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Revised and Extended Analyses of the Pd-Like Ion Spectra Sb VI, Te VII and I VIII

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Abstract

The $4d^95l$ –$4d^95l'$ transitions in the Pd-like ion spectra Sb VI, Te VII and I VIII have been reinvestigated in the 400 – 900 Å wavelength region using vacuum spark sources. In Sb VI and Te VII, the previous analyses of the $4d^95s$ – $4d^95p$ and $4d^95p$ – $4d^95d$ transitions have been extended by respectively six and twenty-six newly classified lines. An additional forty-four and forty-nine lines have been identified as $4d^95d$ – $4d^95f$ transitions leading to the determination of the $4d^95f$ levels in Sb VI and Te VII. For I VIII, the previously identified $4d^95s$ – $4d^95p$ transitions have been remeasured and seven new lines were added. The $4d^95s$ and $4d^95p$ level energies have been revised. An additional forty-seven lines have been identified as $4d^95p$ – $4d^95d$ transitions leading to the determination of the $4d^95d$ levels. Resonance lines have been remeasured for Te VII and I VIII in the grazing incidence region. The $4d^95d$ $^1S_0$ levels, of crucial interest in the development of X–UV lasers, have been established for the first time in all three spectra studied.

1. Introduction

The $4d^95p$ $^1P_1$ – $4d^95d$ $^1S_0$ and $4d^95d$ $^1P_1$ – $4d^95f$ $^1P_1$ transitions in the Pd-like ions are perspectives for the laser effect in the extreme ultraviolet spectral region [1]. For the purpose of modeling a laser medium, not only the levels involved in the laser transitions are needed but also the levels that likely enter the population kinetics. In the Pd – like ions, an extended identification of all the $4d^95l$ and of the nearby $4d^94f$ levels would be necessary to support *ab initio* calculations in a collisional – radiative model of these ions. In this respect the knowledge of the $4d^95l$ configuration energy structures of these ions is far from completeness. At the beginning of the present work, along the Pd I isoelectronic sequence, the $4d^95s$ and $4d^95p$ levels were determined up to Cs X [2–12]; the $4d^95d$ levels were known up to Te VII [3–4, 13–14] except the very important $4d^95d$ $^1S_0$ levels which were established only for Pd I and for Ag II [2]. As for the $4d^95f$ configuration, no level was known except the $J = 1$ ones, determined through the resonance transitions to the ground term $4d^{10}$ $^1S_0$ in Cd III – Cs X [12]. The strongest resonance transitions from the $4d^95p$ and 4f ($J = 1$) levels were identified up to Dy XXI and Ho XXII respectively [11] and extended to Pt XXXIII for some of the $4d^94f$ ($J = 1$) levels [15]. The purpose of the present work is to revise and extend the spectroscopic data for $4d^95l$ configurations in the spectra of Pd-like ions Sb VI, Te VII and I VIII, and in particular, to establish the $4d^95d$ $^1S_0$ level in these ions.

2. Experiment and method of analysis

The spectra of the $4d^95l$ – $4d^95l'$ transitions in Sb VI, Te VII and I VIII were obtained by using a 6.65 m normal incidence spectrograph at the Institute for Spectroscopy (Troitsk, Russia). The spectrograph is equipped with a 1200 l/mm grating and has a plate factor of 1.25 Å/mm. The spectra were recorded on Ilford Q2 photographic plates. Different plasma sources were used for the ionization stage selection. For the excitation of "hot" spectra a 4 kV low-inductance vacuum spark with 10 μF capacitance was used. The peak discharge current of this source could be varied from 30 to 10 kA by using an inductance coil in series. "Cold" spectra were excited in a 1 kV sliding spark with peak currents of 2–3 kA. In both sources we used aluminum electrodes with chemically pure antimony, tellurium or potassium iodide packed into the anode.

The iodine spectrum was also photographed in the 400-800 Å region on a 10.7 m normal incidence spectrograph at the Observatoire de Meudon, equipped with a 3600 l/mm holographic grating leading to a plate factor of about 0.26 Å/mm. This spectrum was excited in a 15 kV vacuum triggered spark with a 4.82 μF capacitance and was recorded on Kodak SWR photographic plates. The iodine spectrum obtained on this spectrograph is better resolved than the one obtained on the Troitsk spectrograph. Therefore the corresponding set of plates was used for finalizing the I VIII analysis.

The energies of the $4d^95l$ levels relative to the ground state are determined by the wavenumbers of the $4d^{10}$ $^1S_0$ – $4d^95p$ and 5f ($J = 1$) resonance transitions. Therefore we paid particular attention to the measurement of the corresponding wavelengths, which are located in the 100–300 Å region and reported in [12]. For a re-measurement of these lines in Te VII and I VIII new spectra were obtained at Troitsk on a 3 m grazing incidence spectrograph with a 3600 l/mm holographic grating and excited in a low-inductance vacuum spark. The accurately measured wavelengths of titanium ions [17] were used as standards in this case and the estimated uncertainty of the wavelength measurements is about 0.003 Å (For Sb VI ion we already published [12] the accurate resonance wavelengths measured by using the Ti-standards).

The spectrograms were measured on an automatic microdensitometer at Troitsk and on a semi-automatic comparator at Meudon. The lines of the O III – O V ions [16] and of the ions of lower ionization stages of the inves-

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tigated atoms were used as wavelength standards. The estimated wavelength measurement accuracy is about 0.003–0.005 Å for the unperturbed lines in the 400–1000 Å region. The line intensities measured at Troitsk on a 1–1000 scale take into account the modeled photoemulsion characteristic curve.

The spectra analyses were carried out by means of the complex spectra identification program IDEN [18] on the basis of predicted energies and transition probabilities derived from the Cowan computer codes [19]. We included into calculations the even $4d^{10}$, $4d^9ns$ ($n = 5,6$), $4d^9nd$ ($n = 5,6$), $4d^85s^2$, $4d^85s5d$, $4d^85d^2$ and $4p^54d^{10}5p$ con-

Table I. *Identified spectral lines in Sb VI.*

gA	*I*(*a*)	λ (Å)	σ (cm^{-1})	$\Delta\sigma$	Transition
5p – 5d and 5p – 6s transitions (addition to [14])					
0.5	45	594.474	168216.0	0.0	5p $^3D_1$ 357446.0 – 6s $^3D_2$ 525662.0
0.1	35	603.364	165737.5	−1.2	5p $^3P_1$ 341970.6 – 5d $^1S_0$ 507709.3
0.3	87	634.301	157654.0	−1.5	5p $^3P_2$ 331122.8 – 5d $^3F_3$ 488778.3
10.3	449	638.160	156700.5	0.5	5p $^1P_1$ 351009.3 – 5d $^1S_0$ 507709.3
0.2	51	640.906	156029.1	1.7	5p $^3P_2$ 331122.8 – 5d $^3D_2$ 487150.2
1.9	125	665.497	150263.7	0.4	5p $^3D_1$ 357446.0 – 5d $^1S_0$ 507709.3
5d – 5f transitions					
0.2	15	650.061	153831.8	0.8	5d $^3D_1$ 485258.0 – 5f $^1P_1$ 639089
4.2	29	719.360	139012.4	−0.4	5d $^1P_1$ 474640.2 – 5f $^3D_1$ 613653
0.4	24	722.089	138487.1	0.7	5d $^3G_4$ 473554.6 – 5f $^1F_3$ 612041
4.7	53	723.116	138290.5	1.4	5d $^3G_3$ 484040.9 – 5f $^3G_3$ 622330
10.2	67	724.671	137993.6	1.4	5d $^3S_1$ 468443.8 – 5f $^3P_2$ 606436
10.8	46	730.114	136964.9	0.5	5d $^3G_4$ 473554.6 – 5f $^1G_4$ 610519
10.6	71	732.926	136439.5	1.5	5d $^3G_5$ 474397.0 – 5f $^3G_5$ 610835
13.0	89	733.272	136375.0	−0.2	5d $^3S_1$ 468443.8 – 5f $^3P_1$ 604819
5.9	73	737.930	135514.3	0.1	5d $^3S_1$ 468443.8 – 5f $^3P_0$ 603958
6.3	49	738.231	135458.9	0.7	5d $^1G_4$ 485906.8 – 5f $^3G_4$ 621365
10.0	56	739.748	135181.3	1.5	5d $^3D_2$ 487150.2 – 5f $^3G_3$ 622330
18.3	98	740.770	134994.6	0.6	5d $^3P_2$ 474361.0 – 5f $^3D_3$ 609355
6.9	53	741.727	134820.5	−1.5	5d $^3P_2$ 474361.0 – 5f $^1D_2$ 609183
13.4	133	743.249	134544.5	1.7	5d $^1P_1$ 474640.2 – 5f $^1D_2$ 609183
7.6	83	743.435	134510.7	0.6	5d $^1F_3$ 477530.9 – 5f $^1F_3$ 612041
19.2	108	743.591	134482.5	−1.1	5d $^3F_2$ 487846.4 – 5f $^3G_3$ 622330
70.7	230	743.703	134462.2	−0.2	5d $^3G_4$ 473554.6 – 5f $^3H_5$ 608017
10.1	96	743.870	134432.1	−1.9	5d $^3D_3$ 476085.0 – 5f $^1G_4$ 610519
18.9	41	744.286	134356.9	0.3	5d $^3P_1$ 482777.4 – 5f $^3D_2$ 617134
19.4	172	744.962	134235.1	−0.3	5d $^1D_2$ 477805.6 – 5f $^1F_3$ 612041
20.5	143	745.282	134177.4	0.4	5d $^3D_1$ 485258.0 – 5f $^3F_2$ 619435
8.0	618b	745.627	134115.3	3.7	5d $^3P_0$ 479541.4 – 5f $^3D_1$ 613653 Sb V
56.8	191	746.843	133897.0	−0.1	5d $^3G_3$ 484040.9 – 5f $^3H_4$ 617938
25.4	89	747.172	133838.1	−0.9	5d $^3D_3$ 476085.0 – 5f $^3F_4$ 609924
2.9	31	748.386	133620.8	0.8	5d $^3G_5$ 474397.0 – 5f $^3H_5$ 608017
7.2	51	748.771	133552.1	0.4	5d $^3F_3$ 488778.3 – 5f $^3G_3$ 622330
21.5	136	750.293	133281.3	−0.5	5d $^3D_2$ 487150.2 – 5f $^3F_3$ 620432
20.3	120	750.360	133269.4	−0.6	5d $^3D_3$ 476085.0 – 5f $^3D_3$ 609355
69.0	252	751.541	133060.0	−0.2	5d $^1G_4$ 485906.8 – 5f $^1H_5$ 618967
36.0	157	751.939	132989.5	1.4	5d $^1F_3$ 477530.9 – 5f $^1G_4$ 610519
86.2	325	753.302	132748.9	−0.1	5d $^3G_5$ 474397.0 – 5f $^3H_6$ 607146
41.6	198	754.231	132585.3	−1.4	5d $^3F_3$ 488778.3 – 5f $^3G_4$ 621365
15.6				−0.3	5d $^3F_2$ 487846.4 – 5f $^3F_3$ 620432
54.7	216	754.413	132553.5	0.1	5d $^3F_4$ 478281.6 – 5f $^3G_5$ 610835
10.9	95	755.320	132394.2	1.1	5d $^1F_3$ 477530.9 – 5f $^3F_4$ 609924
12.8	53	757.156	132073.2	−1.8	5d $^3P_2$ 474361.0 – 5f $^3P_2$ 606436
3.9	15	758.292	131875.2	−0.8	5d $^3D_1$ 485258.0 – 5f $^3D_2$ 617134
17.9	66	759.630	131643.0	0.6	5d $^3F_4$ 478281.6 – 5f $^3F_4$ 609924
7.5	33	759.952	131587.3	−1.3	5d $^3F_2$ 487846.4 – 5f $^3F_2$ 619435
8.2	100m	761.160	131378.4	1.0	5d $^1D_2$ 477805.6 – 5f $^1D_2$ 609183 O V
5.5				−1.3	5d $^1S_0$ 507709.3 – 5f $^1P_1$ 639089
2.2	19	762.924	131074.7	1.3	5d $^3F_4$ 478281.6 – 5f $^3D_3$ 609355
3.0	21	764.087	130875.2	−0.4	5d $^3P_1$ 482777.4 – 5f $^3D_1$ 613653
6.4	55	766.534	130457.4	−0.6	5d $^3P_2$ 474361.0 – 5f $^3P_1$ 604819
2.6	18	767.157	130351.3	0.3	5d $^3D_3$ 476085.0 – 5f $^3P_2$ 606436
8.4	16	769.324	129984.2	0.4	5d $^3D_2$ 487150.2 – 5f $^3D_2$ 617134

gA values are in 10^9 s^{-1} units.
a – arbitrary intensity units over a 1–1000 scale.
$\Delta\sigma$ = difference between the observed and the calculated (derived from the energy levels) values, in cm^{-1}.
b – blended line.
c – masked line.

Table II. *Identified spectral lines in Te VII.*

gA	*I*(*a*)	λ (Å)	σ (cm^{-1})	Δσ	Transition			
Resonance transitions								
1505.0	233*	129.463	772421.5	−3.5	4d $^1S_0$	0.0 – 5f $^1P_1$	772425	
51.2	194*	135.375	738688.8	−0.2	4d $^1S_0$	0.0 – 5f $^3D_1$	738689	
5p – 5d transitions (addition to [14])								
14.6	176	542.582	184304.0	0.1	5p $^1P_1$	430409.1 – 5d $^1S_0$	614713.0	
0.3	12	542.900	184196.1	−0.2	5p $^3P_2$	407633.1 – 5d $^3F_3$	591829.4	
0.3	7	548.823	182208.2	−0.9	5p $^3P_2$	407633.1 – 5d $^3D_2$	589842.2	
0.5	19	552.802	180896.5	2.0	5p $^3F_3$	410934.9 – 5d $^3F_3$	591829.4	
1.3	76	565.120	176953.6	1.5	5p $^3P_2$	407633.1 – 5d $^3P_1$	584585.2	
2.6	40	568.887	175781.8	−0.2	5p $^3D_1$	438931.0 – 5d $^1S_0$	614713.0	
1.3	41	571.535	174967.3	−1.1	5p $^3F_3$	410934.9 – 5d $^3G_3$	585903.3	
1.1	28	584.107	171201.5	−1.7	5p $^3P_2$	407633.1 – 5d $^1D_2$	578836.3	
0.6	16	585.319	170847.0	−1.9	5p $^3F_2$	420980.5 – 5d $^3F_3$	591829.4	
9.0	218	592.152	168875.6	−1.9	5p $^3P_1$	420964.7 – 5d $^3D_2$	589842.2	
2.0	134	592.200	168861.8	0.1	5p $^3F_2$	420980.5 – 5d $^3D_2$	589842.2	
0.6	22	593.230	168568.7	−1.8	5p $^3F_3$	410934.9 – 5d $^3F_4$	579505.4	
3.4	127	595.591	167900.4	−1.0	5p $^3F_3$	410934.9 – 5d $^1D_2$	578836.3	
1.2	50	601.963	166123.2	0.8	5p $^3F_4$	422311.9 – 5d $^1G_4$	588434.3	
2.8	78	613.431	163017.5	1.6	5p $^1D_2$	427539.5 – 5d $^3F_2$	590555.4	
1.4	61	615.977	162343.7	2.0	5p $^3D_3$	429487.7 – 5d $^3F_3$	591829.4	
1.7	75	616.138	162301.3	−1.4	5p $^1D_2$	427539.5 – 5d $^3D_2$	589842.2	
0.4	53	623.611	160356.4	1.9	5p $^3D_3$	429487.7 – 5d $^3D_2$	589842.2	
0.4	56	639.315	156417.4	1.8	5p $^3D_3$	429487.7 – 5d $^3G_3$	585903.3	
1.3	49	642.774	155575.6	1.7	5p $^3F_2$	420980.5 – 5d $^3D_3$	576554.4	
1.2	37	669.568	149350.1	1.5	5p $^3D_3$	429487.7 – 5d $^1D_2$	578836.3	
0.1	9	671.068	149016.1	1.2	5p $^1D_2$	427539.5 – 5d $^3D_3$	576554.4	
0.5	17	680.063	147045.2	1.6	5p $^1D_2$	427539.5 – 5d $^3P_2$	574583.1	
0.5	14	682.535	146512.6	−1.5	5p $^3F_2$	420980.5 – 5d $^3S_1$	567494.6	
0.3	9	683.097	146392.1	−0.9	5p $^3D_2$	441069.6 – 5d $^3D_1$	587462.6	
0.7	16	706.498	141543.2	1.3	5p $^1F_3$	436847.2 – 5d $^1F_3$	578389.1	
5d – 5f	transitions							
0.5	51	595.159	168022.3	−1.3	5d $^3F_4$	579505.4 – 5f $^1G_4$	747529	
9.5	359b	610.847	163707.0	−3.8	5d $^1P_1$	574978.2 – 5f $^3D_1$	738689	O III
19.8	620b	614.188	162816.6	0.2	5d $^3S_1$	567494.6 – 5f $^3P_2$	730311	Te V
10.4	12	615.344	162510.7	2.0	5d $^3G_3$	585903.3 – 5f $^3G_3$	748412	
21.5	36	619.925	161309.8	0.8	5d $^3G_4$	573537.0 – 5f $^1G_4$	734846	
25.0	60	621.024	161024.4	1.0	5d $^3S_1$	567494.6 – 5f $^3P_1$	728518	
3.4	7	621.401	160926.7	0.9	5d $^3P_1$	584585.2 – 5f $^3F_2$	745511	
20.3	42	622.485	160646.4	1.7	5d $^3G_5$	574747.3 – 5f $^3G_5$	735392	
11.2	35	625.672	159828.2	0.8	5d $^3S_1$	567494.6 – 5f $^3P_0$	727322	
0.5	7	626.539	159607.0	−0.7	5d $^3G_3$	585903.3 – 5f $^3F_2$	745511	
7.3	28	628.556	159094.8	0.1	5d $^1G_4$	588434.3 – 5f $^3G_4$	747529	
37.9	72	629.209	158929.7	0.8	5d $^3P_2$	574583.1 – 5f $^3D_3$	733512	
14.6	29	630.097	158705.7	−1.2	5d $^3P_2$	574583.1 – 5f $^1D_2$	733290	
25.6	88	630.635	158570.2	0.4	5d $^3D_2$	589842.2 – 5f $^3G_3$	748412	
137.2	186	631.349	158390.9	−0.1	5d $^3G_4$	573537.0 – 5f $^3H_5$	731928	
27.5	47	631.663	158312.3	0.5	5d $^1P_1$	574978.2 – 5f $^1D_2$	733290	
21.2	37	631.740	158293.1	1.5	5d $^3D_3$	576554.4 – 5f $^1G_4$	734846	
32.9	93	632.315	158148.9	−1.9	5d $^3P_1$	584585.2 – 5f $^3D_2$	742736	
22.8	55	632.533	158094.6	0.7	5d $^1F_3$	578389.1 – 5f $^1F_3$	736483	
39.7	82	632.719	158048.0	−0.4	5d $^3D_1$	587462.6 – 5f $^3F_2$	745511	
35.3	191b	633.485	157856.9	0.3	5d $^3F_2$	590555.4 – 5f $^3G_3$	748412	DI [14]
16.3	31	633.668	157811.4	0.4	5d $^3P_0$	580878.0 – 5f $^3D_1$	738689	
10.5	64	634.067	157712.1	0.1	5d 1S$_0$	614713.0 – 5f $^1P_1$	772425	
58.3	87	634.330	157646.8	0.1	5d $^1D_2$	578836.3 – 5f $^1F_3$	736483	
110.9	169	634.411	157626.6	−0.1	5d $^3G_3$	585903.3 – 5f $^3H_4$	743530	
49.6	85	634.782	157534.3	1.7	5d $^3D_3$	576554.4 – 5f $^3F_4$	734087	
41.3	55	637.122	156955.8	−1.8	5d $^3D_3$	576554.4 – 5f $^3D_3$	733512	
36.6	35	637.614	156834.8	0.0	5d $^3D_2$	589842.2 – 5f $^3F_3$	746677	
4.4	10	638.010	156737.3	1.7	5d $^3D_3$	576554.4 – 5f $^1D_2$	733290	
14.2	160b	638.656	156578.8	−3.8	5d $^3F_3$	591829.4 – 5f $^3G_3$	748412	
70.2	104	639.157	156456.0	−0.9	5d $^1F_3$	578389.1 – 5f $^1G_4$	734846	
164.9	279	639.555	156358.7	0.0	5d $^3G_5$	574747.3 – 5f $^3H_6$	731106	
135.7	186	639.805	156297.7	0.0	5d $^3G_4$	588434.3 – 5f $^1H_5$	744732	
37.4	84	640.526	156121.6	0.0	5d $^3F_2$	590555.4 – 5f $^3F_3$	746677	
103.8	213	641.499	155884.9	−1.7	5d $^3F_4$	579505.4 – 5f $^3G_5$	735392	
23.4	64	642.151	155726.6	−1.3	5d $^3P_2$	574583.1 – 5f $^3P_2$	730311	
47.4	165	642.261	155700.0	0.4	5d $^3F_3$	591829.4 – 5f $^3G_4$	747529	

Table II. *Continued.*

gA	$I(a)$	λ (Å)	σ (cm^{-1})	$\Delta\sigma$	Transition
21.3				2.1	5d $^1F_3$ 578389.1 – 5f $^3F_4$ 734087
5.5	19	642.389	155669.0	0.2	5d $^3D_2$ 589842.2 – 5f $^3F_2$ 745511
5.4	22	643.785	155331.5	−1.3	5d $^1P_1$ 574978.2 – 5f $^3P_2$ 730311
8.6	34	644.031	155272.1	−1.3	5d $^3D_1$ 587462.6 – 5f $^3D_2$ 742736
13.1	42	645.348	154955.1	−0.5	5d $^3F_2$ 590555.4 – 5f $^3F_2$ 745511
35.2	134	646.914	154580.2	−1.4	5d $^3F_4$ 579505.4 – 5f $^3F_4$ 734087
15.6	32	647.435	154455.6	1.9	5d $^1D_2$ 578836.3 – 5f $^1D_2$ 733290
6.2	13	648.913	154103.9	0.1	5d $^3P_1$ 584585.2 – 5f $^3D_1$ 738689
11.8	26	649.629	153934.0	−0.9	5d $^3P_2$ 574583.1 – 5f $^3P_1$ 728518
15.0	39	654.042	152895.4	1.6	5d $^3D_2$ 589842.2 – 5f $^3D_2$ 742736
9.0	66	660.171	151475.9	1.2	5d $^1D_2$ 578836.3 – 5f $^3P_2$ 730311
0.6	523b	700.599	142735.0	−1.8	5d $^3P_1$ 584585.2 – 5f $^3P_0$ 727322
0.1	19	715.010	139858.1	−1.3	5d $^3D_1$ 587462.6 – 5f $^3P_0$ 727322

* – these lines have been identified earlier (see text). See also the footnotes to Table I.

figurations and the odd $4d^9np$ ($n = 5,6$), $4d^9nf$ ($n = 4$–6), $4d^85s5p$, $4d^85p5d$, $4p^54d^{10}5s$ and $4p^54d^{10}5d$ configurations. For the unknown configurations we scaled the Slater energy parameters to 0.85 of their *ab initio* Hartree–Fock values.

Accurate *ab initio* prediction of the $4d^95d\ ^1S_0$ energies is difficult because they depend on the Slater integral G^0(4d, 5d) and on various configuration interactions. We followed the same approach as it was done for Ni-like ions in which the $3d^94p\ ^1P_1$ – $3d^94d\ ^1S_0$ transitions were surveyed by MCDF calculations and corrected for systematic E_{exp}–E_{MCDF} deviations [20]. In the Pd I isoelectronic sequence, considering the laser effect on the $4d^95p\ ^1P_1$ – $4d^95d\ ^1S_0$ transition in Xe IX ($\lambda = 418.1$ Å) [1] as a proof of the correctness of its identification and using the Ag II data [2], we interpolated the known differences between experimental and theoretical wavenumbers of this transition to the other ions.

3. Results and discussion

The preliminary analysis of the obtained spectrograms showed that the spectral lines of Pd-like ions are intense in the "hot" vacuum spark spectra and become weaker or completely absent in the "cold" sliding spark ones. The clear ionization character of the lines was helpful in the present analysis for choosing the lines belonging to a particular spectrum.

The results of our line identifications are presented in Tables I, II and III respectively for Sb VI, Te VII and I VIII.

We completely confirm the previous analyses of the $4d^95s$ – $4d^95p$ and $4d^95p$ – $4d^95d$ transitions in Sb VI and Te VII [7,14] and of the $4d^95p$ – $4d^96s$ transitions in Sb VI [14], our wavelengths and level energies being in good agreement with the previously published data. Therefore only the additional wavelengths are reported here, namely six previously unknown relatively weak lines of the $4d^95p$ – $4d^9(5d + 6s)$ transitions in Sb VI and twenty-six of the $4d^95p$ – $4d^95d$ transitions in Te VII. In both spectra, the $4d^95d\ ^1S_0$ levels were found from respectively three and two transitions to $4d^95p$ levels. Moreover, we newly classified lines corresponding to the $4d^95d$ – $4d^95f$ transitions in Sb VI and Te VII including the $4d^95d\ ^1S_0$ – $4d^95f\ ^1P_1$ transitions in both spectra.

For I VIII, out of the twenty-five $4d^95s$ – $4d^95p$ transitions given in Table III, eighteen were correctly identified in [8]. However our wavelengths show systematic red shifts of about 0.01–0.03 Å against the wavelengths measured in [8]. The resulting revised $4d^95s$ and $4d^95p$ level energies are 10–50 cm^{-1} lower than the previous values. On the basis of the new $4d^95p$ energies we identified the $4d^95p$ – $4d^95d$ transition array and determined the energies of all the $4d^95d$ levels in I VIII, including the $^1S_0$ level. All the forty-six $4d^95p$ $4d^95d$ lines given in Table III are new, the $4d^95d\ ^1S_0$ and $4d^95d\ ^3G_5$ levels being derived each from one single transition. The improved energy values of $4d^95p$ $J = 1$ levels derived from the new measurements are supported by numerous $4d^95s$ – $4d^95p$ and $4d^95p$ – $4d^95d$ transitions. Unfortunately we could not identify unambiguously any $4d^95d$ – $4d^95f$ transition in I VIII, not even the most intense ones. The probable reason is that the source temperature was not high enough to excite a well-developed spectrum of the transitions between high lying configurations.

All the experimentally determined level energies in Sb VI, Te VII and I VIII are respectively given in Tables IV, V and VI, together with the fitted energies and the corresponding wavefunction compositions from the parametric study of the configurations. For the level designations in Tables I–III we used the first *LS*-terms in the level wavefunction compositions given in Tables IV–VI. It should be noted that, for some levels, these first terms do not coincide with the largest percentage terms. It is seen from Tables IV–VI that the *Jj* coupling scheme would be more appropriate than the *LS* coupling scheme for the level designation, but the *LS* labels are used for the sake of consistency with previous papers. The energies of the lower and upper levels are also given for the transitions in Tables I–III.

It is seen from the Tables that all the measured wavenumbers agree with the level energy differences within the accuracy of the averaged level energies (1–2 cm^{-1}). The new resonance wavenumbers agree with the 5–5 transition arrays within an accuracy better than ± 10 cm^{-1}. The measured line intensities are in good agreement with the calculated gA values of the corresponding transitions. The structures of the investigated configurations are described quite well by the least squared fits (LSF) of energy parameters. Moreover, the deviations of the experimental energies from the fitted ones for the separate levels vary monotonously along the isoelectronic sequence.

Table III. *Identified spectral lines in VIII.*

gA	*I*(*a*)	λ (Å)	σ (cm^{-1})	$\Delta\sigma$	Transition			
Resonance transitions								
1803.0	130*	110.479	905147.8	−0.3	4d $^{1}S_{0}$	0	– 5f $^{1}P_{1}$	905148
49.5	50*	115.079	868968.3	1.3	4d $^{1}S_{0}$	0	– 5f $^{3}D_{1}$	868967
33.4	850*	190.152	525895.1	0.1	4d $^{1}S_{0}$	0	– 5p $^{3}D_{1}$	525895
191.3	950*	194.155	515052.4	−5.6	4d $^{1}S_{0}$	0	– 5p $^{1}P_{1}$	515058
0.9	120*	197.947	505185.7	−8.3	4d $^{1}S_{0}$	0	– 5p $^{3}P_{1}$	505194
5p – 5d transitions								
20.9	32	472.262	211746.9	−0.1	5p $^{1}P_{1}$	515058	– 5d $^{1}S_{0}$	726805
2.6	72	515.606	193946.4	−0.6	5p $^{3}F_{2}$	504541	– 5d $^{3}F_{2}$	698488
2.0	22	517.575	193208.6	−0.4	5p $^{3}F_{2}$	504541	– 5d $^{3}D_{2}$	697750
37.1	167	518.353	192918.6	0.6	5p $^{3}P_{2}$	489118	– 5d $^{3}D_{3}$	682036
10.4	55	519.327	192556.8	0.8	5p $^{3}P_{1}$	505194	– 5d $^{3}D_{2}$	697750
4.3	17	519.812	192377.2	1.2	5p $^{3}F_{3}$	492554	– 5d $^{1}D_{2}$	684930
18.1	181	521.435	191778.5	1.5	5p $^{3}F_{3}$	492554	– 5d $^{1}F_{3}$	684331
9.2	36	522.800	191277.7	0.7	5p $^{3}P_{2}$	489118	– 5d $^{1}P_{1}$	680395
55.7	174	524.380	190701.3	1.3	5p $^{3}P_{2}$	489118	– 5d $^{3}P_{2}$	679818
33.0	148	527.756	189481.7	−0.3	5p $^{3}F_{3}$	492554	– 5d $^{3}D_{3}$	682036
73.0	307	530.691	188433.7	−1.3	5p $^{3}F_{2}$	504541	– 5d $^{3}G_{3}$	692976
8.3	54	534.003	187265.0	1.0	5p $^{3}F_{3}$	492554	– 5d $^{3}P_{2}$	679818
11.4	55	536.400	186428.1	0.1	5p $^{3}P_{1}$	505194	– 5d $^{3}P_{1}$	691622
134.0	403	537.673	185986.7	−0.3	5p $^{3}F_{3}$	492554	– 5d $^{3}G_{4}$	678541
17.3	55	545.164	183431.0	1.0	5p $^{1}P_{1}$	515058	– 5d $^{3}F_{2}$	698488
5.8	16	547.367	182692.7	0.7	5p $^{1}P_{1}$	515058	– 5d $^{3}D_{2}$	697750
35.5	198	547.919	182508.6	0.6	5p $^{3}P_{2}$	489118	– 5d $^{3}S_{1}$	671626
14.9	97	548.943	182168.2	0.2	5p $^{3}P_{1}$	505194	– 5d $^{3}P_{0}$	687362
30.5	118	553.916	180532.6	−1.4	5p $^{1}D_{2}$	512442	– 5d $^{3}G_{3}$	692976
7.3	25	554.363	180387.1	−1.9	5p $^{3}F_{2}$	504541	– 5d $^{1}D_{2}$	684930
25.3	108	556.206	179789.5	−0.5	5p $^{3}F_{2}$	504541	– 5d $^{1}F_{3}$	684331
15.9	85	556.371	179736.1	0.1	5p $^{3}P_{1}$	505194	– 5d $^{1}D_{2}$	684930
17.7	166	558.922	178915.8	−0.2	5p $^{3}P_{0}$	516034	– 5d $^{3}D_{1}$	694950
38.5	254	559.305	178793.3	0.3	5p $^{3}F_{4}$	506971	– 5d $^{3}F_{4}$	685764
9.4	44	566.368	176563.6	−0.4	5p $^{1}P_{1}$	515058	– 5d $^{3}P_{1}$	691622
23.9	102	567.078	176342.7	1.7	5p $^{1}F_{3}$	523790	– 5d $^{3}F_{3}$	700131
12.7	77	570.773	175200.8	−0.2	5p $^{3}P_{1}$	505194	– 5d $^{1}P_{1}$	680395
7.6	54	571.216	175065.3	0.3	5p $^{3}F_{4}$	506971	– 5d $^{3}D_{3}$	682036
152.8	382	577.250	173235.1	0.1	5p $^{3}F_{4}$	506971	– 5d $^{3}G_{5}$	680206
29.6	118	579.397	172593.1	0.1	5p $^{3}D_{1}$	525895	– 5d $^{3}F_{2}$	698488
30.9	155	579.752	172487.6	−0.4	5p $^{1}D_{2}$	512442	– 5d $^{1}D_{2}$	684930
122.4	311	579.879	172449.8	−0.2	5p $^{1}F_{3}$	523790	– 5d $^{1}G_{4}$	696240
40.4	292	581.775	171887.9	−1.1	5p $^{1}D_{2}$	512442	– 5d $^{1}F_{3}$	684331
16.8	75	581.881	171856.4	1.4	5p $^{3}D_{1}$	525895	– 5d $^{3}D_{2}$	697750
69.2	232	582.305	171731.3	−0.8	5p $^{3}D_{2}$	528399	– 5d $^{3}F_{3}$	700131
8.2	45	582.849	171571.1	1.1	5p $^{3}F_{4}$	506971	– 5d $^{3}G_{4}$	678541
29.7	258	585.097	170911.8	−0.2	5p $^{3}D_{3}$	514852	– 5d $^{3}F_{4}$	685764
8.0	61	588.676	169872.7	0.7	5p $^{1}P_{1}$	515058	– 5d $^{1}D_{2}$	684930
15.7	119	590.039	169480.2	1.2	5p $^{3}D_{3}$	514852	– 5d $^{1}F_{3}$	684331
29.5	96	590.495	169349.5	−1.5	5p $^{3}D_{2}$	528399	– 5d $^{3}D_{2}$	697750
6.1	43	591.062	169187.0	1.0	5p $^{1}F_{3}$	523790	– 5d $^{3}G_{3}$	692976
29.7	98	598.146	167183.3	−0.7	5p $^{3}D_{3}$	514852	– 5d $^{3}D_{3}$	682036
4.0	20	600.850	166430.9	−1.1	5p $^{3}P_{1}$	505194	– 5d $^{3}S_{1}$	671626
11.1	62	604.828	165336.3	−0.7	5p $^{1}P_{1}$	515058	– 5d $^{1}P_{1}$	680395
13.2	46	606.190	164964.9	−1.1	5p $^{3}D_{3}$	514852	– 5d $^{3}P_{2}$	679818
6.2	28	610.922	163687.1	−1.9	5p $^{3}D_{3}$	514852	– 5d $^{3}G_{4}$	678541
2.1	38	628.210	159182.4	−1.6	5p $^{1}D_{2}$	512442	– 5d $^{3}S_{1}$	671626
5s – 5p transitions								
1.4	58	693.067	144286.2	−0.8	5s $^{3}D_{2}$	381608	– 5p $^{3}D_{1}$	525895
1.9	117	703.316	142183.6	1.6	5s $^{3}D_{2}$	381608	– 5p $^{1}F_{3}$	523790
20.5	370*	732.642	136492.3	0.3	5s $^{3}D_{3}$	378360	– 5p $^{3}D_{3}$	514852
7.8	187*	736.545	135769.0	−1.0	5s $^{3}D_{1}$	392629	– 5p $^{3}D_{2}$	528399
0.8	30	745.805	134083.3	1.3	5s $^{3}D_{3}$	378360	– 5p $^{1}D_{2}$	512442
2.9	114*	749.338	133451.1	1.1	5s $^{3}D_{2}$	381608	– 5p $^{1}P_{1}$	515058
10.7	185*	750.380	133265.8	−0.3	5s $^{3}D_{1}$	392629	– 5p $^{3}D_{1}$	525895
8.5	215*	750.502	133244.2	0.2	5s $^{3}D_{2}$	381608	– 5p $^{3}D_{3}$	514852
12.9	225*	755.234	132409.3	0.3	5s $^{1}D_{2}$	395990	– 5p $^{3}D_{2}$	528399
14.5	272*	764.332	130833.3	−0.8	5s $^{3}D_{2}$	381608	– 5p $^{1}D_{2}$	512442
0.9	10	769.791	129905.3	0.3	5s $^{1}D_{2}$	395990	– 5p $^{3}D_{1}$	525895
34.7	364*	777.537	128611.3	0.3	5s $^{3}D_{3}$	378360	– 5p $^{3}F_{4}$	506971
24.5	278*	782.476	127799.5	−0.5	5s $^{1}D_{2}$	395990	– 5p $^{1}F_{3}$	523790

Table III. *Continued.*

gA	$I(a)$	λ (Å)	σ (cm^{-1})	$\Delta\sigma$	Transition
6.8	202	809.146	123587.1	1.1	5s $^3D_2$ 381608 – 5p $^3P_1$ 505194
3.3	71*	810.341	123404.9	−0.1	5s $^3D_1$ 392629 – 5p $^3P_0$ 516034
4.4	97*	813.450	122933.1	0.1	5s $^3D_2$ 381608 – 5p $^3F_2$ 504541
5.8	77*	839.862	119067.2	−0.8	5s $^1D_2$ 395990 – 5p $^1P_1$ 515058
1.4	41	841.316	118861.4	−0.6	5s $^1D_2$ 395990 – 5p $^3D_3$ 514852
2.2	51*	858.721	116452.3	0.3	5s $^1D_2$ 395990 – 5p $^1D_2$ 512442
6.3	160*	875.701	114194.2	0.2	5s $^3D_3$ 378360 – 5p $^3F_3$ 492554
6.9	165*	893.562	111911.6	−0.4	5s $^3D_1$ 392629 – 5p $^3F_2$ 504541
11.8	190*	901.342	110945.7	−0.3	5s $^3D_2$ 381608 – 5p $^3F_3$ 492554
11.8	211*	902.864	110758.7	0.7	5s $^3D_3$ 378360 – 5p $^3P_2$ 489118
2.1	32	915.719	109203.8	−0.2	5s $^1D_2$ 395990 – 5p $^3P_1$ 505194
2.6	36*	921.220	108551.7	0.7	5s $^1D_2$ 395990 – 5p $^3F_2$ 504541

See the footnotes to Tables I and II.

The LSF and the *ab initio* Hartree–Fock (HF) energy parameters of the studied configurations are presented in Table VII. The average LSF parameter deviations of the fits are given in brackets. All the configuration interaction parameters were fixed at 0.85 of their HF values.

Although the 4d^{9}5d $^1S_0$ level energy in I VIII has been determined only by one single line at 472.262 Å (Table III), its value is secured by the absence of any other suitable line in the corresponding region of the iodine spectrum. Moreover, the experimental energies of this level so as the LSF/HF G^0(4d, 5d) parameter ratios (see Table VII) have very monotonous behaviour along the isoelectronic sequence. On the basis of our results the wavelengths of the laser transition 4d^{9}5p $^1P_1$ – 4d^{9}5d $^1S_0$ can be predicted for Cs X, Ba XI and La XII ions respectively at 375.25 ± 0.20 Å, 340.3 ± 0.3 Å and 311.4 ± 0.5 Å.

Unfortunately we could not identify the other transition of laser interest, 4d^{9}5d $^1P_1$ – 4d^{9}5f $^1P_1$ [1], because it is too weak in the studied ions. According to *ab initio* calculations, the 4d^{9}5d $^1S_0$ – 4d^{9}5f $^1P_1$ transition is more intense for the relatively light Pd-like ions through Xe IX, and has been identified by us in Sb VI and Te VII ions (see Tables I and II).

Furthermore, the present step in the analysis of Pd-like ion spectra did not improve our knowledge of the 4d^{9}4f configurations. Extended observations in higher charged ions where 4d^{9}4f is the lowest odd parity configuration [11] will be necessary. Systematic parametric studies of 4d^{n}4f^m configurations in known spectra are in progress following Cowan's method [19] in order to predict all relevant energy parameters of 4d^{9}4f with the best accuracy.

Table IV. *The level energies for Sb VI* (cm^{-1}).

E(exp)	E(fit)	ΔE	LS-coupling terms	Jj-coupling terms
Even configurations:				
$J = 0$				
0.0	0	0	100% 4d ^1S	100% 4d (3/2,3/2)
479541.4b	479496	45	97% 5d ^3P + 2% 5d ^1S	55% 5d (5/2,5/2)
507709.3	507710	−1	94% 5d ^1S + 4% 6d ^1S	53% 5d (3/2,3/2)
$J = 1$				
253230.6a	253219	11	100% 5s ^3D	100% 5s (3/2,1/2)
468443.8b	468496	−52	82% 5d ^3S + 15% 5d ^3P	61% 5d (5/2,3/2)
474640.2b	474742	−102	51% 5d ^1P + 25% 5d ^3D	64% 5d (5/2,5/2)
482777.4b	482826	−48	41% 5d ^3P + 40% 5d ^1P	53% 5d (3/2,5/2)
485258.0b	485222	36	71% 5d ^3D + 21% 5d ^3P	58% 5d (3/2,3/2)
525023.2b	525020	3	100% 6s ^3D	100% 6s (3/2,1/2)
$J = 2$				
245663.8a	245633	31	68% 5s ^3D + 32% 5s ^1D	92% 5s (5/2,1/2)
256382.2a	256397	−15	68% 5s ^1D + 32% 5s ^3D	92% 5s (3/2,1/2)
474361.0b	474351	10	61% 5d ^3P + 36% 5d ^3D	77% 5d (5/2,3/2)
477805.6b	477820	−15	46% 5d ^1D + 20% 5d ^3D	75% 5d (5/2,5/2)
487150.2b	487145	5	38% 5d ^3D + 41% 5d ^1D	83% 5d (3/2,5/2)
487846.4b	487882	−36	81% 5d ^3F + 12% 5d ^1D	85% 5d (3/2,3/2)
515506.6b	515504	3	53% 6s ^1D + 47% 6s ^3D	99% 6s (5/2,1/2)
525662.0b	525665	−3	53% 6s ^3D + 47% 6s ^1D	99% 6s (3/2,1/2)
$J = 3$				
242916.8a	242944	−28	100% 5s ^3D	100% 5s (5/2,1/2)
476085.0b	476048	37	63% 5d ^3D + 29% 5d ^3F	73% 5d (5/2,3/2)
477530.9b	477530	1	44% 5d ^1F + 24% 5d ^3D	72% 5d (5/2,5/2)
484040.9b	483998	42	73% 5d ^3G + 19% 5d ^1F	90% 5d (3/2,3/2)
488778.3b	488840	−61	50% 5d ^3F + 35% 5d ^1F	94% 5d (3/2,5/2)

Table IV. *Continued.*

E(exp)	E(fit)	ΔE	LS-coupling terms	Jj-coupling terms
514662.0b	514665	−3	100% 6s ^{3}D	100% 6s (5/2,1/2)
$J = 4$				
473554.6b	473544	11	55% 5d ^{3}G + 43% 5d ^{1}G	96% 5d (5/2,3/2)
478281.6b	478297	−16	77% 5d ^{3}F + 18% 5d ^{1}G	94% 5d (5/2,5/2)
485906.8b	485861	46	39% 5d ^{1}G + 40% 5d ^{3}G	97% 5d (3/2,5/2)
$J = 5$				
474397.0b	474300	97	100% 5d ^{3}G	100% 5d (5/2,5/2)
Odd configurations:				
$J = 0$				
349101.6a	349038	63	100% 5p ^{3}P	100% 5p (3/2,3/2)
603958	603940	18	99% 5f ^{3}P + 1% 4f ^{3}P	99% 5f (5/2,5/2)
$J = 1$				
341970.6a	341944	27	86% 5p ^{3}P + 13% 5p ^{3}D	47% 5p (5/2,3/2)
351009.3a	351025	−16	80% 5p ^{1}P + 19% 5p ^{3}D	62% 5p (3/2,1/2)
357446.0a	357440	6	67% 5p ^{3}D + 19% 5p ^{1}P	81% 5p (3/2,3/2)
604819	604972	−153	88% 5f ^{3}P + 11% 5f ^{3}D	80% 5f (5/2,5/2)
613653	613739	−86	86% 5f ^{3}D + 10% 5f ^{3}P	35% 5f (5/2,7/2)
639089	639088	1	54% 5f ^{1}P + 28% 6f ^{1}P	33% 5f (3/2,5/2)
$J = 2$				
331122.8a	331187	−64	82% 5p ^{3}P + 13% 5p ^{3}D	86% 5p (5/2,1/2)
342575.0a	342592	−17	87% 5p ^{3}F + 8% 5p ^{3}D	81% 5p (3/2,1/2)
347920.1a	347987	−67	67% 5p ^{1}D + 20% 5p ^{3}D	72% 5p (5/2,3/2)
359232.1a	359240	−8	59% 5p ^{3}D + 30% 5p ^{1}D	95% 5p (3/2,3/2)
606436	606464	−28	62% 5f ^{3}P + 22% 5f ^{3}D	69% 5f (5/2,7/2)
609183	609182	1	37% 5f ^{1}D + 38% 5f ^{3}F	75% 5f (5/2,5/2)
617134	616995	139	37% 5f ^{3}D + 35% 5f ^{3}P	84% 5f (3/2,7/2)
619435	619486	−51	61% 5f ^{3}F + 22% 5f ^{1}D	90% 5f (3/2,5/2)
$J = 3$				
334262.5a	334173	89	56% 5p ^{3}F + 33% 5p ^{1}F	97% 5p (5/2,1/2)
349411.7a	349304	108	72% 5p ^{3}D + 28% 5p ^{1}F	97% 5p 5/2,3/2)
355419.9a	355461	−41	39% 5p ^{1}F + 44% 5p ^{3}F	97% 5p (3/2,3/2)
609355	609422	−67	33% 5f ^{3}D + 29% 5f ^{3}F	40% 5f (5/2,5/2)
612041	612079	−38	37% 5f ^{1}F + 20% 5f ^{3}G	54% 5f (5/2,7/2)
620432	620449	−17	38% 5f ^{3}F + 32% 5f ^{3}G	86% 5f (3/2,7/2)
622330	622364	−34	40% 5f ^{3}G + 49% 5f ^{1}F	84% 5f (3/2,5/2)
$J = 4$				
342977.0a	343057	−80	100% 5p ^{3}F	100% 5p (5/2,3/2)
609924	609835	89	80% 5f ^{3}F + 13% 5f ^{3}G	81% 5f (5/2,7/2)
610519	610506	13	42% 5f ^{1}G + 30% 5f ^{3}G	79% 5f (5/2,5/2)
617938	617979	−41	72% 5f ^{3}H + 15% 5f ^{1}G	90% 5f (3/2,5/2)
621365	621363	2	33% 5f ^{3}G + 29% 5f ^{1}G	73% 5f (3/2,7/2)
$J = 5$				
608017	607898	119	60% 5f ^{3}H + 38% 5f ^{1}H	98% 5f (5/2,5/2)
610835	610868	−33	76% 5f ^{3}G + 18% 5f ^{1}H	97% 5f (5/2,7/2)
618967	618913	54	43% 5f ^{1}H + 35% 5f ^{3}H	97% 5f (3/2,7/2)
$J = 6$				
607146	607067	79	100% 5f ^{3}H	100% 5f (5/2,7/2)

a – energy value taken from [7].

b – energy value taken from [14]. Note that the two $J = 2$ levels at 515506.6 and 525662.0 cm^{-1} have their LS designations exhanged compared with [14].

$\Delta E = E(\text{exp}) - E(\text{fit})$.

Table V. *The level energies for Te VII* (cm^{-1}).

E(exp)	E(fit)	ΔE	LS-coupling terms	Jj-coupling terms
Even configurations:				
$J = 0$				
0.0	0	0	100% 4d ^{1}S	100% 4d (3/2,3/2)
580878.0b	580806	72	98% 5d ^{3}P + 2% 5d ^{1}S	54% 5d (5/2,5/2)
614713.0	614715	−2	95% 5d ^{1}S + 3% 6d ^{1}S	53% 5d (3/2,3/2)
$J = 1$				
320311.6a	320298	14	100% 5s ^{3}D	100% 5s (3/2,1/2)
567494.6b	567549	−54	82% 5d ^{3}S + 16% 5d ^{3}P	62% 5d (5/2,3/2)
574978.2b	575125	−147	51% 5d ^{1}P + 25% 5d ^{3}D	65% 5d (5/2,5/2)
584585.2b	584656	−71	38% 5d ^{3}P + 42% 5d ^{1}P	47% 5d (3/2,5/2)

Table V. *Continued.*

E(exp)	*E*(fit)	Δ*E*	*LS*-coupling terms	*Jj*-coupling terms
587462.6b	587413	50	69% 5d ^{3}D + 24% 5d ^{3}P	52% 5d (3/2,3/2)
647795.2b	647790	5	100% 6s ^{3}D	100% 6s (3/2,1/2)
$J=2$				
311123.3a	311091	32	65% 5s ^{3}D + 35% 5s ^{1}D	94% 5s (5/2,1/2)
323571.2a	323588	−17	65% 5s ^{1}D + 35% 5s ^{3}D	94% 5s (3/2,1/2)
574583.1b	574569	14	59% 5d ^{3}P + 38% 5d ^{3}D	80% 5d (5/2,3/2)
578836.3b	578860	−24	45% 5d ^{1}D + 22% 5d ^{3}P	78% 5d (5/2,5/2)
589842.2b	589852	−10	35% 5d ^{3}D + 46% 5d ^{1}D	75% 5d (3/2,5/2)
590555.4b	590591	−35	82% 5d ^{3}F + 9% 5d ^{3}D	78% 5d (3/2,3/2)
636483.1b	636479	4	53% 6s ^{1}D + 47% 6s ^{3}D	99% 6s (5/2,1/2)
648496.0b	648501	−5	53% 6s ^{3}D + 47% 6s ^{1}D	100% 6s (3/2,1/2)
$J=3$				
308119.2a	308148	−29	100% 5s ^{3}D	100% 5s (5/2,1/2)
576554.4b	576528	27	60% 5d ^{3}D + 31% 5d ^{3}F	76% 5d (5/2,3/2)
578389.1b	578398	−9	42% 5d ^{1}F + 27% 5d ^{3}D	75% 5d (5/2,5/2)
585903.3b	585867	37	72% 5d ^{3}G + 20% 5d ^{1}F	90% 5d (3/2,3/2)
591829.4b	591890	−60	51% 5d ^{3}F + 35% 5d ^{1}F	95% 5d (3/2,5/2)
635542.2b	635547	−4	100% 6s ^{3}D	100% 6s (5/2,1/2)
$J=4$				
573577.0b	573542	35	56% 5d ^{3}G + 42% 5d ^{1}G	97% 5d (5/2,3/2)
579505.4b	579504	1	77% 5d ^{3}F + 19% 5d ^{1}G	95% 5d (5/2,5/2)
588434.3b	588373	61	39% 5d ^{1}G + 40% 5d ^{3}G	97% 5d (3/2,5/2)
$J=5$				
574747.3b	574633	114	100% 5d ^{3}G	100% 5d (5/2,5/2)
Odd configurations:				
$J=0$				
429850.3a	429791	59	100% 5p ^{3}P	100% 5p (3/2,3/2)
727322	727347	−25	100% 5f ^{3}P	99% 5f (5/2,5/2)
$J=1$				
420964.7a	420929	36	83% 5p ^{3}P + 16% 5p ^{3}D	44% 5p (5/2,3/2)
430409.1a	430428	−19	81% 5p ^{1}P + 17% 5p ^{3}D	57% 5p (3/2,1/2)
438931.0a	438927	4	67% 5p ^{3}D + 18% 5p ^{1}P	83% 5p (3/2,3/2)
728518	728547	−29	88% 5f ^{3}P + 11% 5f ^{3}D	80% 5f (5/2,5/2)
738689	738753	−64	87% 5f ^{3}D + 11% 5f ^{3}P	36% 5f (5/2,7/2)
772425	772424	1	62% 5f ^{1}P + 19% 6f ^{1}P	36% 5f (3/2,5/2)
$J=2$				
407633.1a	407716	−83	80% 5p ^{3}P + 15% 5p ^{3}D	88% 5p (5/2,1/2)
420980.5a	420999	−19	87% 5p ^{3}F + 7% 5p ^{3}D	84% 5p (3/2,1/2)
427539.5a	427620	−81	66% 5p ^{1}D + 20% 5p ^{3}D	76% 5p (5/2,3/2)
441069.6a	441085	−15	58% 5p ^{3}D + 29% 5p ^{1}D	96% 5p (3/2,3/2)
730311	730338	−27	64% 5f ^{3}P + 23% 5f ^{3}D	70% 5f (5/2,7/2)
733290	733352	−62	38% 5f ^{1}D + 39% 5f ^{3}F	74% 5f (5/2,5/2)
742736	742646	90	29% 5f ^{3}D + 29% 5f ^{3}P	68% 5f (3/2,7/2)
745511	745416	95	61% 5f ^{3}F + 22% 5f ^{1}D	90% 5f (3/2,5/2)
$J=3$				
410934.9a	410829	106	55% 5p ^{3}F + 33% 5p ^{1}F	98% 5p (5/2,1/2)
429487.6a	429371	117	72% 5p ^{3}D + 27% 5p ^{1}F	97% 5p (5/2,3/2)
436847.2a	436878	−31	39% 5p ^{1}F + 45% 5p ^{3}F	98% 5p (3/2,3/2)
733512	733527	−15	49% 5f ^{3}D + 47% 5f ^{3}F	63% 5f (5/2,5/2)
736483	736441	42	43% 5f ^{1}F + 21% 5f ^{3}G	61% 5f (5/2,7/2)
746677	746538	139	39% 5f ^{3}F + 29% 5f ^{3}G	89% 5f (3/2,7/2)
748412	748507	−95	45% 5f ^{3}G + 47% 5f ^{1}F	90% 5f (3/2,5/2)
$J=4$				
422311.9a	422386	−74	100% 5p ^{3}F	100% 5p (5/2,3/2)
734087	734141	−54	80% 5f ^{3}F + 15% 5f ^{3}G	79% 5f (5/2,7/2)
734846	734846	0	44% 5f ^{1}G + 28% 5f ^{3}G	76% 5f (5/2,5/2)
743530	743704	−174	74% 5f ^{3}H + 15% 5f ^{1}G	92% 5f (3/2,5/2)
747529	747502	27	38% 5f ^{3}G + 30% 5f ^{1}G	80% 5f (3/2,7/2)
$J=5$				
731928	731816	112	59% 5f ^{3}H + 40% 5f ^{1}H	98% 5f (5/2,5/2)
735392	735416	−24	71% 5f ^{3}G + 17% 5f ^{1}H	90% 5f (5/2,7/2)
744732	744767	−35	42% 5f ^{1}H + 36% 5f ^{3}H	98% 5f (3/2,7/2)
$J=6$				
731106	730990	116	100% 5f ^{3}H	100% 5f (5/2,7/2)

See the footnotes to Table IV.

Table VI. *The level energies for I VIII* (cm^{-1}).

E(exp)	E(fit)	ΔE	LS-coupling terms	Jj-coupling terms
Even Configurations:				
$J = 0$				
0	0	0	100% 4d ^{1}S	100% 4d (3/2,3/2)
687273?	687221	52	98% 5d ^{3}P + 2% 5d ^{1}S	54% 5d (5/2,5/2)
726805	726806	−1	95% 5d ^{1}S + 2% 6d ^{1}S	53% 5d (3/2,3/2)
$J = 1$				
392629a	392613	16	100% 5s ^{3}D	100% 5s (3/2,1/2)
671626	671690	−64	82% 5d ^{3}S + 16% 5d ^{3}P	64% 5d (5/2,3/2)
680395	680556	−161	51% 5d ^{1}P + 25% 5d ^{3}D	67% 5d (5/2,5/2)
691622	691698	−76	34% 5d ^{3}P + 44% 5d ^{1}P	51% 5d (3/2,3/2)
694950	694874	76	66% 5d ^{3}D + 28% 5d ^{3}P	52% 5d (3/2,5/2)
–	777213	–	100% 6s ^{3}D	100% 6s (3/2,1/2)
$J = 2$				
381608a	381577	31	63% 5s ^{3}D + 37% 5s ^{1}D	95% 5s (5/2,1/2)
395990a	396008	−18	63% 5s ^{1}D + 37% 5s ^{3}D	95% 5s (3/2,1/2)
679818	679770	48	56% 5d ^{3}P + 40% 5d ^{3}D	83% 5d (5/2,3/2)
684930	684942	−12	45% 5d ^{1}D + 24% 5d ^{3}P	80% 5d (5/2,5/2)
697750	697772	−22	28% 5d ^{3}D + 51% 5d ^{1}D	60% 5d (3/2,5/2)
698488	698518	−30	80% 5d ^{3}F + 16% 5d ^{3}D	63% 5d (3/2,3/2)
–	763907	–	54% 6s ^{1}D + 46% 6s ^{3}D	100% 6s (5/2,1/2)
–	777987	–	54% 6s ^{3}D + 46% 6s ^{1}D	100% 6s (3/2,1/2)
$J = 3$				
378360a	378388	−28	100% 5s ^{3}D	100% 5s (5/2,1/2)
682036	682015	21	56% 5d ^{3}D + 32% 5d ^{3}F	80% 5d (5/2,3/2)
684331	684353	−22	41% 5d ^{1}F + 31% 5d ^{3}D	79% 5d (5/2,5/2)
692976	692933	43	72% 5d ^{3}G + 21% 5d ^{1}F	91% 5d (3/2,3/2)
700131	700215	−84	52% 5d ^{3}F + 34% 5d ^{1}F	95% 5d (3/2,5/2)
–	762884	–	100% 6s ^{3}D	100% 6s (5/2,1/2)
$J = 4$				
678541	678524	17	56% 5d ^{3}G + 42% 5d ^{1}G	97% 5d (5/2,3/2)
685764	685760	4	77% 5d ^{3}F + 19% 5d ^{1}G	96% 5d (5/2,5/2)
696240	696165	75	39% 5d ^{1}G + 40% 5d ^{3}G	97% 5d (3/2,5/2)
$J = 5$				
680206	680069	137	100% 5d ^{3}G	100% 5d (5/2,5/2)
Odd Configurations:				
$J = 0$				
516034a	516027	7	100% 5p ^{3}P	100% 5p (3/2,3/2)
–	856214	–	100% 5f ^{3}P	100% 5f (5/2,5/2)
$J = 1$				
505194	505116	78	80% 5p ^{3}P + 20% 5p ^{3}D	45% 5p (3/2,1/2)
515058a	515083	−25	82% 5p ^{1}P + 14% 5p ^{3}D	52% 5p (3/2,1/2)
525895a	525884	11	66% 5p ^{3}D + 18% 5p ^{1}P	84% 5p (3/2,3/2)
–	857564	–	88% 5f ^{3}P + 11% 5f ^{3}D	81% 5f (5/2,5/2)
–	868961	–	86% 5f ^{3}D + 11% 5f ^{3}P	42% 5f (3/2,5/2)
–	904447	–	76% 5f ^{1}P + 12% 4f ^{1}P	46% 5f (3/2,5/2)
$J = 2$				
489118a	489214	−96	78% 5p ^{3}P + 16% 5p ^{3}D	90% 5p (5/2,1/2)
504541a	504563	−22	87% 5p ^{3}F + 6% 5p ^{3}D	87% 5p (3/2,1/2)
512442a	512554	−112	66% 5p ^{1}D + 19% 5p ^{3}D	80% 5p (5/2,3/2)
528399a	528424	−25	58% 5p ^{3}D + 29% 5p ^{1}D	96% 5p (3/2,3/2)
–	859618	–	63% 5f ^{3}P + 24% 5f ^{3}D	69% 5f (5/2,7/2)
–	862905	–	39% 5f ^{3}F + 38% 5f ^{1}D	74% 5f (5/2,5/2)
–	873827	–	37% 5f ^{3}P + 36% 5f ^{3}D	85% 5f (3/2,7/2)
–	876887	–	61% 5f ^{3}F + 22% 5f ^{1}D	90% 5f (3/2,5/2)
$J = 3$				
492554a	492449	105	54% 5p ^{3}F + 33% 5p ^{1}F	98% 5p (5/2,1/2)
514852a	514739	113	73% 5p ^{3}D + 27% 5p ^{1}F	98% 5p (5/2,3/2)
523790a	523782	8	39% 5p ^{1}F + 46% 5p ^{3}F	98% 5p (3/2,3/2)
–	863109	–	48% 5f ^{3}D + 48% 5f ^{3}F	64% 5f (5/2,5/2)
–	866058	–	46% 5f ^{1}F + 21% 5f ^{3}G	63% 5f (5/2,7/2)
–	878106	–	40% 5f ^{3}F + 25% 5f ^{3}G	92% 5f (3/2,7/2)
–	879982	–	50% 5f ^{3}G + 43% 5f ^{1}F	93% 5f (3/2,5/2)
$J = 4$				
506971a	507014	−43	100% 5p ^{3}F	100% 5p 5/2,3/2)
–	863826	–	79% 5f ^{3}F + 17% 5f ^{3}G	75% 5f (5/2,7/2)
–	864560	–	46% 5f ^{1}G + 27% 5f ^{3}G	73% 5f (5/2,5/2)
–	874961	–	75% 5f ^{3}H + 15% 5f ^{1}G	93% 5f (3/2,5/2)
–	879214	–	45% 5f ^{3}G + 35% 5f ^{1}G	95% 5f (3/2,7/2)

Table VI. *Continued.*

E(exp)	*E*(fit)	ΔE	*LS*-coupling terms	*Jj*-coupling terms
$J = 5$				
–	861087	–	58% 5f ^{3}H + 41% 5f ^{1}H	98% 5f (5/2,5/2)
–	865140	–	78% 5f ^{3}G + 17% 5f ^{1}H	98% 5f (5/2,7/2)
–	876104	–	42% 5f ^{1}H + 37% 5f ^{3}H	98% 5f (3/2,7/2)
$J = 6$				
–	860354	–	100% 5f ^{3}H	100% 5f (5/2,7/2)

a – corrected energy value for a level previously known [8].

Table VII. *Hartree–Fock (HF) and Least-Square-Fitted (LSF) energy parameters for Sb VI, Te VII and I VIII* (cm^{-1}).

		Sb VI			Te VII			I VIII	
Parameter	HF	LSF	LSF/HF	HF	LSF	LSF/HF	HF	LSF	LSF/HF
Even configurations:									
*E*av(4d^{10})	0	1639(57)	–	0	1607(71)	–	0	1575(84)	–
*E*av(5s)	250780	248635(29)	0.985	317504	314695(36)	0.986	389311	385867(43)	0.987
ζ(4d)	3974	4112(25)	1.035	4700	4861(31)	1.034	5504	5692(36)	1.034
*G*0(4d,5s)	16656	14526(264)	0.872	17406	15362(332)	0.883	18133	16173(406)	0.892
*E*av(5d)	477697	480194(14)	1.002	579908	581511(18)	1.000	687251	687858(27)	0.998
ζ(4d)	4010	4132(12)	1.030	4738	4883(16)	1.031	5544	5717(18)	1.031
ζ(5d)	507	619(17)	1.222	699	837(22)	1.197	925	1089(27)	1.177
*F*2(4d,5d)	21686	19281(132)	0.889	25482	22825(167)	0.896	29161	26219(202)	0.899
*F*4(4d,5d)	9673	9771(176)	1.010	11645	11931(223)	1.025	13584	14211(268)	1.046
*G*0(4d,5d)	5119	3944(9)	0.771	6019	4705(11)	0.782	6886	5445(13)	0.791
*G*2(4d,5d)	6327	5915(177)	0.935	7521	7105(214)	0.945	8675	8239(236)	0.950
*G*4(4d,5d)	5213	4874(146)	0.935	6250	5903(178)	0.945	7258	6892(197)	0.950
*E*av(6s)	517112	519180(29)	1.001	639342	640863(36)	1.000	769811	769836(fix)	0.998
ζ(4d)	4012	4144(23)	1.033	4742	4899(29)	1.033	5550	5710(fix)	1.033
*G*0(4d,6s)	4033	3641(282)	0.903	4420	4027(354)	0.911	4792	4409(fix)	0.920
St.Dev.		56			71			84	
Odd configurations:									
*E*av(5p)	345528	346467(24)	0.998	426729	425807(27)	0.994	512171	510424(27)	0.993
ζ(4d)	3988	4130(25)	1.036	4714	4880(27)	1.035	5518	5707(26)	1.034
ζ(5p)	6607	7446(49)	1.127	8493	9436(53)	1.111	10627	11648(52)	1.096
*F*2(4d,5p)	34728	29395(215)	0.846	38346	32704(248)	0.853	41806	36054(253)	0.862
*G*1(4d,5p)	11011	9899(84)	0.899	11882	10740(91)	0.904	12715	11567(89)	0.910
*G*3(4d,5p)	10412	9360(80)	0.899	11432	10333(90)	0.904	12400	11280(87)	0.910
*E*av(5f)	612143	613614(20)	1.000	737660	738421(21)	0.999	868702	868540(fix)	0.998
ζ(4d)	4000	4117(18)	1.029	4726	4819(20)	1.020	5533	5717(fix)	1.015
ζ(5f)	42	42(fix)	1.000	67	67(fix)	1.000	96	96(fix)	1.000
*F*2(4d,5f)	20025	17144(194)	0.856	22422	19324(214)	0.862	24366	21125(fix)	0.867
*F*4(4d,5f)	11591	10507(432)	0.906	12627	12118(482)	0.960	13194	13194(fix)	1.000
*G*1(4d,5f)	20972	11752(80)	0.560	21134	11731(79)	0.555	19788	11081(fix)	0.560
*G*3(4d,5f)	13157	11501(386)	0.874	13822	11734(413)	0.849	13540	11626(fix)	0.850
*G*5(4d,5f)	9297	8127(273)	0.874	9925	8425(296)	0.849	9891	8493(fix)	0.850
St.Dev.		81			90			89	

All the configuration interaction parameters were fixed at 0.85 HF values.

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