E+07	−1.84	0.06
2278.201	100	p	43894.28	5s21	5p31	2278.2064	0.0069	1.15E+07	−2.05	0.10
2300.017	3000		43477.94	5s13	5p13	2300.0106	0.0069	3.20E+08	−0.60	0.32
2374.041	400		42122.27	5s21	5p23	2374.0394	0.0066	1.24E+08	−0.98	0.18
2395.369	150		41747.22	5s21	5p21	2395.3622	0.0074	5.30E+07	−1.34	0.18
2401.966	5		41632.56	4d85	5p13	2401.9604	0.0079	1.70E+07	−1.82	0.08
2424.306	5	x	41248.92	5s33	5p53	2424.2853	0.0077	9.67E+06	−2.07	0.06
2437.169	400		41031.21	5s33	5p41	2437.1620	0.0077	1.06E+08	−1.04	0.43
2442.837	12		40936.01	4d83	5p23	2442.8328	0.0063	1.75E+07	−1.80	0.08
2446.321	300		40877.71	5s11	5p11	2446.3174	0.0081	3.70E+07	−1.48	0.21
2465.420	3		40561.04	4d83	5p21	2465.4152	0.0072	8.56E+06	−2.11	0.03
2472.650	400		40442.44	5s23	5p25	2472.6384	0.0077	6.44E+07	−1.23	0.03
2487.961	400		40193.56	5s25	5p43	2487.9527	0.0077	1.38E+08	−0.89	0.32
2549.253	1		39227.18	5s23	5p11	2549.2424	0.0079	9.27E+06	−2.05	0.02

[a] Symbols: dc, doubly classified; p, perturbed; u, unresolved from close line; s, shaded to shorter wavelength; *l*, shaded to longer wavelength; x, not included in level optimization; d, double line; c, complex. A, blended or obscured by Y VI; B, perturbed by O II; C, perturbed by Si IV; D, intensity much higher than expected; E, perturbed by second order line; F, perturbed ghost of Si IV line; G, perturbed by Si IV; H, uncertain stage of ionization; J, perturbed by Y III; K, perturbed by Si II; L, perturbed by C I; M, perturbed by unknown impurity; [b] Level codes are explained in Table 2.

3. Spectrum Analysis and Level Values

The analysis was carried out in a manner similar to that used for the recent analysis of Mo V [11]. As described there "Interpretation of the spectrum was guided by calculations of the level structures and transition probabilities with the Hartree-Fock code of Cowan [12]. Further guidance was provided by construction of two-dimensional transition arrays with the computer spreadsheet method described by Reader [13]."

The odd parity energy levels are given in Table 2, the even levels in Table 3. In addition to the usual spectroscopic designations in either LS or J_1l (pair) coupling, the levels are given shorthand designations that are used in the classification of the spectral lines. The shorthand designations are explained in the footnotes to Tables 2 and 3. As described in [11] "The values of the energy levels were optimized with the computer program ELCALC, an iterative procedure in which the observed wave numbers are weighted according to the inverse square of their uncertainties. The uncertainties of the level values given by this procedure are also listed." (The program ELCALC was written by L. J. Radziemski of the Research Corporation, Tucson, Arizona 85712. The procedure and definition of level value uncertainties have been described by Radziemski and Kaufman [14].) For the level optimization only the most reliably classified lines were used. That is, lines that were very weak or that appeared with suspiciously high intensities were excluded.

Figure 1 shows a schematic overview of the positions of the $4s^24p^5$, $4s4p^6$, $4s^24p^44d$, 5s, 5p, 5d, and 6s, configurations. It also shows the calculated positions of the $4s^24p^44f$ and $4s4p^54d$ configurations.

Table 2. Odd parity levels (cm^{-1}) of Y V.

Configuration	Term	*J*	Desig. [a]	Energy	Uncert.	No. Trans.
$4s^24p^5$	^2P	3/2	p5 3	0.00	0.86	70
		1/2	p5 1	12460.12	1.05	46
$4s^24p^45p$	$(^3P_2)[1]$	3/2	5p13	341856.85	0.09	26
	$(^3P_2)[2]$	5/2	5p15	342193.59	0.16	23
	$(^3P_2)[1]$	1/2	5p11	345442.71	0.09	24
	$(^3P_2)[3]$	5/2	5p25	346658.00	0.10	26
	$(^3P_2)[3]$	7/2	5p17	346841.13	0.18	13
	$(^3P_1)[0]$	1/2	5p21	352605.14	0.09	20
	$(^3P_2)[2]$	3/2	5p23	352980.10	0.07	31
	$(^3P_0)[1]$	1/2	5p31	354751.98	0.10	21
	$(^3P_1)[2]$	3/2	5p33	355073.09	0.08	41
	$(^3P_1)[2]$	5/2	5p35	357042.76	0.11	29
	$(^3P_0)[1]$	3/2	5p43	359326.26	0.08	40
	$(^3P_1)[1]$	1/2	5p41	360635.14	0.08	25
	$(^3P_1)[1]$	3/2	5p53	360853.08	0.09	39
	$(^1D_2)[3]$	5/2	5p45	366490.78	0.11	22
	$(^1D_2)[3]$	7/2	5p27	368917.16	0.16	14
	$(^1D_2)[1]$	3/2	5p63	371491.26	0.09	30
	$(^1D_2)[2]$	3/2	5p73	374277.21	0.09	31
	$(^1D_2)[2]$	5/2	5p55	374641.58	0.14	23
	$(^1D_2)[1]$	1/2	5p51	378488.47	0.11	19
	$(^1S_0)[1]$	1/2	5p61	395993.26	0.30	5
	$(^1S_0)[1]$	3/2	5p83	397637.50	0.22	13

[a] Designations are given with a short form of the configuration (two places) followed by the ordinal number of the calculated *J*-value for the configuration (one place) and the *J* value (one place). For example, 5p73 indicates the seventh level with *J* = 3 for the $4p^45p$ configuration. p5 3 and p5 1 indicate the *J* = 3/2 and 1/2 levels of the $4p^5$ configuration, respectively.

Table 3. Even parity energy levels (cm^{-1}) of Y V.

Configuration	Term	*J*	Desig. [a]	Energy	Uncert.	No. Trans.
$4s4p^6$	^2S	1/2	4p61	170945.58	0.95	8
$4s^24p^44d$	$(^3P)^4D$	5/2	4d15	218417.13	0.51	9
	$(^3P)^4D$	7/2	4d17	218556.80	0.64	4
	$(^3P)^4D$	3/2	4d13	219373.81	0.45	11
	$(^3P)^4D$	1/2	4d11	220794.66	0.78	10
	$(^3P)^4F$	9/2	4d19	229786.64	0.98	1
	$(^3P)^4F$	7/2	4d27	233703.76	0.46	7
	$(^1D)^2P$	1/2	4d21	233712.36	0.37	12
	$(^3P)^4F$	5/2	4d25	237677.66	0.37	10
	$(^3P)^4F$	3/2	4d23	238215.09	0.37	16
	$(^3P)^4P$	1/2	4d31	238898.28	0.40	11
	$(^3P)^4P$	3/2	4d33	239132.83	0.30	18
	$(^1D)^2D$	3/2	4d43	240949.32	0.34	12
	$(^3P)^2F$	7/2	4d37	242336.33	0.54	6
	$(^3P)^4P$	5/2	4d35	244311.56	0.32	11
	$(^1D)^2P$	3/2	4d53	244613.24	0.31	15
	$(^1D)^2D$	5/2	4d45	247861.17	0.34	11
	$(^1D)^2G$	7/2	4d47	250882.71	0.46	4
	$(^1D)^2G$	9/2	4d29	251052.40	0.99	1
	$(^3P)^2F$	5/2	4d55	251403.88	0.38	9
	$(^1D)^2F$	5/2	4d65	263184.02	0.26	10
	$(^1D)^2F$	7/2	4d57	266196.75	0.38	6
	$(^1S)^2D$	3/2	4d63	281244.51	0.25	9
	$(^1S)^2D$	5/2	4d75	286001.66	0.29	6
	$(^1D)^2S$	1/2	4d41	294965.68	0.12	8
	$(^3P)^2P$	3/2	4d73	297071.14	0.10	14
	$(^3P)^2D$	5/2	4d85	300224.19	0.10	13
	$(^3P)^2P$	1/2	4d51	302664.42	0.12	7
	$(^3P)^2D$	3/2	4d83	312044.02	0.08	13
$4s^24p^45s$	$(^3P_2)[2]$	5/2	5s15	294102.42	0.11	12
	$(^3P_2)[2]$	3/2	5s13	298378.79	0.09	17
	$(^3P_0)[0]$	1/2	5s11	304564.94	0.10	9
	$(^3P_1)[1]$	3/2	5s23	306215.37	0.08	16
	$(^3P_1)[1]$	1/2	5s21	310857.80	0.09	11
	$(^1D_2)[2]$	5/2	5s25	319132.57	0.10	8
	$(^1D_2)[2]$	3/2	5s33	319603.81	0.10	11
	$(^1S_0)[0]$	1/2	5s31	345802.30	0.29	3
$4s^24p^45d$	$(^3P_2)[3]$	7/2	5d17	418265.33	0.27	3
	$(^3P_2)[2]$	5/2	5d15	418310.18	0.44	2
	$(^3P_2)[2]$	3/2	5d13	418914.39	0.15	9
	$(^3P_2)[1]$	1/2	5d11	419977.22	0.18	7
	$(^3P_2)[4]$	9/2	5d19	420403.65	0.42	1
	$(^3P_2)[4]$	7/2	5d27	421426.57	0.28	3
	$(^3P_2)[0]$	1/2	5d21	423350.97	0.13	10
	$(^3P_2)[1]$	3/2	5d23	424830.47	0.16	13
	$(^3P_2)[3]$	5/2	5d25	425077.72	0.27	8
	$(^3P_1)[1]$	1/2	5d31	429551.65	0.17	10
	$(^3P_0)[2]$	3/2	5d33	430343.90	0.17	9
	$(^3P_0)[2]$	5/2	5d35	430533.98	0.19	9
	$(^3P_1)[3]$	7/2	5d37	430760.23	0.68	2
	$(^3P_1)[1]$	3/2	5d43	431435.60	0.12	11
	$(^3P_1)[2]$	5/2	5d45	432673.11	0.19	7
	$(^3P_1)[3]$	5/2	5d55	434647.00	0.16	10
	$(^3P_1)[2]$	3/2	5d53	435071.28	0.14	9
	$(^1D_2)[4]$	7/2	5d47	442365.90	0.30	3
	$(^1D_2)[4]$	9/2	5d29	442704.55	0.41	1
	$(^1D_2)[0]$	1/2	5d41	444128.77	0.18	9
	$(^1D_2)[1]$	3/2	5d63	444983.93	0.18	13
	$(^1D_2)[2]$	5/2	5d65	445299.76	0.20	7

Table 3. *Cont.*

Configuration	Term	*J*	Desig. [a]	Energy	Uncert.	No. Trans.
	$(^1D_2)[3]$	7/2	5d57	446600.43	0.29	3
	$(^1D_2)[3]$	5/2	5d75	446709.00	0.22	6
	$(^1D_2)[1]$	1/2	5d51	447277.48	0.22	6
	$(^1D_2)[2]$	3/2	5d73	448357.54	0.24	8
	$(^1S_0)[2]$	5/2	5d85	470989.78	0.43	2
	$(^1S_0)[2]$	3/2	5d83	471484.11	0.35	5
$4s^24p^46s$	$(^3P_2)[2]$	5/2	6s15	435670.71	0.23	10
	$(^3P_2)[2]$	3/2	6s13	437171.00	0.22	13
	$(^3P_0)[0]$	1/2	6s11	446209.20	0.32	7
	$(^3P_1)[1]$	3/2	6s23	446718.25	0.29	8
	$(^3P_1)[1]$	1/2	6s21	448774.76	0.36	7
	$(^1D_2)[2]$	5/2	6s25	459636.57	0.63	5
	$(^1D_2)[2]$	3/2	6s33	459761.34	0.27	6
	$(^1S_0)[0]$	1/2	6s31	486067.68	0.58	5
$4s^24p^46d$	$(^3P_2)[3]$	5/2	6d25 [c]	493116	49	1
	$(^3P_2)[1]$	3/2	6d23 [b]	493146	16	2
	$(^3P_1)[1]$	3/2	6d43 [c]	501351	75	1
	$(^3P_1)[3]$	5/2	6d55 [c]	503137	18	1
	$(^3P_1)[2]$	3/2	6d53 [b]	503788	12	2
	$(^1D_2)[0]$	1/2	6d41 [b]	514253	13	2
	$(^1D_2)[2]$	3/2	6d73 [b]	515011	16	2
	$(^1D_2)[2]$	5/2	6d65 [c]	515762	19	1
	$(^1D_2)[1]$	1/2	6d51 [b]	515882	13	2
	$(^1S_0)[2]$	3/2	6d83 [b]	543052	14	2
$4s^24p^47s$	$(^3P_2)[2]$	5/2	7s15 [c]	498271	74	1
	$(^3P_2)[2]$	3/2	7s13 [b]	499020	12	2
	$(^3P_1)[1]$	3/2	7s23 [c]	509051	18	1
	$(^3P_1)[1]$	1/2	7s21 [b]	509817	13	2
	$(^1D_2)[2]$	5/2	7s25 [c]	522000	19	1
	$(^1D_2)[2]$	3/2	7s33 [c]	522129	18	1
	$(^1S_0)[0]$	1/2	7s31 [c]	544803	20	1

[a] Designations are explained in Table 2; 4p61 indicates the $J = 1/2$ level of $4s4p^6$; [b] Tentative designation; not included in LSF; [c] Tentative level with tentative designation; not included in LSF.

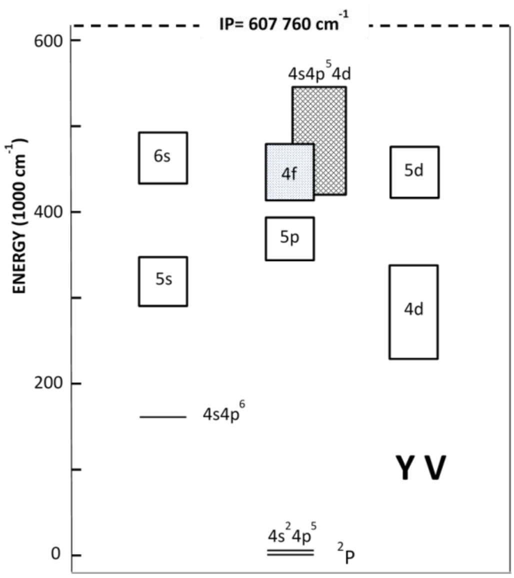

Figure 1. Schematic overview of the observed configurations of Y V. The calculated positions of the $4s^24p^44f$ and $4s4p^54d$ configurations are also shown.

3.1. $4s^2 4p^4 4d$ Levels

Nearly all levels of this configuration were given in [4]. Remaining as unknown were $(^3P)^4D_{1/2,7/2}$, $(^3P)^4F_{7/2,9/2}$, $(^3P)^2F_{7/2}$, $(^1D)^2G_{7/2,9/2}$, and $(^1D)^2F_{7/2}$. These levels have now been established based on their transitions to $4p^45p$. All values for these levels reported in [6] are spurious.

The $4p^44d$ $(^3P)^4F_{9/2}$ (4d19) and $(^1D)^2G_{9/2}$ (4d29) levels are necessarily based on only a single transition. However, the lines assigned to these transitions are both very strong and place the $J = 9/2$ levels close to their predicted positions. There is no doubt as to their identifications.

The structure of the $4p^44d$ configuration is shown in Figure 2. This is similar to Figure 1 of [4], except that we show here the observed positions of levels that were previously unknown.

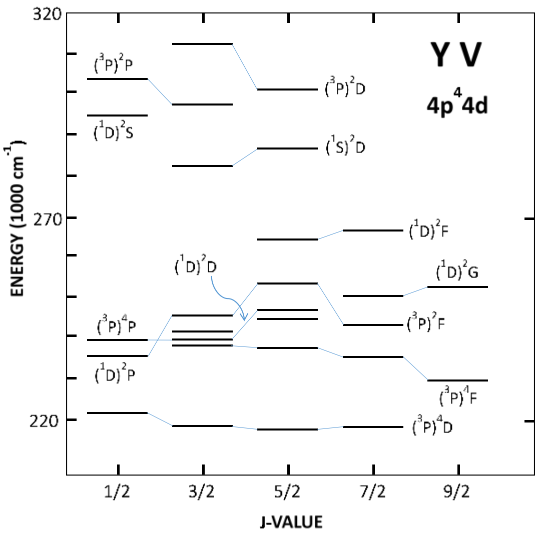

Figure 2. Structure of the $4s^24p^44d$ configuration of Y V.

3.2. $4s^2 4p^4 5s$ Levels

The levels of the $4s^24p^45s$ configuration, which were complete in [4], have improved values as a result of their combinations with $4p^45p$. In Figure 3 we give the structure of the $4p^45s$ configuration. This is the same as Figure 2 of [4], except that here we designate the levels in J_1l-coupling, rather than J_1j-coupling.

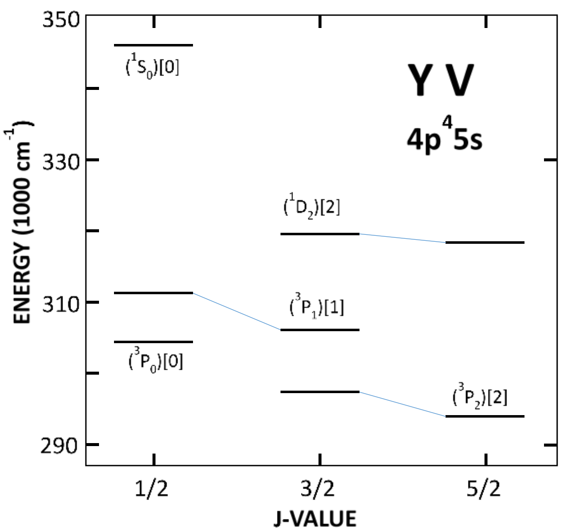

Figure 3. Structure of the $4s^24p^45s$ configuration of Y V.

3.3. $4s^2 4p^4 5p$ Levels

All levels of this configuration have been located. Of the 21 levels of this configuration given in [6], only three could be confirmed (345444, 360851, and 374278 cm^{-1}). The levels at 342193 and 355076 cm^{-1} were confirmed, but were found to have incorrect *J*-values. The structure of the $4p^4 5p$ levels is shown in Figure 4. The levels are designated in $J_1 l$-coupling.

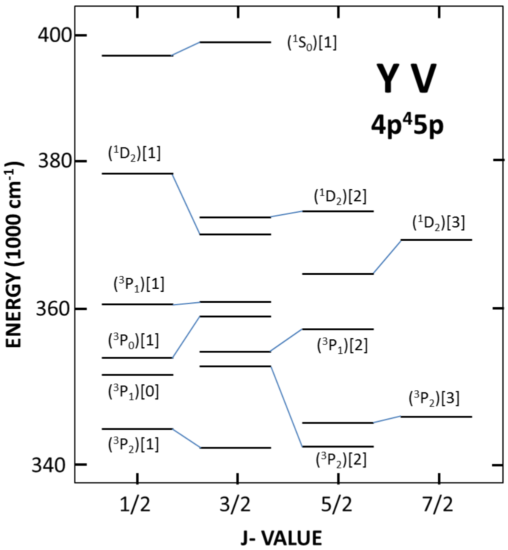

Figure 4. Structure of the $4s^2 4p^4 5p$ configuration of Y V.

3.4. $4s^2 4p^4 5d$ and $4s^2 4p^4 6s$ Levels

The $4p^4 5d$ and 6s configurations lie very close in energy and are treated together. The levels are shown in Figure 5; they are designated in $J_1 l$-coupling. As with $4p^4 4d$, the $J = 9/2$ levels could be established by only a single line. However, there is little doubt as to the identifications. A few of the levels of these configurations given in [5] could be confirmed, although some of the J-values and configuration assignments had to be revised. All of the $4p^4 5d$ levels of [6] were found to be spurious.

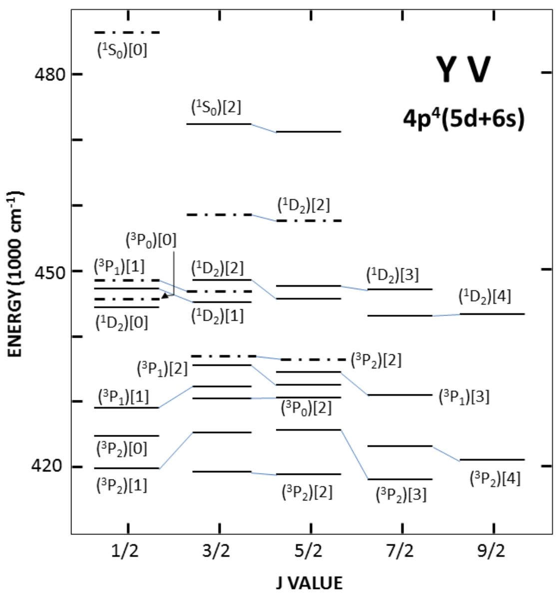

Figure 5. Structures of the $4s^2 4p^4 5d$ and $4s^2 4p^4 6s$ configurations of Y V. The $4s^2 4p^4 6s$ levels are shown as dashed.

3.5. $4s^24p^46d$ and $4s^24p^47s$ Levels

Based on our calculations, we were able to assign a number of low wavelength lines with clear Y V character as transitions to the ground term from levels of $4p^46d$ and 7s. For pairs of lines with wave number differences that closely match the $4p^5$ ^2P interval, the implied levels are relatively certain. However, the designations are considered to be tentative. Where the levels are based on single transitions, the line and level identifications are even less certain. None of these levels were included in the least-squares-fits, described below.

None of the information for the $4p^5$-$4p^46d$, 7s transitions and $4p^46d$,7s levels of Zahid-Ali et al. [5] could be confirmed.

3.6. $4s^24p^44f$ and $4s4p^54d$ Configurations

Extensive efforts to find levels of these configurations were not successful. Levels of $4p^44f$ were given in [6], but it is almost certain that all of them are spurious.

4. Theoretical Interpretation

4.1. Odd Parity Configurations

As in [11] "The observed configurations were interpreted theoretically by making least-squares fits of the energy parameters to the observed levels with the Cowan suite of codes, RCN (Hartree-Fock), RCG (energy matrix diagonalization), and RCE (least-squares parameter fitting) [12]. The Hartree-Fock code was run in a relativistic mode (HFR) with a correlation term in the potential. Breit energies were not included. For the initial calculations the HFR values were scaled by factors of 0.85 for the direct electrostatic parameters F^k, the exchange electrostatic parameters G^k, and the configuration interaction parameters R^k." The odd configurations $4s^24p^5$, $4s^24p^45p$, $4s^24p^44f$, and $4s4p^54d$ were treated as a single group.

The Hartree-Fock and least-squares fitted parameters for the odd configurations are given in Table 4. For these calculations, the $4p^45p$ exchange electrostatic parameters, $G^0(4p5p)$ and $G^2(4p5p)$, were linked at their HFR ratio. The LSF/HFR ratio of 0.836 is satisfactory. The configuration interaction (CI) parameters for the $4s^24p^5$-$4s^24p^45p$ interaction were held fixed at their scaled HFR values. All other CI parameters and parameters for $4s^24p^44f$ and $4s4p^54d$ were fixed at their scaled HFR values. The value of the effective interaction parameter $\alpha(4p4p)$ for the $4p^45p$ configuration was fixed at the value observed for the $4p^4$ core of Y VI [7]. In Table 4, only values for the observed configurations $4s^24p^5$ and $4s^24p^45p$ are given.

Table 4. Hartree-Fock and least–squares fitted parameters for the odd configurations of Y V. Mean error of fit 179 cm^{-1}.

Configuration	Parameter	HFR	LSF	Unc.	LSF/HFR
$4s^24p^5$	$E_{av}(4s^24p^5)$	8182	8400	134	
	ζ_{4p}	7941	8369	170	1.054
$4s^24p^45p$	$E_{av}(4s^24p^45p)$	364894	360966	40	0.989
	$F^2(4p4p)$	78434	65400	358	0.834
	$\alpha(4p4p)$		−56 [a]		
	ζ_{4p}	8458	8679	108	1.026
	ζ_{5p}	1688	2016	85	1.194
	$F^2(4p5p)$	22406	20623	364	0.920
	$G^0(4p5p)$	4773	3988 [b]	49	0.836
	$G^2(4p5p)$	6387	5337 [b]	66	0.836
Config. Interaction					
$4s^24p^5$-$4s^24p^45p$	$R^0(4p4p,4p5p)$	2217	1885 [c]		0.850
	$R^2(4p4p,4p5p)$	10661	9062 [c]		0.850

[a] Fixed at value from $4p^4$ of Y VI [7]; [b] Linked in LSF fit; [c] Fixed at scaled HFR value.

The calculated level values and eigenvector compositions for the odd configurations are given in Table 5. This table gives the percentage compositions for the three leading eigenvector states in LS-coupling and the percentage for the leading eigenvector state in J_1l-coupling. As can be seen there is not much mixing between the 4s^{2}4p^5 and the 4s^{2}4p^{4}5p configurations, and 4s^{2}4p^{4}5p has essentially no mixture of either 4s^{2}4p^{4}4f or 4s4p^{5}4d.

Table 5. Calculated energy levels (cm^{-1}) and percentage compositions for the odd levels of Y V.

J	Observed	Calculated	O−C	%J_1l	Percentage Composition (LS-Coupling)								
3/2	0	0	0		99%	4p^5	(^{1}S)^{2}P						
1/2	12460	12460	0		99%	4p^5	(^{1}S)^{2}P	1%	4s4p^{5}4d	(^{1}P)^{2}P			
3/2	341857	341900	−43	41% (^{3}P$_2$)[1]	66%	4p^{4}5p	(^{3}P)^{4}P	9%	4p^{4}5p	(^{3}P)^{4}S	8%	4p^{4}5p	(^{1}D)^{2}P
5/2	342194	342140	54	83% (^{3}P$_2$)[2]	73%	4p^{4}5p	(^{3}P)^{4}P	21%	4p^{4}5p	(^{3}P)^{4}D	3%	4p^{4}5p	(^{1}D)^{2}D
1/2	345443	345735	−292	55% (^{3}P$_2$)[1]	50%	4p^{4}5p	(^{3}P)^{4}P	21%	4p^{4}5p	(^{3}P)^{2}P	17%	4p^{4}5p	(^{1}D)^{2}P
5/2	346658	346626	32	78% (^{3}P$_2$)[3]	62%	4p^{4}5p	(^{3}P)^{2}D	16%	4p^{4}5p	(^{3}P)^{4}D	12%	4p^{4}5p	(^{3}P)^{4}P
7/2	346841	346682	159	92% (^{3}P$_2$)[3]	92%	4p^{4}5p	(^{3}P)^{4}D	8%	4p^{4}5p	(^{1}D)^{2}F			
1/2	352605	352708	−103	59% (^{3}P$_1$)[0]	37%	4p^{4}5p	(^{3}P)^{4}P	22%	4p^{4}5p	(^{3}P)^{2}P	17%	4p^{4}5p	(^{3}P)^{4}D
3/2	352980	352884	96	36% (^{3}P$_2$)[2]	35%	4p^{4}5p	(^{3}P)^{4}D	24%	4p^{4}5p	(^{3}P)^{2}D	18%	4p^{4}5p	(^{3}P)^{2}P
1/2	354752	354622	130	62% (^{3}P$_0$)[1]	70%	4p^{4}5p	(^{3}P)^{4}D	11%	4p^{4}5p	(^{3}P)^{4}P	10%	4p^{4}5p	(^{3}P)^{2}S
3/2	355073	355061	12	35% (^{3}P$_1$)[2]	47%	4p^{4}5p	(^{3}P)^{4}D	35%	4p^{4}5p	(^{3}P)^{2}P	9%	4p^{4}5p	(^{1}D)^{2}P
5/2	357043	356868	175	95% (^{3}P$_1$)[2]	59%	4p^{4}5p	(^{3}P)^{4}D	27%	4p^{4}5p	(^{3}P)^{2}D	13%	4p^{4}5p	(^{3}P)^{4}P
3/2	359326	359369	−43	70% (^{3}P$_0$)[1]	29%	4p^{4}5p	(^{3}P)^{2}D	25%	4p^{4}5p	(^{3}P)^{4}S	15%	4p^{4}5p	(^{3}P)^{4}P
3/2	360853	360766	87	65% (^{3}P$_1$)[1]	47%	4p^{4}5p	(^{3}P)^{4}S	41%	4p^{4}5p	(^{3}P)^{2}D	5%	4p^{4}5p	(^{3}P)^{4}P
1/2	360635	361119	−484	61% (^{3}P$_1$)[1]	72%	4p^{4}5p	(^{3}P)^{2}S	14%	4p^{4}5p	(^{3}P)^{2}P	6%	4p^{4}5p	(^{3}P)^{4}D
5/2	366491	366367	124	87% (^{1}D$_2$)[3]	87%	4p^{4}5p	(^{1}D)^{2}F	7%	4p^{4}5p	(^{3}P)^{2}D	4%	4p^{4}5p	(^{1}D)^{2}D
7/2	368917	368795	122	91% (^{1}D$_2$)[3]	91%	4p^{4}5p	(^{1}D)^{2}F	8%	4p^{4}5p	(^{3}P)^{4}D			
3/2	371491	371556	−65	62% (^{1}D$_2$)[1]	62%	4p^{4}5p	(^{1}D)^{2}P	17%	4p^{4}5p	(^{1}D)^{2}D	11%	4p^{4}5p	(^{3}P)^{2}P
3/2	374277	374172	105	76% (^{1}D$_2$)[2]	76%	4p^{4}5p	(^{1}D)^{2}D	16%	4p^{4}5p	(^{3}P)^{2}P	7%	4p^{4}5p	(^{1}D)^{2}P
5/2	374642	374641	1	92% (^{1}D$_2$)[2]	92%	4p^{4}5p	(^{1}D)^{2}D	3%	4p^{4}5p	(^{1}D)^{2}F	2%	4p^{4}5p	(^{3}P)^{4}P
1/2	378488	378486	2	64% (^{1}D$_2$)[1]	64%	4p^{4}5p	(^{1}D)^{2}P	34%	4p^{4}5p	(^{3}P)^{2}P	1%	4p^{4}5p	(^{3}P)^{2}S
1/2	395993	395986	7	84% (^{1}S$_0$)[1]	84%	4p^{4}5p	(^{1}S)^{2}P	6%	4p^{4}5p	(^{3}P)^{2}P	5%	4p^{4}5p	(^{3}P)^{4}D
3/2	397637	397712	−75	86% (^{1}S$_0$)[1]	86%	4p^{4}5p	(^{1}S)^{2}P	3%	4p^{4}5p	(^{3}P)^{2}D	3%	4p^{4}5p	(^{3}P)^{4}D

4.2. Even Parity Configurations

The parameters for the even configurations are given in Table 6. Here, the 4s4p^6, 4p^{4}4d, 5s, 5d, 6s, 6d, and 7s configurations were treated as single group. For the initial calculations the HFR values were scaled by factors of 0.85 for the direct electrostatic parameters F^k, the exchange electrostatic parameters G^k, and the configuration interaction parameters R^k. All the parameters that were allowed to vary were well defined in the fit and have reasonable ratios to the HFR values. The exchange parameters G^1(4p5d) and G^3(4p5d) were linked at their HFR ratio. The CI parameters for the 4s4p^6-4s^{2}4p^{4}4d and 4s4p^6-4s^{2}4p^{4}5d interactions were also linked at their HFR ratio. The fitted values are reasonable. The other CI parameters and all of the parameters for 4p^{4}6d and 4p^{4}7s were held fixed at their scaled HFR values. As described in [4] the interaction of 4s4p^6 ^{2}S$_{1/2}$ with the 4s^{2}4p^{4}4d (^{1}D)^{2}S level is great, with a mutual repulsion of ~31,000 cm^{-1}. On the other hand, interaction between 4s4p^6 and 4s^{2}4p^{4}5d is negligible. The value of the effective interaction parameter α(4p4p) for the 4p^{4}4d, 5s, 5d, and 6s configurations was again fixed at the value observed for the 4p^4 core of Y VI [7]. The calculated level values and eigenvector compositions for the even levels are given in Table 7. This table gives the percentage compositions for the three leading eigenvector states in LS-coupling and the percentage for the leading eigenvector state in J_1l-coupling, where appropriate. As can be seen, the purity of the states of the 4p^{4}4d configuration in LS-coupling is low, leading to low leading percentages for many of the levels. Even though the 4p^{4}5d and 4p^{4}6s configurations are practically coincident, there is not much mixing of states.

Table 6. Hartree-Fock and least-squares fitted parameters for the even configurations of Y V. Mean error of fit 273 cm^{-1}.

Configuration	Parameter	HF	LSF	Unc.	LSF/HFR
$4s4p^6$	$E_{av}(4s4p^6)$	215344	203602	511	0.942
$4s^24p^44d$	$E_{av}(4s^24p^44d)$	255431	251213	55	0.982
	$F^2(4p4p)$	77057	63230	629	0.821
	$\alpha(4p4p)$		−56 [a]		
	ζ_{4p}	8132	8494	156	1.045
	ζ_{4d}	507	612	73	1.209
	$F^2(4p4d)$	62105	53714	481	0.865
	$G^1(4p4d)$	76519	61136	169	0.799
	$G^3(4p4d)$	47207	39325	921	0.833
$4s^24p^45s$	$E_{av}(4s^24p^45s)$	314448	309938	101	0.985
	$F^2(4p4p)$	78065	64882	811	0.831
	$\alpha(4p4p)$		−56 [a]		
	ζ_{4p}	8391	8647	254	1.031
	$G^1(4p5s)$	7780	6747	374	0.867
$4s^24p^45d$	$E_{av}(4s^24p^45d)$	438648	434854	54	0.991
	$F^2(4p4p)$	78487	65109	485	0.830
	$\alpha(4p4p)$		−56 [a]		
	ζ_{4p}	8452	8827	119	1.044
	ζ_{5d}	146	214	61	1.463
	$F^2(4p5d)$	16322	13742	557	0.842
	$G^1(4p5d)$	10162	6965 [b]	260	0.685
	$G^3(4p5d)$	7247	4967 [b]	185	0.685
$4s^24p^46s$	$E_{av}(4s^24p^46s)$	453803	450227	103	0.991
	$F^2(4p4p)$	78549	64962	784	0.827
	$\alpha(4p4p)$		−56 [a]		
	ζ_{4p}	8477	8833	223	1.042
	$G^1(4p6s)$	2422	2041	372	0.843
Config. Interaction					
$4s4p^6$-$4s^24p^44d$	$R^1(4p4p,4s4d)$	86708	66719 [c]	419	0.769
$4s4p^6$-$4s^24p^45d$	$R^1(4p4p,4s5d)$	30749	23660 [c]	149	0.769
$4s4p^6$-$4s^24p^45s$	$R^1(4p4p,4s5s)$	2884	2452 [d]		0.850
$4s4p^6$-$4s^24p^46s$	$R^1(4p4p,4s6s)$	668	567 [d]		0.850
$4s^24p^44d$-$4s^24p^45s$	$R^2(4p4d,4p5s)$	−9422	−8009 [d]		0.850
	$R^1(4p4d,5s4p)$	−1919	−1631 [d]		0.850
$4s^24p^44d$-$4s^24p^46s$	$R^2(4p4d,4p6s)$	−5249	−4462 [d]		0.850
	$R^1(4p4d,6s4p)$	−1888	−1605 [d]		0.850

[a] Fixed at value from $4p^4$ of Y VI [7]; [b,c] Linked in groups in LSF fit; [d] Fixed at scaled HFR value.

Table 7. Calculated energy levels (cm^{-1}) and percentage compositions for the even levels of Y V.

J	Obs.	Calc.	O−C	% J_1l	Percentage Composition (LS-Coupling)								
1/2	170946	170944	2		75%	4s4p^6	(^{2}S)^{2}S	24%	4p^{4}4d	(^{1}D)^{2}S			
5/2	218417	218286	131		90%	4p^{4}4d	(^{3}P)^{4}D	3%	4p^{4}4d	(^{3}P)^{4}F	2%	4p^{4}4d	(^{3}P)^{4}P
7/2	218557	218521	36		92%	4p^{4}4d	(^{3}P)^{4}D	5%	4p^{4}4d	(^{3}P)^{4}F	2%	4p^{4}4d	(^{1}D)^{2}F
3/2	219374	219237	137		88%	4p^{4}4d	(^{3}P)^{4}D	4%	4p^{4}4d	(^{3}P)^{4}P	3%	4p^{4}4d	(^{1}D)^{2}D
1/2	220795	220814	−19		88%	4p^{4}4d	(^{3}P)^{4}D	5%	4p^{4}4d	(^{1}D)^{2}P	4%	4p^{4}4d	(^{3}P)^{2}P
9/2	229787	229647	140		91%	4p^{4}4d	(^{3}P)^{4}F	9%	4p^{4}4d	(^{1}D)^{2}G			
7/2	233704	233513	191		72%	4p^{4}4d	(^{3}P)^{4}F	14%	4p^{4}4d	(^{3}P)^{2}F	11%	4p^{4}4d	(^{1}D)^{2}G
1/2	233712	234734	−1022		45%	4p^{4}4d	(^{1}D)^{2}P	39%	4p^{4}4d	(^{3}P)^{2}P	11%	4p^{4}4d	(^{3}P)^{4}D
5/2	237678	237425	253		94%	4p^{4}4d	(^{3}P)^{4}F	3%	4p^{4}4d	(^{3}P)^{4}D	2%	4p^{4}4d	(^{1}S)^{2}D
3/2	238215	237945	270		63%	4p^{4}4d	(^{3}P)^{4}F	11%	4p^{4}4d	(^{1}S)^{2}D	10%	4p^{4}4d	(^{3}P)^{4}P
1/2	238898	238811	87		91%	4p^{4}4d	(^{3}P)^{4}P	4%	4p^{4}4d	(^{3}P)^{2}P	3%	4p^{4}4d	(^{1}D)^{2}P
3/2	239133	239284	−151		44%	4p^{4}4d	(^{3}P)^{4}P	22%	4p^{4}4d	(^{3}P)^{4}F	20%	4p^{4}4d	(^{1}D)^{2}P
3/2	240949	240804	145		38%	4p^{4}4d	(^{1}D)^{2}D	24%	4p^{4}4d	(^{3}P)^{2}D	10%	4p^{4}4d	(^{3}P)^{4}F
7/2	242336	242673	−337		48%	4p^{4}4d	(^{3}P)^{2}F	20%	4p^{4}4d	(^{3}P)^{4}F	20%	4p^{4}4d	(^{1}D)^{2}G
5/2	244312	244201	111		77%	4p^{4}4d	(^{3}P)^{4}P	7%	4p^{4}4d	(^{1}S)^{2}D	6%	4p^{4}4d	(^{3}P)^{2}D
3/2	244613	245018	−405		39%	4p^{4}4d	(^{3}P)^{4}P	24%	4p^{4}4d	(^{1}D)^{2}P	22%	4p^{4}4d	(^{3}P)^{2}P
5/2	247861	247600	262		40%	4p^{4}4d	(^{1}D)^{2}D	23%	4p^{4}4d	(^{3}P)^{2}D	16%	4p^{4}4d	(^{3}P)^{4}P
7/2	250883	250572	311		68%	4p^{4}4d	(^{1}D)^{2}G	22%	4p^{4}4d	(^{3}P)^{2}F	8%	4p^{4}4d	(^{1}D)^{2}F
9/2	251052	250641	411		91%	4p^{4}4d	(^{1}D)^{2}G	9%	4p^{4}4d	(^{3}P)^{4}F			
5/2	251404	252009	−605		67%	4p^{4}4d	(^{3}P)^{2}F	17%	4p^{4}4d	(^{1}D)^{2}F	10%	4p^{4}4d	(^{1}D)^{2}D
5/2	263184	263228	−44		80%	4p^{4}4d	(^{1}D)^{2}F	11%	4p^{4}4d	(^{3}P)^{2}F	7%	4p^{4}4d	(^{1}D)^{2}D
7/2	266197	266306	−109		82%	4p^{4}4d	(^{1}D)^{2}F	15%	4p^{4}4d	(^{3}P)^{2}F	1%	4p^{4}4d	(^{1}D)^{2}G
3/2	281245	281192	53		62%	4p^{4}4d	(^{1}S)^{2}D	26%	4p^{4}4d	(^{1}D)^{2}D	4%	4p^{4}4d	(^{1}D)^{2}P
5/2	286002	286024	−22		72%	4p^{4}4d	(^{1}S)^{2}D	16%	4p^{4}4d	(^{1}D)^{2}D	4%	4p^{4}4d	(^{3}P)^{2}F
5/2	294102	294060	42	93%($^3P_2$)[2]	93%	4p^{4}5s	(^{3}P)^{4}P	6%	4p^{4}5s	(^{1}D)^{2}D			
1/2	294966	295069	−103		62%	4p^{4}4d	(^{1}D)^{2}S	20%	4s4p6	(^{2}S)^{2}S	8%	4p^{4}4d	(^{1}D)^{2}P
3/2	297071	296670	401		47%	4p^{4}4d	(^{3}P)^{2}P	36%	4p^{4}4d	(^{1}D)^{2}P	7%	4p^{4}4d	(^{1}D)^{2}D
3/2	298379	298417	−38	79%($^3P_2$)[2]	47%	4p^{4}5s	(^{3}P)^{2}P	43%	4p^{4}5s	(^{3}P)^{4}P	8%	4p^{4}5s	(^{1}D)^{2}D
5/2	300224	300747	−523		62%	4p^{4}4d	(^{3}P)^{2}D	20%	4p^{4}4d	(^{1}D)^{2}D	14%	4p^{4}4d	(^{1}S)^{2}D
1/2	302664	301985	679		44%	4p^{4}4d	(^{3}P)^{2}P	38%	4p^{4}4d	(^{1}D)^{2}P	10%	4p^{4}4d	(^{1}D)^{2}S
1/2	304565	304602	−37	57%($^3P_0$)[0]	90%	4p^{4}5s	(^{3}P)^{4}P	5%	4p^{4}5s	(^{1}S)^{2}S	2%	4p^{4}4d	(^{1}D)^{2}S
3/2	306215	306149	66	89%($^3P_1$)[1]	56%	4p^{4}5s	(^{3}P)^{4}P	42%	4p^{4}5s	(^{3}P)^{2}P	2%	4p^{4}5s	(^{1}D)^{2}D
1/2	310858	310839	19	66%($^3P_1$)[1]	95%	4p^{4}5s	(^{3}P)^{2}P	4%	4p^{4}5s	(^{1}S)^{2}S			
3/2	312044	312297	−253		54%	4p^{4}4d	(^{3}P)^{2}D	20%	4p^{4}4d	(^{1}S)^{2}D	13%	4p^{4}4d	(^{1}D)^{2}D
5/2	319133	319168	−35	93%($^1D_2$)[2]	93%	4p^{4}5s	(^{1}D)^{2}D	6%	4p^{4}5s	(^{3}P)^{4}P			
3/2	319604	319699	−95	88%($^1D_2$)[2]	88%	4p^{4}5s	(^{1}D)^{2}D	10%	4p^{4}5s	(^{3}P)^{2}P	1%	4p^{4}5s	(^{3}P)^{4}P
1/2	345802	345752	50	88%($^1S_0$)[0]	88%	4p^{4}5s	(^{1}S)^{2}S	6%	4p^{4}5s	(^{3}P)^{4}P	5%	4p^{4}5s	(^{3}P)^{2}P

Table 7. *Cont.*

J	Obs.	Calc.	O−C	% $J_1 l$	Percentage Composition (LS-Coupling)								
7/2	418265	418341	−76	91%($^3P_2$)[3]	73%	$4p^45d$	$(^3P)^4D$	20%	$4p^45d$	$(^3P)^4F$	5%	$4p^45d$	$(^1D)^2F$
5/2	418310	418347	−37	57%($^3P_2$)[2]	71%	$4p^45d$	$(^3P)^4D$	10%	$4p^45d$	$(^3P)^4P$	10%	$4p^45d$	$(^3P)^4F$
3/2	418914	418953	−39	60%($^3P_2$)[2]	60%	$4p^45d$	$(^3P)^4D$	22%	$4p^45d$	$(^3P)^4P$	5%	$4p^45d$	$(^1D)^2D$
1/2	419977	420043	−66	78%($^3P_2$)[1]	44%	$4p^45d$	$(^3P)^4D$	29%	$4p^45d$	$(^3P)^4P$	15%	$4p^45d$	$(^3P)^2P$
9/2	420404	420469	−65	91%($^3P_2$)[4]	91%	$4p^45d$	$(^3P)^4F$	9%	$4p^45d$	$(^1D)^2G$			
7/2	421427	421205	222	89%($^3P_2$)[4]	66%	$4p^45d$	$(^3P)^2F$	23%	$4p^45d$	$(^3P)^4F$	9%	$4p^45d$	$(^1D)^2G$
1/2	423351	423374	−23	83%($^3P_2$)[0]	55%	$4p^45d$	$(^3P)^4P$	28%	$4p^45d$	$(^3P)^2P$	9%	$4p^45d$	$(^1D)^2S$
3/2	424830	424828	2	64%($^3P_2$)[1]	41%	$4p^45d$	$(^3P)^4P$	30%	$4p^45d$	$(^3P)^2D$	13%	$4p^45d$	$(^3P)^2P$
5/2	425078	425015	63	53%($^3P_2$)[3]	33%	$4p^45d$	$(^3P)^2D$	27%	$4p^45d$	$(^3P)^2F$	17%	$4p^45d$	$(^3P)^4P$
1/2	429552	429752	−200	86%($^3P_1$)[1]	49%	$4p^45d$	$(^3P)^4D$	34%	$4p^45d$	$(^3P)^2P$	9%	$4p^45d$	$(^1D)^2P$
3/2	430344	430325	19	67%($^3P_0$)[2]	71%	$4p^45d$	$(^3P)^4F$	13%	$4p^45d$	$(^3P)^4D$	8%	$4p^45d$	$(^1S)^2D$
5/2	430534	430524	10	51%($^3P_0$)[2]	58%	$4p^45d$	$(^3P)^4F$	15%	$4p^45d$	$(^3P)^4P$	14%	$4p^45d$	$(^3P)^4D$
7/2	430760	430623	137	97%($^3P_1$)[3]	53%	$4p^45d$	$(^3P)^4F$	24%	$4p^45d$	$(^3P)^2F$	22%	$4p^45d$	$(^3P)^4D$
3/2	431436	431423	13	53%($^3P_1$)[1]	23%	$4p^45d$	$(^3P)^4P$	23%	$4p^45d$	$(^3P)^4D$	21%	$4p^45d$	$(^3P)^2D$
5/2	432673	432560	113	97%($^3P_1$)[2]	48%	$4p^45d$	$(^3P)^4P$	33%	$4p^45d$	$(^3P)^2F$	11%	$4p^45d$	$(^3P)^4F$
5/2	434647	434607	40	51%($^3P_1$)[3]	47%	$4p^45d$	$(^3P)^2D$	34%	$4p^45d$	$(^3P)^2F$	4%	$4p^45d$	$(^3P)^4P$
3/2	435071	435299	−228	39%($^3P_1$)[2]	61%	$4p^45d$	$(^3P)^2P$	19%	$4p^45d$	$(^3P)^2D$	8%	$4p^45d$	$(^1D)^2P$
5/2	435671	435664	7	92%($^3P_2$)[2]	92%	$4p^46s$	$(^3P)^4P$	7%	$4p^46s$	$(^1D)^2D$	1%	$4p^45d$	$(^3P)^2D$
3/2	437171	437167	4	89%($^3P_2$)[2]	69%	$4p^46s$	$(^3P)^2P$	21%	$4p^46s$	$(^3P)^4P$	8%	$4p^46s$	$(^1D)^2D$
7/2	442366	442275	91	90%($^1D_2$)[4]	90%	$4p^45d$	$(^1D)^2G$	7%	$4p^45d$	$(^3P)^2F$	2%	$4p^45d$	$(^3P)^4F$
9/2	442705	442669	36	91%($^1D_2$)[4]	91%	$4p^45d$	$(^1D)^2G$	9%	$4p^45d$	$(^3P)^4F$			
1/2	444129	444050	79	79%($^1D_2$)[0]	79%	$4p^45d$	$(^1D)^2S$	11%	$4p^45d$	$(^1D)^2P$	8%	$4p^45d$	$(^3P)^4P$
3/2	444984	444917	67	80%($^1D_2$)[1]	80%	$4p^45d$	$(^1D)^2P$	6%	$4p^45d$	$(^3P)^4P$	5%	$4p^45d$	$(^3P)^2P$
5/2	445300	445422	−122	59%($^1D_2$)[2]	59%	$4p^45d$	$(^1D)^2D$	36%	$4p^45d$	$(^1D)^2F$	1%	$4p^45d$	$(^3P)^4P$
1/2	446210	446244	−34	59%($^3P_0$)[0]	92%	$4p^46s$	$(^3P)^4P$	7%	$4p^46s$	$(^1S)^2S$			
7/2	446600	446452	148	93%($^1D_2$)[3]	93%	$4p^45d$	$(^1D)^2F$	3%	$4p^45d$	$(^3P)^4D$	2%	$4p^45d$	$(^3P)^2F$
5/2	446709	446619	90	56%($^1D_2$)[3]	56%	$4p^45d$	$(^1D)^2F$	32%	$4p^45d$	$(^1D)^2D$	7%	$4p^45d$	$(^3P)^2D$
3/2	446718	446692	26	96%($^3P_1$)[1]	74%	$4p^46s$	$(^3P)^4P$	22%	$4p^46s$	$(^3P)^2P$	2%	$4p^45d$	$(^1D)^2P$
1/2	447277	447284	−7	41%($^1D_2$)[1]	41%	$4p^45d$	$(^1D)^2P$	34%	$4p^46s$	$(^3P)^2P$	13%	$4p^45d$	$(^3P)^2P$
3/2	448358	448574	−216	78%($^1D_2$)[2]	78%	$4p^45d$	$(^1D)^2D$	18%	$4p^45d$	$(^3P)^2D$	1%	$4p^45d$	$(^1D)^2P$
1/2	448775	448783	−8	45%($^3P_1$)[1]	61%	$4p^46s$	$(^3P)^2P$	25%	$4p^45d$	$(^1D)^2P$	8%	$4p^45d$	$(^3P)^2P$
5/2	459637	459629	8	92%($^1D_2$)[2]	93%	$4p^46s$	$(^1D)^2D$	7%	$4p^46s$	$(^3P)^4P$			
3/2	459761	459765	−4	91%($^1D_2$)[2]	91%	$4p^46s$	$(^1D)^2D$	7%	$4p^46s$	$(^3P)^2P$	1%	$4p^46s$	$(^3P)^4P$
5/2	470990	471048	−58	88%($^1S_0$)[2]	88%	$4p^45d$	$(^1S)^2D$	3%	$4p^45d$	$(^3P)^2F$	3%	$4p^45d$	$(^3P)^4P$
3/2	471484	471481	3	86%($^1S_0$)[2]	86%	$4p^45d$	$(^1S)^2D$	5%	$4p^45d$	$(^3P)^4F$	4%	$4p^45d$	$(^3P)^2D$
1/2	486068	486067	1	88%($^1S_0$)[0]	88%	$4p^46s$	$(^1S)^2S$	7%	$4p^46s$	$(^3P)^4P$	4%	$4p^46s$	$(^3P)^2P$

5. $4s4p^6$-$4s^24p^45p$ Transitions

Transitions between the $4s4p^6$ and $4s^24p^45p$ configurations are normally forbidden as two electron jumps. However, because of configuration interaction between $4s4p^6$ and $4s^24p^44d$, they can in fact take place. We observe six of them in Y V. The wavelengths for these transitions are long relative to the resonance lines and serve to improve the accuracy of the excited levels.

6. Ritz Wavelengths

We determined Ritz wavelengths for all of the lines by differencing the energy level values in Tables 2 and 3. The Ritz wavelengths are given in Table 1. The uncertainties of the calculated wavelengths correspond to the square root of the sum of the squares of the uncertainties of the combining levels. The Ritz values have uncertainties that are as low as ±0.0004 Å. Those lines with uncertainties in the Ritz wavelengths of ±0.0020 Å or less should serve well as wavelength standards in the deep VUV.

7. Oscillator Strengths

Table 1 lists the transition probabilities g_UA and log g_Lf for each observed line as calculated with wavefunctions obtained from the fitted energy parameters. Here, f is the oscillator strength, g_U is the statistical weight of the upper level $2J_U + 1$ and g_L is the statistical weight of the lower level $2J_L + 1$. The A-values are compared with recently published ab initio values in Section 9 below.

Since there are no experimental values for the transition probabilities of Y V, it is difficult to estimate the uncertainty of the calculated values. One guide is the cancellation factor. This is the ratio of the calculated transition probability to a value calculated with all parts of the wave function taken as positive [12]. Low cancellation factors generally indicate a larger uncertainty in the calculated values. Indeed, many of the values in Table 1 have low cancellation factors. The present calculated transition probabilities can be considered as qualitative estimates of the relative intensities of the lines. Based on general experience, we estimate the uncertainties to be about ±50%.

8. Ionization Energy

An ionization energy of 605,000 ± 4000 cm^{-1} was obtained in [4] by estimating a value for n*($4p^45s$) of 2.98 ± 0.02. On the basis of their observed $4s^24p^4ns$(n = 5–7) and nd(n = 4–6) series, Zahid-Ali, Chaghtai, and Singh [5] revised this downward slightly to 604,700 ± 2500 cm^{-1}. Since many of the levels used in their determination are now known to be spurious, this value must be re-determined.

For our new determination, we use the centers-of-gravity of the $4p^45s$ and $4p^46s$ configurations together with an estimated value for the change in effective quantum number Δn^*($4p^46s$-$4p^45s$) = n^*($4p^46s$)-n^*($4p^45s$). This allows us to find the limit of the $4p^4ns$ series, which is the center-of-gravity of the $4p^4$ configuration of Y VI.

From the observed levels in Table 3, we find the centers-of-gravity of the $4p^45s$ and $4p^46s$ configurations as 309,955.06 and 450,284.98 cm^{-1}, respectively. Our value for Δn^*($4p^46s$-$4p^45s$) is taken from Δn^*($4p^66s$-$4p^65s$) for the one-electron atom Nb V [15], 1.03577. We use Cowan's Hartree-Fock code to estimate the change in going from Nb V to Y V. For Nb V we calculate Δn^*($4p^66s$-$4p^65s$) as 1.0394 and for Y V we calculate Δn^*($4p^46s$-$4p^45s$) as 1.0369, a difference of 0.0025. We thus estimate Δn^*($4p^46s$-$4p^45s$) for Y V as 1.03577 − 0.00251 = 1.0333, with an estimated uncertainty of ±0.0015. This produces a limit of 621,810 ± 300 cm^{-1}. The effective quantum numbers for Y V are n^*(5s) = 2.966(1) and n^*(6s) = 3.999(3). Correcting for the energy of the center-of-gravity of $4p^4$ in Y VI, 14 051 cm^{-1} [7], we obtain for the ionization energy of Y V 607,760 ± 300 cm^{-1} (75.353 ± 0.037 eV). (Conversion from cm^{-1} to eV was done with the factor 8065.54429(18) cm^{-1}/eV [16].)

9. Comparison with ab Initio Calculations

Recently, two sets of ab initio calculations for the levels and oscillator strengths of Y V have appeared. Singh et al. [17] used a multiconfiguration Dirac-Fock (MCDF) approach to make calculations for transitions within the n = 4 complex; $4s^24p^5$, $4s4p^6$, $4s^24p^44d$. Aggarwal and Keenan [18] used the General-purpose Relativistic Atomic Structure Package (GRASP) for calculations within the same complex of n = 4 configurations. Both calculations are based on new versions of the Grant atomic structure code. Froese Fischer [19] has discussed the accuracy that might be expected from calculations for complex atoms with GRASP, in particular as applied to the Br-like ion W^{39+}.

Comparisons of our present results with those of the ab initio calculations of [17,18] are given in Tables 8–10. The index numbers for the levels in these tables are those used in [17,18]. The wavelengths for Aggarwal and Keenan [18] in Table 8 are differences of the GRASP3 energies in their Table 3. It should be noted that the level with index 25 in [17] is misprinted $4s^24p^4(^1D)4d\ ^2P_{3/2}$; it should be $4s^24p^4(^1S)4d\ ^2D_{3/2}$, as given in [18].

The main difference between the results of [17,18] and our present results is that the energies of the levels designated $4s^24p^4(^3P)4d\ ^2P_{1/2}$ (index 28) and $4s^24p^4(^1D)4d\ ^2S_{1/2}$ (index 30) are reversed in order of energy. That is, the level with index 28 corresponds to our level 4d51, and the level with index 30 corresponds to our level 4d41.

That our present order is correct can be seen from the fact that $(^3P)^2P$ has little interaction with $4s4p^6\ ^2S$, and its position is largely fixed by the internal parameters of $4p^44d$. If omitted from the LSF calculation, the calculated energy is very close to the observed value. So, there is no doubt about this assignment. This leaves the level at 294,965 cm^{-1} as the only possibility for $(^1D)^2S$. The position of $(^1D)^2S$ is harder to pin down, because it is affected not only by the internal parameters of $4p^44d$, but also by the amount of its upward displacement due to interaction with $4s4p^6\ ^2S$. In our present calculations this uncertainty is removed, because when the level is included in the LSF, the CI parameter R^1(4p4p,4s4d) takes a fitted value that has a reasonable ratio to HFR. This conclusion is supported by the observed line intensities, which follow the predicted pattern for these two levels. See for example the lines at 339.023, 353.976, 330.398, and 344.583 Å in Table 8. It is clear that in the MCDF calculations the upward displacement of $4s^24p^4(^1D)4d\ ^2S_{1/2}$ due to interaction with $4s4p^6\ ^2S_{1/2}$ is a little too large. The LSF/HFR scale factor of 0.769 for this interaction in Table 6 also reflects this circumstance.

In Table 8 we compare the wavelengths and transition probabilities A (s^{-1}) found from GRASP with our present results. The values of A(present) in this table are those given in Table 1 divided by the statistical weight of the upper level $2J_u$+1. A notable disagreement for the transition probabilities for the $4s^24p^5\ ^2P_{3/2}$-$4s^24p^44d\ (^3P)^4F_{3/2}$ transition (indices 1–12), observed at 419.792 Å. Both Singh et al. [17] and Aggarwal and Keenan [18] find an extremely low transition probability for this transition. However, we obtain a somewhat higher A-value, and it is indeed observed as a reasonably strong line. This transition is nominally forbidden as an inter-combination line in LS-coupling because of the change of spin. However, although the $4p^44d$ level (238,215 cm^{-1} observed value) has a leading percentage composition in LS coupling of 63% $4p^44d\ (^3P)^4F_{3/2}$, the full percentage compositions show that it actually has a total doublet character of about 31%. This accounts for our calculated transition probability and observed line strength. Singh et al. [17] report a composition of 88% $4p^44d\ (^3P)^4F_{3/2}$ for this level, with no secondary percentage mentioned. Percentage compositions were not reported by Aggarwal and Keenan [18]. The present percentage compositions for Y V are practically the same as were given in [4]. This paper was not cited in either [17] or [18].

Other striking differences can be seen in Table 8. The values found by all three calculations for the $4s^24p^5\ ^2P_{3/2}$-$4s^24p^44d(^1S)\ ^4D_{5/2}$ transition (indices 1–26) are extremely discrepant. The value of Aggarwal [18] is a little closer to our present value. The values for the $4s^24p^5\ ^2P_{1/2}$-$4s^24p^44d\ (^3P)^4D_{3/2}$ transition (indices 2–6) also disagree by a large amount. Still, they all predict that this will be a very weak line, and in fact it has not been observed.

Table 8. Comparison of wavelengths λ (Å) and transition probabilities A (s^{-1}) for Y V calculated with the MCDF2 method of Singh et al. [17] and the GRASP3 method of Aggarwal and Keenan [18] with present values. Index numbers are those used in [17,18]. Blank spaces indicate that line was not observed. Designations are for the upper levels in the transition.

Lower Level	Upper Level	Desig.	Index	λ [17]	λ [18]	λ (obs)	A [17]	A [18]	A (Pres.)	CF	Int (obs)
$4s^24p^5\ ^2P_{3/2}$	$4s4p^6\ ^2S_{1/2}$	4p61	3	594	555.817	584.982	3.41E+08	6.4885E+08	8.30E+08	0.03	50000
(index = 1)	$4s^24p^44d(^3P)^4D_{5/2}$	4d15	4	466	447.189	457.838	8.49E+06	1.4695E+07	7.05E+06	0.00	
	$(^3P)^4D_{3/2}$	4d13	6	464	445.053	455.846	5.17E+06	5.7124E+06	6.85E+06	0.00	35
	$(^3P)^4D_{1/2}$	4d11	7	461	442.088	452.911	2.69E+06	1.9727E+06	6.30E+06	0.00	5
	$(^1D)^2P_{1/2}$	4d21	10	427	410.339	451.974	1.10E+07	2.4808E+06	4.77E+07	0.00	25
	$(^3P)^4F_{5/2}$	4d25	11	425	410.674	420.737	9.04E+07	1.3428E+08	1.40E+08	0.74	1500
	$(^3P)^4F_{3/2}$	4d23	12	423	409.298	419.792	2.44E+06	2.4683E+06	7.80E+07	0.01	400
	$(^3P)^4P_{3/2}$	4d33	14	418	403.024	418.179	3.73E+08	4.1741E+08	4.15E+08	0.02	600
	$(^1D)^2D_{3/2}$	4d43	15	414	399.946	415.027	2.77E+08	2.3712E+08	3.05E+08	0.01	1500
	$(^3P)^4P_{5/2}$	4d35	17	410	395.482	409.312	1.10E+08	1.2373E+08	2.13E+08	0.02	1500
	$(^1D)^2P_{3/2}$	4d53	18	408	393.779	408.806	8.38E+07	6.7013E+06	3.28E+07	0.00	10
	$(^1D)^2D_{5/2}$	4d45	19	403	389.248	403.452	3.66E+08	2.4821E+08	3.55E+08	0.01	1500
	$(^3P)^2F_{5/2}$	4d55	22	396	382.946	397.767	1.49E+08	2.2968E+08	1.14E+08	0.01	1000
	$(^1D)^2F_{5/2}$	4d65	23	374	362.156	379.963	2.34E+08	3.3501E+08	4.00E+08	0.14	1000
	$(^1S)^2D_{3/2}$	4d63	25	346	345.203	355.564	1.06E+09	3.1288E+09	2.29E+09	0.09	1500
	$(^1S)^2D_{5/2}$	4d75	26	341	341.242	349.648	5.28E+07	1.4890E+09	1.56E+08	0.00	800
	$(^3P)^2P_{3/2}$	4d73	27	319	324.443	336.621	1.27E+11	1.0669E+11	1.18E+11	0.88	5000
	$(^3P)^2P_{1/2}$	4d51	28	315	320.652	330.398	1.07E+11	6.8148E+10	5.30E+09	0.05	300
	$(^3P)^2D_{5/2}$	4d85	29	311	318.592	333.084	1.55E+11	1.2220E+11	1.31E+11	0.82	10000
	$(^1D)^2S_{1/2}$	4d41	30	309	310.266	339.023	3.70E+10	5.8584E+10	1.17E+11	0.71	3000
	$(^3P)^2D_{3/2}$	4d83	31	301	308.303	320.467	6.68E+09	4.2526E+09	2.36E+09	0.03	500
$4p^5\ ^2P_{1/2}$	$4s4p^6\ ^2S_{1/2}$	4p61	3	640	595.852	630.973	1.59E+08	3.0194E+08	5.45E+07	0.04	30000
(index = 2)	$4s^24p^44d(^3P)^4D_{3/2}$	4d13	6	491	470.358		1.47E+05	7.9784E+04	1.18E+06	0.00	
	$(^3P)^4D_{1/2}$	4d11	7	488	467.049	479.994	3.11E+06	1.7391E+06	4.92E+06	0.00	1
	$(^1D)^2P_{1/2}$	4d21	10	450	431.756	451.974	5.58E+07	2.7075E+07	4.77E+07	0.00	25
	$(^3P)^4F_{3/2}$	4d23	12	446	430.603	442.947	2.89E+07	4.0470E+07	9.35E+06	0.00	300
	$(^3P)^4P_{1/2}$	4d31	13	441	423.647	441.622	1.30E+07	1.1362E+07	3.80E+07	0.01	25
	$(^3P)^4P_{3/2}$	4d33	14	441	423.664	441.161	2.24E+07	2.7072E+06	4.13E+06	0.00	2
	$(^1D)^2D_{3/2}$	4d43	15	436	420.265	437.661	3.20E+08	3.2991E+08	3.25E+08	0.01	500
	$(^1D)^2P_{3/2}$	4d53	18	430	413.461	430.753	2.86E+07	1.7387E+07	1.78E+07	0.00	500
	$(^1S)^2D_{3/2}$	4d63	25	361	360.235	372.047	1.92E+09	5.6428E+08	3.05E+09	0.06	4000
	$(^3P)^2P_{3/2}$	4d73	27	332	337.687	351.355	3.32E+09	2.3159E+09	8.95E+08	0.02	800
	$(^3P)^2P_{1/2}$	4d51	28	328	333.582	344.583	1.03E+11	3.9796E+10	9.85E+10	0.82	2000
	$(^1D)^2S_{1/2}$	4d41	30	321	322.356	353.976	2.85E+10	4.1111E+10	5.60E+09	0.05	1500
	$(^3P)^2D_{3/2}$	4d83	31	312	320.238	333.796	1.46E+11	1.2065E+11	1.29E+11	0.83	5000

Both Singh et al. [17] and Aggarwal and Keenan [18] compare their calculated level values with the observed values given in the NIST Atomic Spectra Database [20]. Since we have made a number of revisions to the $4p^44d$ levels, a new comparison is called for. This is given in Table 9.

Table 9. Comparison of level energies E (cm^{-1}) for Y V calculated with the MCDF2 method of Singh et al. [17] and the GRASP3 method of Aggarwal and Keenan [18] with present experimental energies. Index numbers are those used in [17,18].

Configuration	Term	Desig.	Index	J	E [17]	E [18]	E (Present)
$4s^24p^5$	^2P	p5 3	1	3/2	0	0.00	0.00
	^2P	p5 1	2	1/2	12147.85	12088.59	12460.12
$4s4p^6$	^2S	4p61	3	1/2	168478.74	179915.44	170945.58
$4s^24p^44d$	$(^3P)^4D$	4d15	4	5/2	214469.38	223619.16	218417.13
	$(^3P)^4D$	4d17	5	7/2	214524.25	223608.19	218556.80
	$(^3P)^4D$	4d13	6	3/2	215610.64	224692.39	219373.81
	$(^3P)^4D$	4d11	7	1/2	217092.09	226199.07	220794.66
	$(^3P)^4F$	4d19	8	9/2	227122.02	235877.84	229786.64
	$(^3P)^4F$	4d27	9	7/2	231522.46	240231.10	233703.76
	$(^1D)^2P$	4d21	10	1/2	234342.70	243700.97	233712.36
	$(^3P)^4F$	4d25	11	5/2	235024.04	243502.35	237677.66
	$(^3P)^4F$	4d23	12	3/2	236230.17	244320.98	238215.09
	$(^3P)^4P$	4d31	13	1/2	238754.11	248134.33	238898.28
	$(^3P)^4P$	4d33	14	3/2	239017.48	248124.45	239132.83
	$(^1D)^2D$	4d43	15	3/2	241420.71	250033.87	240949.32
	$(^3P)^2F$	4d37	16	7/2	242276.66	251012.72	242336.33
	$(^3P)^4P$	4d35	17	5/2	244197.05	252856.30	244311.56
	$(^1D)^2P$	4d53	18	3/2	244932.29	253949.27	244613.24
	$(^1D)^2D$	4d45	19	5/2	248290.23	256905.58	247861.17
	$(^1D)^2G$	4d29	20	9/2	251033.65	259335.15	251052.40
	$(^1D)^2G$	4d47	21	7/2	251351.88	259728.01	250882.71
	$(^3P)^2F$	4d55	22	5/2	252383.41	261133.73	251403.88
	$(^1D)^2F$	4d65	23	5/2	267274.68	276123.76	263184.02
	$(^1D)^2F$	4d57	24	7/2	270072.96	278936.31	266196.75
	$(^1S)^2D$	4d63	25	3/2	289079.36	289685.02	281244.51
	$(^1S)^2D$	4d75	26	5/2	293095.72	293047.35	286001.66
	$(^3P)^2P$	4d73	27	3/2	313792.06	308220.63	297071.14
	$(^3P)^2P$	4d51	28	1/2	317095.13	311864.99	302664.42
	$(^3P)^2D$	4d85	29	5/2	321122.47	313880.85	300224.19
	$(^1D)^2S$	4d41	30	1/2	323306.23	322304.24	294965.68
	$(^3P)^2D$	4d83	31	3/2	332502.17	324356.31	312044.02

The percentage compositions for $4s4p^6$ and $4s^24p^44d$ obtained in the present work are compared with those obtained in the MCDF calculations of Singh et al. [17] in Table 10. The general agreement is qualitatively reasonable.

Table 10. Comparison of the present percentage compositions for the $4s4p^6$ and $4s^24p^44d$ configurations of Y V (in bold type) with those of Singh et al. [17] (in parentheses). Level values are in cm^{-1}.

Index	Desig.	*J*	*E* (obs) [a]	Percentage Composition											
3	4p61	1/2	170946	**75**(69)%	4s ^2S	**24**(30)%	$(^1D)^2S$								
4	4d15	5/2	218417	**90**(92)%	$(^3P)^4D$	**3**%	$(^3P)^4F$	**2**%	$(^3P)^4P$						
5	4d17	7/2	218557	**92**(94)%	$(^3P)^4D$	**5**%	$(^3P)^4F$	**2**%	$(^1D)^2F$						
6	4d13	3/2	219374	**88**(91)%	$(^3P)^4D$	**4**%	$(^3P)^4P$	**3**%	$(^1D)^2D$						
7	4d11	1/2	220795	**88**(91)%	$(^3P)^4D$	**5**%	$(^1D)^2P$	**4**%	$(^3P)^2P$						
8	4d19	9/2	229787	**91**(93)%	$(^3P)^4F$	**9**%	$(^1D)^2G$								
9	4d27	7/2	233704	**72**(81)%	$(^3P)^4F$	**14**%	$(^3P)^2F$	**11**%	$(^1D)^2G$						
10	4d21	1/2	233712	**45**(45)%	$(^1D)^2P$	**39**(40)%	$(^3P)^2P$	**11**%	$(^3P)^4D$						
11	4d25	5/2	237678	**94**(94)%	$(^3P)^4F$	**3**%	$(^3P)^4D$	**2**%	$(^1S)^2D$						
12	4d23	3/2	238215	**63**(88)%	$(^3P)^4F$	**11**%	$(^1S)^2D$	**10**%	$(^3P)^4P$						
13	4d31	1/2	238898	**91**(92)%	$(^3P)^4P$	**4**%	$(^3P)^2P$	**3**%	$(^1D)^2P$						
14	4d33	3/2	239133	**44**(56)%	$(^3P)^4P$	**22**%	$(^3P)^4F$	**20**(22)%	$(^1D)^2P$						
15	4d43	3/2	240949	**38**(40)%	$(^1D)^2D$	**24**(25)%	$(^3P)^2D$	**10**%	$(^3P)^4F$						
16	4d37	7/2	242336	**48**(57)%	$(^3P)^2F$	**20**%	$(^3P)^4F$	**20**(19)%	$(^1D)^2G$						
17	4d35	5/2	244312	**77**(89)%	$(^3P)^4P$	**7**%	$(^1S)^2D$	**6**%	$(^3P)^2D$						
18	4d53	3/2	244613	**39**(24)%	$(^3P)^4P$	**24**(33)%	$(^1D)^2P$	**21**(27)%	$(^3P)^2P$						
19	4d45	5/2	247861	**40**(42)%	$(^1D)^2D$	**23**(25)%	$(^3P)^2D$	**16**%	$(^3P)^4P$	**12**(17%)	$(^3P)^2F$				
20	4d29	9/2	251052	**91**(93)%	$(^1D)^2G$	**9**%	$(^3P)^4F$								
21	4d47	7/2	250883	**68**(73)%	$(^1D)^2G$	**22**(19)%	$(^3P)^2F$	**8**%	$(^1D)^2F$						
22	4d55	5/2	251404	**67**(65)%	$(^3P)^2F$	**17**(16)%	$(^1D)^2F$	**10**%	$(^1D)^2D$						
23	4d65	5/2	263184	**80**(83)%	$(^1D)^2F$	**11**%	$(^3P)^2F$	**7**%	$(^1D)^2D$						
24	4d57	7/2	266197	**82**(83)%	$(^1D)^2F$	**15**%	$(^3P)^2F$	**1**%	$(^1D)^2G$						
25	4d63	3/2	281245	**62**(67)%	$(^1S)^2D$	**26**(26)%	$(^1D)^2D$	**4**%	$(^1D)^2P$						
26	4d75	5/2	286002	**72**(74)%	$(^1S)^2D$	**16**(16)%	$(^1D)^2D$	**4**%	$(^3P)^2F$						
27	4d73	3/2	297071	**47**(51)%	$(^3P)^2P$	**36**(41)%	$(^1D)^2P$	**7**%	$(^1D)^2D$						
28	4d51	1/2	302664	**44**(38)%	$(^3P)^2P$	**38**(37)%	$(^1D)^2P$	**10**(17)%	$(^1D)^2S$	**3**%	4s ^2S				
29	4d85	5/2	300224	**62**(65)%	$(^3P)^2D$	**20**(21)%	$(^1D)^2D$	**14**%	$(^1S)^2D$						
30	4d41	1/2	294966	**62**(53)%	$(^1D)^2S$	**20**(22)%	4s ^2S	**8**%	$(^1D)^2P$	**6**%	$(^3P)^2P$				
31	4d83	3/2	312044	**54**(60)%	$(^3P)^2D$	**20**(18)%	$(^1S)^2D$	**13**(17)%	$(^1D)^2D$						

[a] Present value from Table 3.

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