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Semi-Empirical Oscillator Strengths and Lifetimes for the P IV Spectrum

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Abstract

In this work numerical codes carried out in a multiconfiguration Hartree-Fock relativistic (HFR) approach for the P IV ion are used to obtain the oscillator strengths of each transition as well as the lifetimes of each energy level. With the existing data from several authors that contributed to the spectrum using different light sources, and optimizing the electrostatic parameters by a least-squares procedure when replacing the theoretical values by the experimental ones in the energy matrices, one obtains closer values and according to the observations for the intensities, and also of the lifetimes closer to those that would be obtained experimentally.

Keywords

P IV Spectrum, Atomic Transitions, Energy Levels, Oscillator Strengths, Lifetimes

1. Introduction

P IV spectrum is a member of the Mg-like isoelectronic sequence with a complete core plus a double-electron valence shell giving singlets and triplets terms. This sequence has several terms of perturbations, a numerous spin-forbidden lines, and also configuration interactions. Some transitions can be explained by a mixing of one or both involved terms with a perturbing term, indicating that each of them possesses a large portion of the wave function of the other ones.

The first analysis of P IV was made by Bowen and Millikan [1] (1925), who identified 23 lines connecting 14 levels belonging to 8 terms. Wavelengths above 2000 Å, were taken from Geuter [2] (1907). The observations in the vacuum ultraviolet region were made by using a vacuum spark between electrodes of magnesium or silicon containing compounds of phosphorus. Another recording of phosphorus in the vacuum ultraviolet was made by Queney [3] in 1929, classifying one line (1902). In 1932 Bowen [4] published observations of 32 additional lines in the same region and enlarged the term system to 29 levels of 15 terms which have been verified in more recent work, although the label of one term has been changed. A new contribution to the analysis of P IV was made by Robinson [5] (1937) using a vacuum spark with beryllium electrodes filled with red phosphorus and extending the observations towards shorter wavelengths. Toresson [6] suggested the change of the terms 3s3d $^1D_2$ and $3p^{2\,1}D_2$ in earlier analyses. Zare [7] [8] indicated that there is a strong mutual interaction between these two ^1D terms along the all isoelectronic sequence, and there is no way to distinguish the terms experimentally. Spectral analysis given by Fawcett [9] for the term $3p3d\,^1P$ has been rejected and replaced by a level now established by 12 combinations. The new value has confirmed the suggestion given by Victor *et al.* [10] to interchange the names $3p3d\,^1P$ and $3p4s\,^1P$ in the íon Si III, since $3p3d\,^1P$ will then run more nearly parallel to the other $3p3d$ terms in the isoelectronic sequence along. Spectral analysis given by Fawcett for higher members of the isoelectronic sequence, from C1 VI to Cr XII, became to be incompatible with the most recent data. Zetterberg and Magnusson [11] studied this ion with complete spectral analysis with new measurements in the whole region from 256 to 9600 Å. The used light source and the spectrographs had a sliding spark in vacuum. Red phosphorus was packed in drilled holes in beryllium electrodes. Between 9800 and 2000 Å the spectrum was recorded by a Jarrell-Ash spectrograph with a plate factor of 5 Å/mm in the first order. In the vacuum region from 2550 to 200 Å, the spectrograms have been taken with a 3 m normal incidence spectrograph using two different gratings and the plate factor of 2.77 Å/mm in the first order. Lines of different ionization stages were separated by varying the inductance in the discharge circuit. P IV lines appear to be best with one or two turns of the coil and a voltage of 6 kV. Fisher and Godefroid [12] [13] have done extensive MCHF calculations of transitions probabilities for lines that involved singlets reporting an appreciable mixing of the configuration when the energies are very close. The plunging configurations and Rydberg series of the $3snf\,^1F$ lower members are strongly mixed. The relativistic and non-relativistic analysis of percentage composition of levels have shown that the upper and lower eigenvectors of the interaction are respectively dominated for $3s4f$ and $3p3d$ with the terms ^1F. Martin *et al.* [14] compiled all the known energy levels of all the phosphorus ions.

The ionization energy limit for this ion derived by means of a polarization formula applied to terms of the $3snh$, $3sni$ and $3snk$ series is estimated as being 414,922.8 ± 1.0 cm^{-1} (51.4443 ± 0.0002 eV) [11].

So then, the purpose of this study is to present the oscillator strengths and lifetimes for experimentally known electric dipole transitions and energy levels for this spectrum. In order to obtain these values, the reduced matrix elements are calculated by using an optimization of the energy parameters which were adjusted from a least-squares procedure. In this adjustment, the code fits experimental levels by varying the electrostatic parameters. This procedure improves the values of the wavelengths σ in,

$$gf = \frac{8\pi mca_0\sigma}{3h} \tag{1}$$

with S being the electric dipole line strength. Also the quantities, $y^{\gamma}_{\beta J}$ and $y^{\gamma'}_{\beta' J'}$ that measure the total strength of the spectral line in

$$S^{1/2}_{\gamma\gamma'} = \sum_{\beta}\sum_{\beta'} y^{\gamma}_{\beta J} \left\langle \beta J \left\| \mathrm{P}^1 \right\| \beta' J' \right\rangle y^{\gamma'}_{\beta' J'} \tag{2}$$

were improved in this new fitting. Considering that,

$$P(\gamma J) = \sum A(\gamma J, \gamma' J') \tag{3}$$

as the probability per unit time of an atom in a specific state γJ to make a spontaneous transition to any state with lower energy being $A(\gamma J, \gamma' J')$ the Einstein spontaneous emission transition probability rate related to the natural lifetime $\tau(\gamma J)$ of a state by,

$$\tau(\gamma J) = \left(\sum A(\gamma J, \gamma' J')\right)^{-1} \tag{4}$$

These equations must to be applied to an isolated atom. Matter or radiation interaction will tend to reduce their values. In this way, the values for gf and lifetime given in this work were calculated according to previous equations.

For to convert the wavelengths $\lambda_{vac} = n\lambda_{air}$ given by the code, were used the relation [15],

$$n = 1.0 + 8342.13\times10^{-8} + \frac{2406030.0}{130.0\times10^{8} - \sigma^2} + \frac{15997.0}{38.9\times10^{8} - \sigma^2} \tag{5}$$

for the index of refraction (dry air containing 0.03 CO_2 by volume at normal pressure and T = 15˚C).

2. Methodology of Calculation

The theoretical predictions for the energy level values were obtained diagonalizing the energy matrices with appropriate Hartree-Fock relativistic (HFR) values for the electrostatic parameters. In these computations all strong configuration interactions were included and HFR method is used to give a better accuracy in many cases. For this purpose, the computer code developed by Cowan [16] was employed. The main purpose is to reach a fitting to the experimental energy levels, minimizing the uncertainties as much as possible, using the least-squares method for each parity. The standard deviation is less than one percent of the energy range covered by the energy levels. The accuracy is related in the computation of the gf and lifetimes values. The propagated experimental uncertainties of the input data, in the optimization of the energy levels, does not influence the process, being small values when are compared to the uncertanties coming from the fitting. The radial integrals E_{AV}, F^k, G^k and R^k are considered simply as adjustable parameters, whose values are to be determined empirically so as to give the best possible fitting between the calculated eigenvalues and the observed energy levels. The values for the optimized electrostatic parameters substitute their corresponding theoretical values, and the are used again to calculate energy matrices.

3. Results and Discussion

The P IV spectrum is characterized by strong interactions among their configurations yelding a mixture of levels that difficult a severe analysis. These effects of perturbations are stronger on the singlet levels, namely in $3p^2$, $3s3d$, $3s4d$, $3s5g$, $3s6s$, $3p4p$ and $3d^2$. He same effect appears in the $3p3d$, $3s4f$, $3p4s$, $3s5p$, $3s5f$, $3p4d$ and $3s8f$ configurations. There are many examples of spin-forbidden lines caused by near coincidence of singlet and triplet levels with the same J-value.

Also, configuration interactions are numerous. Apparent two-electron transitions, such as 3s5p ^1P - $3p4p\ ^1P$, $3s4d\ ^3D$ - $3p4s\ ^3P$ or $3p^2\ ^1D$ - $3snf\ ^1F$, $3s6s\ ^3$S - $3p4p\ ^3S$, can be explained by a mixing of one or both of the involved terms with a perturbing term. The term $3p^{2\,1}D$ combines just like $3s3d\ ^1D$, indicating that each of them possesses a large portion of the wavefunction of the other one. The perturbation of $3s7p\ ^3P$ by the inverted $3p4d\ ^3P$ term is also evident. The energy levels used in our fitting method are from spectral analyses [11], even though the code has exchanged values making it difficult to adjust the electrostatic parameters. The fittings were achieved by considering some simplifications such as keeping fixed those singlet energy levels that exchanged their values due to mutual interactions, —$3p3d\ ^1F$ (fitted 290 3268; experimental 314 4237), $3s4f\ ^1F$ (fitted 314 4251 - experimental 290 3277), $3p4s\ ^1P$ (fitted 316 8828 - experimental 327 8735), $3s5p\ ^1P$ (fitted 321 0106 - experimental 316 8888), $3s8f\ ^1F$ (fitted 385 9827 - experimental 388 1242), $3p4d\ ^1F$ (fitted 388 1209 - experimental 385 9800), —and where there was no success in reproducing the observed structure these levels were not included in the calculations of *gf* and lifetimes, however, we retain the percentage compositions with the values indicated by the adjustment.

Standard deviation reached for each parity as 10 cm^{-1} and 17 cm^{-1}, for even and odd configurations, respectively, were satisfactory for the aims of this work [16]. The leading eigenvector percentages are in accordance with those provided by the numerical code [16].

In **Table 1** (for the vacuum region) and **Table 2** (in the air), are shown the results for the oscillator strengths. A comparison with the observed wavelegenths values derived from previous works, as well as their nomenclatures of intensities adopted are also shown. **Table 3** (even configurations) and **Table 4** (odd configurations) for the lifetimes values, are shown as well as the eigenvectors percentages composition.

4. Conclusion

Semi-empirical values of oscillator strengths and lifetimes for the known spec-

Table 1. P IV wavelengths and semi-empirical oscillator strengths calculated in the region vacuum-ultraviolet.

gf	Intensity and shape	$\lambda_{Obs.}$ (Å)	$\lambda_{Calc.}$ (Å)	$\sigma_{Calc.}$ (cm^{-1})	Lower			Upper	
0.0072	1	256 453	256 4555	389 9312	$3s^2$	$^1S_0$	-	$3s9p$	$^1P_1$
0.0086	2	261 477	261 4716	382 7161	$3s^2$	$^1S_0$	-	$3s8p$	$^1P_1$
0.0116	4	269 117	261 1171	371 5855	$3s^2$	$^1S_0$	-	$3s7p$	$^1P_1$
0.0173	6	282 301	282 2990	354 2343	$3s^2$	$^1S_0$	-	$3s6p$	$^1P_1$
0.0032	1	304 364	304 3653	328 5531	$3s3p$	$^3P_1$	-	$3s10d$	$^3D_2$
0.0010	1	,,	304 3658	328 5531	$3s3p$	$^3P_1$	-	$3s10d$	$^3D_1$
0.0060	1	304 805	304 7985	328 0856	$3s3p$	$^3P_2$	-	$3s10d$	$^3D_3$
0.0011	1	,,	304 7993	328 0847	$3s3p$	$^3P_2$	-	$3s10d$	$^3D_2$
0.0001	1	,,	304 7999	328 0841	$3s3p$	$^3P_2$	-	$3s10d$	$^3D_1$
0.0005	6	,,	306 9883	325 7453	$3s3p$	$^3P_0$		$3s10s$	$^3S_1$
0.0015	0	307 203	306 9883	325 5163	$3s3p$	$^3P_1$	-	$3s10s$	$^3S_1$
0.0026	1	307 648	307 6471	325 0476	$3s3p$	$^3P_2$	-	$3s10s$	$^3S_1$
0.0021	1	308 402	308 3986	324 2559	$3s3p$	$^3P_0$	-	$3s9d$	$^3D_1$
0.0040	2	308 615	308 6160	324 0273	$3s3p$	$^3P_1$	-	$3s9d$	$^3D_2$
0.0013	2	308 615	308 6165	324 0267	$3s3p$	$^3P_1$	-	$3s9d$	$^3D_1$
0.0085	3	309 060	309 0615	323 5602	$3s3p$	$^3P_2$	-	$3s9d$	$^3D_3$
0.0015	3	,,	309 0622	323 5594	$3s3p$	$^3P_2$	-	$3s9d$	$^3D_2$
0.0001	3	,,	309 0628	323 5589	$3s3p$	$^3P_2$	-	$3s9d$	$^3D_1$
0.0026	1	312 566	312 5660	319 9315	$3s3p$	$^3P_1$	-	$3s9s$	$^3S_1$
0.0044	2	313 024	313 0247	319 4636	$3s3p$	$^3P_2$	-	$3s9s$	$^3S_1$
0.0030	2	314 300	314 3026	318 1648	$3s3p$	$^3P_0$	-	$3s8d$	$^3D_1$
0.0019	5	314 512	314 1410	318 3283	$3s^2$	$^1S_0$	-	$3p4s$	$^3P_1$
0.0066	5	,,	314 5284	317 9363	$3s3p$	$^3P_1$	-	$3s8d$	$^3D_2$
0.0022	5	,,	314 5296	317 9351	$3s3p$	$^3P_1$	-	$3s8d$	$^3D_1$
0.0123	3	314 991	314 9916	317 4688	$3s3p$	$^3P_2$	-	$3s8d$	$^3D_3$
0.0013	3	314 991	314 9919	317 4684	$3s3p$	$^3P_2$	-	$3s8d$	$^3D_2$
0.0001	3	314 991	314 9931	317 4672	$3s3p$	$^3P_2$	-	$3s8d$	$^3D_1$
0.0014	1	320 462	320 4601	312 0513	$3s3p$	$^3P_0$	-	$3s8s$	$^3S1$
0.0042	2	320 701	320 6961	311 8216	$3s3p$	$^3P_1$	-	$3s8s$	$^3S_1$
0.0071	2	321 172	321 1781	311 3538	$3s3p$	$^3P_2$	-	$3s8s$	$^3S_1$
0.0046	2	323 502	323 5039	309 1153	$3s3p$	$^3P_0$	-	$3s7d$	$^3D_1$
0.0096	3	323 734	323 7383	308 8915	$3s3p$	$^3P_1$	-	$3s7d$	$^3D_2$
0.0178	4	324 221	324 2197	308 4328	$3s3p$	$^3P_2$	-	$3s7d$	$^3D_3$
0.1468	2	325 651	325 6447	307 0831	$3s^2$	$^1S_0$	-	$3p3d$	$^1P_1$
0.0025	3	333 758	333 7582	299 6181	$3s3p$	$^3P_0$	-	$3s7s$	$^3S_1$

Continued

0.0074	4	334 013	334 0142	299 3885	$3s3p$	$^3P_1$	-	$3s7s$	$^3S_1$
0.0128	5	334 538	334 5343	298 9230	$3s3p$	$^3P_2$	-	$3s7s$	$^3S_1$
0.0075	3	338 841	338 8416	295 1231	$3s3p$	$^3P_0$	-	$3s6d$	$^3D_1$
0.0168	5	339 101	339 8613	294 2377	$3s3p$	$^3P_1$	-	$3s6d$	$^3D_2$
0.0229	6	339 633	339 6331	294 4353	$3s3p$	$^3P_2$	-	$3s6d$	$^3D_3$
0.0037	1	346 490	346 4904	288 6083	$3s3p$	$^1P_1$	-	$3s10s$	$^1S_0$
0.0000	0	351 808	351 8111	284 2429	$3s3p$	$^3P_1$	-	$3p4p$	$^1D_2$
0.0043	2	353 236	353 2354	283 0974	$3s3p$	$^1P_1$	-	$3s9s$	$^1S_0$
0.0055	2 b	356 364	356 3649	280 6112	$3s3p$	$^1P_1$	-	$3s8d$	$^1D_2$
0.0112	2	,,	356 4066	280 5784	$3s3p$	$^3P_2$	-	$3p4p$	$^3S_1$
0.0107	5	357 708	357 7277	279 5422	$3s3p$	$^3P_1$	-	$3p4p$	$^3P_2$
0.0110	5	357 837	357 8229	279 4679	$3s3p$	$^3P_0$	-	$3p4p$	$^3P_1$
0.0120	5	358 132	358 1171	279 2382	$3s3p$	$^3P_1$	-	$3p4p$	$^3P_1$
0.0320	8 b	358 328	358 3275	279 0743	$3s3p$	$^3P_2$	-	$3p4p$	$^3P_2$
0.0079	8 b	,,	358 3720	279 0397	$3s3p$	$^3P_1$	-	$3p4p$	$^3P_0$
0.0110	6	358 736	358 7182	278 7704	$3s3p$	$^3P_2$	-	$3p4p$	$^3P_1$
0.0051	5	358 999	358 9827	278 5649	$3s3p$	$^3P_0$	-	$3s6s$	$^3S_1$
0.0155	7	359 293	359 2789	278 3353	$3s3p$	$^3P_1$	-	$3s6s$	$^3S_1$
0.0253	8	359 899	359 8839	277 8674	$3s3p$	$^3P_2$	-	$3s6s$	$^3S_1$
0.0065	7	361 514	361 5237	276 6070	$3s3p$	$^3P_0$	-	$3p4p$	$^3D_1$
0.0110	7	,,	361 5374	276 5966	$3s3p$	$^3P_1$	-	$3p4p$	$^3D_2$
0.0324	8	361 629	361 6775	276 4894	$3s3p$	$^3P_2$	-	$3p4p$	$^3D_3$
0.0047	4	361 802	361 8241	276 3774	$3s3p$	$^3P_1$	-	$3p4p$	$^3D_1$
0.0026	5	362 133	362 1500	276 1287	$3s3p$	$^3P_2$	-	$3p4p$	$^3D_2$
0.0001	1	362 412	362 2450	276 0563	$3s3p$	$^3P_2$	-	$3p4p$	$^3D_1$
0.0068	2	363 467	363 4678	275 1276	$3s3p$	$^1P_1$	-	$3s8s$	$^1S_0$
0.0000	1	363 933	363 9296	274 7784	$3s3p$	$^1P_1$	-	$3s8s$	$^3S_1$
0.0117	3	367 660	367 6527	271 9958	$3s3p$	$^1P_1$	-	$3s7d$	$^1D_2$
0.0280	7	371 299	371 2876	269 3330	$3s3p$	$^3P_0$	-	$3s5d$	$^3D_1$
0.0622	8	371 504	371 4961	269 1818	$3s3p$	$^3P_1$	-	$3s5d$	$^3D_2$
0.0211	5	371 611	371 6044	269 1033	$3s3p$	$^3P_1$	-	$3s5d$	$^3D_1$
0.1134	9	372 001	371 9997	268 8174	$3s3p$	$^3P_2$	-	$3s5d$	$^3D_3$
0.0207	5	372 150	372 1429	268 7140	$3s3p$	$^3P_2$	-	$3s5d$	$^3D_2$
0.0014	2	372 256	372 2517	268 6355	$3s3p$	$^3P_2$	-	$3s5d$	$^3D_1$
0.0148	5	380 152	380 1439	263 0583	$3s3p$	$^1P_1$	-	$3s7s$	$^1S_0$
0.0182	6	386 752	386 2796	258 8798	$3s3p$	$^1P_1$	-	$3s6d$	$^1D_2$
0.1041	14	388 318 0.315[R]	388 3154	257 5226	$3s^2$	$^1S_0$	-	$3s4p$	$^1P_1$

Continued

0.0010	6	389 698		389 6922	256 6128	$3s^2$	$^1S_0$	-	$3s4p$	$^3P_1$
0.0126	5	392 901		392 9707	254 4719	$3s3p$	$^1P_1$	-	$3p4p$	$^1S_0$
0.0117	8	404 535		404 5324	247 1989	$3s3p$	$^1P_1$	-	$3p4p$	$^1D_2$
0.0000	4	409 827		409 8309	244 0031	$3s3p$	$^1P_1$	-	$3p4p$	$^3S_1$
0.0177	6	412 521		412 5212	242 4118	$3s3p$	$^1P_1$	-	$3s6s$	$^1S_0$
0.0087	7	414 604		414 6044	241 1938	$3s3p$	$^3P_0$	-	$3s5s$	$^3S_1$
0.0168	9	414 999	5.022^R	414 9995	240 9642	$3s3p$	$^3P_1$	-	$3s5s$	$^3S_1$
0.0830	10	415 805	0.815^R	415 8068	240 4963	$3s3p$	$^3P_2$	-	$3s5s$	$^3S_1$
0.0003	1	417 828		417 8259	239 3341	$3p^2$	$^1D_2$	-	$3s10f$	$^1F_3$
0.0559	9	424 235		424 2118	235 7313	$3s3p$	$^1P_1$	-	$3p4p$	$^1P_1$
0.0396	2	424 983		424 9937	235 3025	$3p^2$	$^1D_2$	-	$3s9f$	$^1F_3$
0.0117	2	429 475		429 4234	232 8704	$3s3p$	$^1P_1$	-	$3s5d$	$^1D_2$
0.3225	1	433 838		433 8390	230 5002	$3p^2$	$^1D_2$	-	$3p4d$	$^1P_1$
0.0189	9	443 803		443 8020	225 3257	$3s3p$	$^3P_0$	-	$3s4d$	$^3D_1$
0.0425	10	444 245	0.249^R	444 2447	225 1011	$3s3p$	$^3P_1$	-	$3s4d$	$^3D_2$
0.0789	11	445 158	0.194^R	445 1553	224 6407	$3s3p$	$^3P_2$	-	$3s4d$	$^3D_3$
0.0006	1	445 810		445 8244	224 3035	$3p^2$	$^1D_2$	-	$3s8p$	$^1P_1$
0.0000	0	446 121		446 1165	224 1567	$3p^2$	$^3P_2$	-	$3s9p$	$^3P_1$
0.0000	0	,,		446 1165	224 1567	$3p^2$	$^3P_2$	-	$3s9p$	$^3P_2$
0.0001	0	448 466		448 4673	222 9817	$3p^2$	$^3P_2$	-	$3p4d$	$^1P_1$
0.0202	2	450 448		450 4477	222 0013	$3p^2$	$^1D_2$	-	$3p4d$	$^1D_2$
0.1096	4	453 707		453 7162	222 0402	$3p^2$	$^1D_2$	-	$3s7f$	$^1F_3$
0.0286	1	455 466		455 4653	219 5557	$3p^2$	$^3P_2$	-	$3p4d$	$^3P_2$
0.0000	0	461 834		461 8317	216 0613	$3p^2$	$^3P_1$	-	$3s8p$	$^3P_0$
0.0000	0	,,		461 8317	216 0613	$3p^2$	$^3P_1$	-	$3s8p$	$^3P_1$
0.0012	0	462 050		462 0488	216 4273	$3p^2$	$^3P_1$	-	$3p4d$	$^3D_1$
0.0943	2	462 185		858 5173	216 3586	$3p^2$	$^3P_2$	-	$3p4d$	$^3D_3$
0.0159	1	462 625		864 6893	216 1556	$3p^2$	$^3P_2$	-	$3p4d$	$^3D_2$
0.0000	0	462 827		,,	216 0610	$3p^2$	$^3P_2$	-	$3s8p$	$^3P_1$
0.0000	0	,,		,,	216 0610	$3p^2$	$^3P_2$	-	$3s8p$	$^3P_2$
0.0012	2	463 060		463 0589	215 9553	$3p^2$	$^3P_2$	-	$3p4d$	$^3D_1$
0.0037	4	463 843		463 8442	215 5896	$3p^2$	$^3P_2$	-	$3p4d$	$^3F_2$
0.0006	3 bl P III	468 502		468 5177	213 4391	$3p^2$	$^1D_2$	-	$3s7p$	$^1P_1$
0.2115	5	480 756		484 6893	208 0045	$3p^2$	$^1D_2$	-	$3s6f$	$^1F_3$
0.0000	0 b	484 757		484 7871	206 2761	$3p^2$	$^3P_1$	-	$3s7p$	$^3P_0$
0.0000	0 b	,,		484 7171	206 2961	$3p^2$	$^3P_1$	-	$3s7p$	$^3P_1$
0.0000	0 b	,,		484 7380	206 2970	$3p^2$	$^3P_1$	-	$3s7p$	$^3P_2$

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0.0423	7 bl P III	485 453	485 4644	205 9883	$3s3p$	$^{1}P_{1}$	-	$3s5s$	$^{1}S_{0}$
0.0000	0	485 854	485 8408	205 8287	$3p^{2}$	$^{3}P_{2}$	-	$3s7p$	$^{3}P_{1}$
0.0000	0	,,	485 8408	205 8287	$3p^{2}$	$^{3}P_{2}$	-	$3s7p$	$^{3}P_{2}$
0.0303	6 b	491 008	491 0008	203 6626	$3s3d$	$^{3}D_{1}$	-	$3s9f$	$^{3}F_{2}$
0.0056	6 b	,,	491 0008	203 6626	$3s3d$	$^{3}D_{2}$	-	$3s9f$	$^{3}F_{2}$
0.0449	6 b	,,	491 0008	203 6626	$3s3d$	$^{3}D_{2}$	-	$3s9f$	$^{3}F_{3}$
0.0002	6 b	,,	491 0008	203 6626	$3s3d$	$^{3}D_{3}$	-	$3s9f$	$^{3}F_{2}$
0.0056	6 b	,,	491 0008	203 6626	$3s3d$	$^{3}D_{3}$	-	$3s9f$	$^{3}F_{3}$
0.0649	6 b	,,	491 0008	203 6626	$3s3d$	$^{3}D_{3}$	-	$3s9f$	$^{3}F_{4}$
0.0036	1 b	498 968	498 9709	200 4125	$3s3d$	$^{3}D_{3}$	-	$3s9p$	$^{3}P_{2}$
0.0006	1 b	,,	498 9709	200 4125	$3s3d$	$^{3}D_{2}$	-	$3s9p$	$^{3}P_{2}$
0.0019	1 b	,,	498 9709	200 4125	$3s3d$	$^{3}D_{2}$	-	$3s9p$	$^{3}P_{1}$
0.0000	1 b	,,	498 9709	200 4125	$3s3d$	$^{3}D_{1}$	-	$3s9p$	$^{3}P_{2}$
0.0006	1 b	,,	498 9709	200 4125	$3s3d$	$^{3}D_{1}$	-	$3s9p$	$^{3}P_{1}$
0.0009	1 b	,,	498 9709	200 4125	$3s3d$	$^{3}D_{1}$	-	$3s9p$	$^{3}P_{0}$
0.1069	5 b	505 387	505 6928	196 5823	$3s3d$	$^{3}D_{3}$	-	$3s8f$	$^{3}F_{4}$
0.0092	5 b	,,	505 6928	196 5823	$3s3d$	$^{3}D_{3}$	-	$3s8f$	$^{3}F_{3}$
0.0739	5 b	,,	505 6928	196 5823	$3s3d$	$^{3}D_{2}$	-	$3s8f$	$^{3}F_{3}$
0.0499	5 b	,,	505 6928	196 5823	$3s3d$	$^{3}D_{1}$	-	$3s8f$	$^{3}F_{2}$
0.0000	3	509 964	509 9750	196 0880	$3p^{2}$	$^{1}D_{2}$	-	$3s6p$	$^{1}P_{1}$
0.0004	4	519 171	519 1716	192 6145	$3s3d$	$^{3}D_{2}$	-	$3p4d$	$^{3}D_{3}$
0.0006	4	,,	519 17 17	192 6144	$3s3d$	$^{3}D_{3}$	-	$3p4d$	$^{3}D_{3}$
0.0002	4	519 718	519 7194	192 4115	$3s3d$	$^{3}D_{1}$	-	$3p4d$	$^{3}D_{2}$
0.0008	4	,,	519 7194	192 4114	$3s3d$	$^{3}D_{2}$	-	$3p4d$	$^{3}D_{2}$
0.0003	4	,,	519 7195	192 4114	$3s3d$	$^{3}D_{3}$	-	$3p4d$	$^{3}D_{2}$
0.0078	0 bl	519 930	519 9361	192 3312	$3s3d$	$^{3}D_{3}$	-	$3p4d$	$^{3}F_{4}$
0.0014	1 bl	519 973	519 9748	1923170	$3s3d$	$^{3}D_{1}$	-	$3s8p$	$^{3}P_{0}$
0.0011	1 bl	519 973	519 9748	1923170	$3s3d$	$^{3}D_{1}$	-	$3s8p$	$^{3}P_{1}$
0.0032	1 bl	519 973	519 9748	1923170	$3s3d$	$^{3}D_{2}$	-	$3s8p$	$^{3}P_{1}$
0.0011	1 bl	519 973	519 9748	192 3170	$3s3d$	$^{3}D_{2}$	-	$3s8p$	$^{3}P_{2}$
0.0059	1 bl	519 973	519 9748	192 3170	$3s3d$	$^{3}D_{3}$	-	$3s8p$	$^{3}P_{2}$
0.0000	4	520 246	520 2462	192 3170	$3s3d$	$^{3}D_{1}$	-	$3p4d$	$^{3}D_{1}$
0.0000	4	520 246	520 2462	192 3170	$3s3d$	$^{3}D_{2}$	-	$3p4d$	$^{3}D_{1}$
0.0004	0	520 751	520 7523	192 0299	$3s3d$	$^{3}D_{2}$	-	$3p4d$	$^{3}F_{3}$
0.0041	0	,,	520 7523	192 0299	$3s3d$	$^{3}D_{3}$	-	$3p4d$	$^{3}F_{3}$
0.0006	1	521 246	521 2466	191 8477	$3s3d$	$^{3}D_{1}$	-	$3p4d$	$^{3}F_{2}$
0.0000	1	,,	,,	191 8477	$3s3d$	$^{3}D_{2}$	-	$3p4d$	$^{3}F_{2}$

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0.0000	1	„	„	191 8477	3s3d	$^3D_3$	-	3p4d	$^3F_2$
0.0042	6	525 932	525 9340	190 1379	3s3p	$^1P_1$	-	3s4d	$^1D_2$
0.0000	5	528 672	528 6791	189 1500	3s3d	$^3D2$	-	3s7f	$^1F3$
0.0000	5	„	528 6792	189 1500	3s3d	$^3D3$	-	3s7f	$^1F3$
0.0912	8 b	528 834	528 8339	189 0953	3s3d	$^3D_1$	-	3s7f	$^3F_2$
0.1352	8 b	„	528 8339	189 0953	3s3d	$^3D_2$	-	3s7f	$^3F_3$
0.0169	8 b	„	528 8339	189 0953	3s3d	$^3D_2$	-	3s7f	$^3F_2$
0.1955	8 b	„	528 8339	189 0953	3s3d	$^3D_3$	-	3s7f	$^3F_4$
0.0169	8 b	„	528 8339	189 0953	3s3d	$^3D_3$	-	3s7f	$^3F_3$
0.0005	8 b	„	528 8340	189 0953	3s3d	$^3D_3$	-	3s7f	$^3F_2$
0.0000	1	530 534	530 5350	188 4871	$3p^2$	$^3P_1$	-	3s6p	$^3P_1$
0.0001	1	531 758	531 7630	188 0537	$3p^2$	$^3P_2$	-	3s6p	$^3P_2$
0.0015	0	532 312	532 3152	187 0572	$3p^2$	$^1S_0$	-	3s8p	$^1P_1$
0.5154	6	533 297	532 3082	187 5088	$3p^2$	$^1D_2$	-	3s5f	$^1F_3$
0.0001	3 b	549 221	549 1956	182 0845	3s3d	$^3D_1$	-	3s7p	$^3P_2$
0.0020	3 b	„	549 1956	182 0845	3s3d	$^3D_2$	-	3s7p	$^3P_2$
0.0110	3 b	„	549 1957	182 0845	3s3d	$^3D_3$	-	3s7p	$^3P_2$
0.0019	3 b	„	549 2587	182 0636	3s3d	$^3D_1$	-	3s7p	$^3P_1$
0.0058	3 b	„	549 2587	182 0636	3s3d	$^3D_2$	-	3s7p	$^3P_1$
0.0026	3 b	„	549 2835	182 0553	3s3d	^3D_l	-	3s7p	$^3P_0$
0.4047	10 bl P III	568 038	568 0243	176 0482	3s3d	$^3D_3$	-	3s6f	$^3F_4$
0.2798	10 bl P III	„	568 0270	176 0480	3s3d	$^3D_3$	-	3s6f	$^3F_3$
0.0350	10 bl P III	„	568 0270	176 0480	3s3d	$^3D_3$	-	3s6f	$^3F_2$
0.1889	10 bl P III	„	568 0270	176 0480	3s3d	$^3D_2$	-	3s6f	$^3F_3$
0.0350	10 bl P III	„	568 0290	176 0474	3s3d	$^3D_2$	-	3s6f	$^3F_2$
0.0010	10 bl P III	„	568 0290	176 0474	3s3d	$^3D_1$	-	3s6f	$^3F_2$
0.0242	2	573 760	573 7561	174 2901	3s3d	$^1D_2$	-	3s9f	$^1F_3$
0.0000	0	602 945	602 9526	165 8505	3s3p	$^3P_1$	-	3s4s	$^1S_0$
0.0001	4	608 613	608 6078	164 3094	3s3d	$^3D1$	-	3s6p	$^3P_2$
0.0000	4	608 613	608 6078	164 3094	3s3d	$^3D2$	-	3s6p	$^3P_2$
0.0248	4	608 613	608 6078	164 3094	3s3d	$^3D_3$	-	3s6p	$^3P_2$
0.0044	4	608 741	608 7351	164 2750	3s3d	$^3D_1$	-	3s6p	$^3P_1$
0.0132	4	608 741	608 7869	164 2749	3s3d	$^3D_2$	-	3s6p	$^3P_1$
0.0059		608 741	608 7876	164 2748	3s3d	$^3D_1$	-	3s6p	$^3P_0$
0.0009	0	624 129	624 1430	160 2197	$3p^2$	$^1D_2$	-	3p4s	$^3P_2$
0.0092	4	625 724	625 7720	159 8026	$3p^2$	$^1D_2$	-	3p4s	$^3P_1$
0.0480	7	627 374	627 3741	159 3945	3s3d	$^1D_2$	-	3s7f	$^1F_3$

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0.1040	12	629 008 8.983[B]	629 0090	158 9802	3s3p	$^3P_0$	-	3s4s	$^3S_1$
0.3114	13	629 914 0.914[B]	629 9185	158 7507	3s3p	$^3P_1$	-	3s4s	$^3S_1$
0.5175	14	631 779 0.765[B]	631 7804	158 2828	3s3p	$^3P_2$	-	3s4s	$^3S_1$
0.0167	5	634 928	634 9282	157 4981	$3p^2$	$^3P_0$	-	3s5p	$^3P_1$
0.0250	6	635 501	635 5022	157 3559	$3p^2$	$^3P_1$	-	3s5p	$^3P_2$
0.0126	6	635 915	635 9150	157 2537	$3p^2$	$^3P_1$	-	3s5p	$^3P_1$
0.0153	5	636 124	636 1233	157 2022	$3p^2$	$^3P_1$	-	3s5p	$^3P_0$
0.0714	7	637 398	637 3990	156 8876	$3p^2$	$^3P_2$	-	3s5p	$^3P_2$
0.0209	6	637 817	637 8142	156 7855	$3p^2$	$^3P_2$	-	3s5p	$^3P_1$
1.0758	12	648 482 0.507[R]	648 4805	154 2066	3s3d	$^3D_3$	-	3s5f	$^3F_4$
0.7437	12	,,	648 4838	154 2058	3s3d	$^3D_2$	-	3s5f	$^3F_3$
0.0930	12	,,	648 4839	154 2058	3s3d	$^3D_3$	-	3s5f	$^3F_3$
0.5020	12	,,	648 4839	154 2058	3s3d	$^3D_1$	-	3s5f	$^3F_2$
0.0930	12	,,	648 4839	154 2058	3s3d	$^3D_2$	-	3s5f	$^3F_2$
0.2859	7	652 836 0.79[B]	652 8233	153 1808	$3p^2$	$^3P_1$	-	3p4s	$^3P_2$
0.2206	6	653 528 0.51[B]	653 5601	153 0081	$3p^2$	$^3P_0$	-	3p4s	$^3P_1$
0.1662	6	654 569 0.54[B]	654 6057	152 7637	$3p^2$	$^3P_1$	-	3p4s	$^3P_1$
0.8542	8	654 839 0.86[B]	654 8251	152 7125	$3p^2$	$^3P_2$	-	3p4s	$^3P_2$
0.2323	7	655 778 0.78[B]	655 7572	152 4955	$3p^2$	$^3P_1$	-	3p4s	$^3P_0$
0.0087	1	656 029	656 0320	152 4316	3s3d	$^1D_2$	-	3s7p	$^1P_1$
0.2792	7	656 583 0.55[B]	656 6184	152 2954	$3p^2$	$^3P_2$	-	3p4s	$^3P_1$
0.0004	5	662 219	662 2220	151 0068	3s3p	$^3P_1$	-	3s3d	$^1D_2$
0.0001	3	664 277	664 2801	150 5389	3s3p	$^3P_2$	-	3s3d	$^1D_2$
0.2358	6	671 400	671 1370	149 0009	$3p^2$	$^1D_2$	-	3p3d	$^1P_1$
0.0996	7	680 306	680 3055	146 9924	3s3d	$^1D_2$	-	3s6f	$^1F_3$
0.0000	2	683 571	683 5639	146 2921	3s3d	$^1D_2$	-	3s6f	$^3F_3$
0.0000	2	683 571	680 5664	146 2916	3s3d	$^1D_2$	-	3s6f	$^3F_2$
0.0008	3	726 811	726 8085	137 5878	3s4s	$^1S_0$	-	3s7p	$^1P_1$
0.0010	6	751 069	751 0703	133 1433	3s3d	$^3D_1$	-	3s5p	$^3P_2$
0.0151	6	751 069	751 0703	133 1433	3s3d	$^3D_2$	-	3s5p	$^3P_2$
0.0844	6	751 069	751 0703	133 1433	3s3d	$^3D_3$	-	3s5p	$^3P_2$
0.0151	6	751 651	751 6469	133 0401	3s3d	$^3D_1$	-	3s5p	$^3P_1$
0.0452	6	751 651	751 6469	133 0401	3s3d	$^3D_2$	-	3s5p	$^3P_1$
0.0201	5	751 944	751 9380	132 9897	3s3d	$^3D_1$	-	3s5p	$^3P_0$
0.0001	2	765 958	765 9556	130 5559	3s4p	$^1P_1$	-	3s9s	$^3S_1$
0.0012	2	772 382	772 3890	129 4716	3s4p	$^3P_1$	-	3s8d	$^3D_1$
0.0035	2	772 382	771 3890	129 4716	3s4p	$^3P_1$	-	3s8d	$^3D_2$

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0.2174	11	776 353 0.340^{B}	776 3532	128 8074	3s3p	$^1P_1$	-	3s4s	$^1S_0$
0.0069	0	785 590	785 5912	127 2910	3p3d	$^3F_2$	-	3d2	$^1D_2$
0.0149	2	788 580	788 5851	126 8094	3s4s	$^3S_1$	-	3s6p	$^3P_2$
0.0089	1	788 797	788 7984	126 7752	3s4s	$^3S_1$	-	3s6p	$^3P_1$
0.3274	8	790 508	790 5058	126 5013	3s3d	$^1D_2$	-	3s5f	$^1F_3$
0.0001	3	790 844	790 8631	126 4441	3s3p	$^3P_1$	-	3p2	$^1S_0$
0.0075	5	798 803	798 8031	125 1872	$3p^2$	$^1D_2$	-	3p3d	$^3D_3$
0.0018	3	799 326	799 3272	125 1048	$3p^2$	$^1D_2$	-	3p3d	$^3D_2$
0.0059	3	810 595	810 6507	123 3577	$3p^2$	$^1S_0$	-	3p4s	$^3P_1$
0.0173	0	814 386	814 3790	122 7290	3s4p	$^1P_1$	-	3s8s	$^1S_0$
3.0931	5	817 786	817 7868	122 2813	3p3d	$^1D_2$	-	3d2	$^1D_2$
0.8645	16	823 179 0.177^{B}	823 1794	121 4802	3s3p	$^3P_0$	-	3s3d	$^3D_1$
1.9413	17	824 730 0.733^{B}	824 7379	121 2506	3s3p	$^3P_1$	-	3s3d	$^3D_2$
0.6471	17	824 730 0.733^{B}	824 7379	121 2506	3s3p	$^3P_1$	-	3s3d	$^3D_1$
3.6100	18	827 932 0.932^{B}	827 9324	120 7828	3s3p	$^3P_2$	-	3s3d	$^3D_3$
0.6446	18	827 932 0.932B	827 9324	120 7828	3s3p	$^3P_2$	-	3s3d	$^3D_2$
0.0430	18	827 932 0.932B	827 9324	120 7828	3s3p	$^3P_2$	-	3s3d	$^3D_1$
0.1791	2	842 689	842 6882	118 6680	3p3d	$^3F_2$	-	3d2	$^3F_3$
1.5713	6	842 867	842 8662	118 6421	3p3d	$^3F_2$	-	3d2	$^3F_2$
0.1741	2	844 148	844 1401	118 4643	3p3d	$^3F_3$	-	3d2	$^3F_4$
2.0811	7	844 420	844 4178	118 4247	3p3d	$^3F_3$	-	3d2	$^3F_3$
0.1956	m P III	844 646	844 6178	118 3990	3p3d	$^3F_3$	-	3d2	$^3F_2$
1.0166	8	845 969 0.964B	845 9643	118 2086	$3p^2$	$^3P_0$	-	3p3d	$^3D_1$
2.9456	9	846 415	846 4147	118 1454	3p3d	$^3F_4$	-	3d2	$^3F_4$
0.1963	3	846 701	846 6977	118 1059	3p3d	$^3F_4$	-	3d2	$^3F_3$
2.3458	10	847 019 6.999^{B}	847 0075	118 0616	$3p^2$	$^3P_1$	-	3p3d	$^3D_2$
1.0381	m P III	847 669 0.660^{B}	847 6876	117 9646	$3p^2$	$^3P_1$	-	3p3d	$^3D_1$
5.0676	12	849 799 0.799^{B}	849 8004	117 6750	$3p^2$	$^3P_2$	-	3p3d	$^3D_3$
1.2577	9	850 392 0.390^{B}	850 3921	117 5928	$3p^2$	$^3P_2$	-	3p3d	$^3D_2$
0.1141	6	851 091 0.094^{B}	850 9877	117 4963	$3p^2$	$^3P_2$	-	3p3d	$^3D_1$
0.4310	7	860 479 0.48^{B}	860 4777	116 2145	$3p^2$	$^3P_1$	-	3p3d	$^3P_0$
0.1956	6	861 531 0.517^{B}	861 5304	116 0725	$3p^2$	$^3P_1$	-	3p3d	$^3P_1$
0.9136	8	863 300 0.288^{B}	863 2952	115 8347	$3p^2$	$^3P_1$	-	3p3d	$^3P_2$
0.4822	6	865 026 0.018^{B}	865 0216	115 6039	$3p^2$	$^3P_2$	-	3p3d	$^3P_1$
1.2570	8	866 807 0.820^{B}	866 8076	115 3659	$3p^2$	$^3P_2$	-	3p3d	$^3P_2$
2.8618	5	868 336	868 3355	115 1629	3p3d	$^3P_2$	-	3d2	$^3P_2$
1.3061	5	,,	868 3355	11516067	3p3d	$^3P_2$	-	3d2	$^3P_1$

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1.0053	3	870 148	870 1491	114 9249	3p3d	$^3P_1$	-	3d2	$^3P_2$
0.5246	3	,,	870 1491	114 9249	3p3d	$^3P_1$	-	3d2	$^3P_1$
0.9742	3	870 148	870 1494	114 9248	3p3d	$^3P_1$	-	3d2	$^3P_0$
5.9377	9 bl	875 087 0.132[R]	875 1320	114 2744	3s3d	$^3D3$	-	3s4f	$^3F_4$
0.0121	9 bl	,,	875 1320	114 2744	3s3d	$^3D3$	-	3s4f	$^3F_2$
4.1034	7 bl	875 143	875 1416	114 2676	3s3d	$^3D_2$	-	3s4f	$^3F_3$
0.5091	7 bl	,,	875 1442	114 2676	3s3d	$^3D_3$	-	3s4f	$^3F_3$
2.7672	6 bl	875 175	875 1747	114 2625	3s3d	$^3D_1$	-	3s4f	$^3F_2$
0.5099	6 bl	,,	875 1763	114 2625	3s3d	$^3D_2$	-	3s4f	$^3F_2$
0.0145	6 bl	,,	875 1767	114 2625	3s3d	$^3D_3$	-	3s4f	$^3F_2$
4.7784	17	877 476 0.493[R*]	877 4823	113 9638	3s3p	$^1P_1$	-	3s3d	$^1D_2$
0.0037	0	880 022	880 0321	113 6320	3p3d	$^1D_2$	-	3d2	$^3F_2$
0.0677	3	884 724	884 7154	113 0328	3p3d	$^3D_1$	-	3d2	$^3P_2$
0.3639	3	,,	884 7177	1130314	3p3d	$^3D_1$	-	3d2	$^3P_1$
0.2140	3	,,	884 7246	113 0305	3p3d	$^3D_1$	-	3d2	$^3P_0$
0.5622	4	885 468	885 4567	112 9360	3p3d	$^3D_2$	-	3d2	$^3P_2$
0.5246	4	,,	885 4698	112 9338	3p3d	$^3P_1$	-	3d2	$^3P_1$
1.4330	5	886 101	886 1019	112 8538	3p3d	$^3D_3$	-	3d2	$^3P_2$
1.3668	7	888 957	888 9612	112 4910	$3p^2$	$^1S_0$	-	3p3d	$^1P_1$
0.0105	0	901 521	901 5307	110 9225	3s4p	$^3P_1$	-	3s7s	$^3S_1$
0.0311	m P II	902 822	902 7279	110 7754	3s4p	$^3P_2$	-	3s7s	$^3S_1$
0.0323	0	903 191	903 1955	110 7180	3s4p	$^1P_1$	-	3s7s	$^1S_0$
2.4673	9	918 497	918 4976	108 8739	$3p^2$	$^1D_2$	-	3p3d	$^1D_2$
0.0036	0	941 363	941 3612	106 2292	3s4p	$^1P_1$	-	3s6d	$^1D_2$
1.5045	20	950 655 0.662[R]	950 6549	105 1906	$3s^2$	$^1S_0$	-	3s3p	$^1P_1$
0.0274	2	967 741	967 7731	103 3345	3p3d	$^3F_3$	-	3s6g	$^3G_4$
0.0020	2	,,	967 7777	103 3296	3p3d	$^3F_3$	-	3s6g	$^3G_3$
0.0399	1	970 694	970 6939	103 0189	3p3d	$^3F_4$	-	3s6g	$^3G_5$
0.0018	1	,,	970 6949	103 0157	3p3d	$^3F_4$	-	3s6g	$^3G_4$
0.0012	3	978 614	978 6126	102 1856	3s4p	$^1P_1$	-	3p4p	$^1S_0$
0.0015	0	986 569	986 5721	101 3607	$3p^2$	$^3P_2$	-	3p3d	$^1D_2$
0.0647	0 bl	1001 811	1001 8249	99 8178	3s4d	$^3D_1$	-	3s9f	$^3F2$

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0.0958	0 bl	1001 875		1001 8740	99 8130	3s4d	$^3D_2$	-	3s9f	$^3F3$
0.0120	0 bl	1001 875		1001 8740	99 8129	3s4d	$^3D_2$	-	3s9f	$^3F2$
0.1386	0 bl	1001 950		1001 9480	99 8056	3s4d	$^3D_3$	-	3s9f	$^3F4$
0.0120	0 bl	1001 950		1001 9480	99 8056	3s4d	$^3D_3$	-	3s9f	$^3F3$
0.0003	0 bl	1001 950		1001 9480	99 8056	3s4d	$^3D_3$	-	3s9f	$^3F2$
0.5264	7	1006 229	0.237^{B}	1006 2365	99 38079	$3p^2$	$^1D_2$	-	3s4p	$^1P_1$
0.0078	0	1012 108		1012 0963	988 7938	3s3d	$^1D_2$	-	3p4s	$^3P_1$
0.7317	15	1025 563	0.564^{R}	1025 5739	97 5064	3s3p	$^3P_1$	-	3p2	$^3P_2$
2.4726	15	1025 678		1025 6759	97 4970	3p3d	$^3D_1$	-	3d2	$^3F_2$
3.6604	2	1026 418		1026 4167	97 4263	3p3d	$^3D_2$	-	3d2	$^3F_3$
5.3975	2	1026 874		1026 8678	97 3835	3p3d	$^3D_3$	-	3d2	$^3F_4$
0.5845	14	1028 096	0.093^{R}	1028 0909	97 2677	3s3p	$^3P_0$	-	3p2	$^3P_1$
0.4373	15	1030 517	0.511^{R}	1030 5230	97 0381	3s3p	$^3P_1$	-	3p2	$^3P_1$
2.1845	15	,,		1030 5184	970 0385	$3p^2$	$^3P_2$	-	3p2	$^3P_2$
0.5817	14	1033 111	0.099^{R}	1033 1250	96 7937	3s3p	$^3P_1$	-	3p2	$^3P_0$
0.7254	14	1035 517	0.505^{R}	1035 5154	96 5703	3s3p	$^3P_2$	-	3p2	$^3P_1$
0.0381	1	1045 550		1045 4816	95 6488	3s4s	$^3S_1$	-	3s5p	$^3P_2$
0.0009	0	1048 277		1048 2507	95 3951	3s4d	$^3D_2$	-	3p4d	$^1P_1$
0.9078	5	1054 114		1054 1139	94 8667	3s4p	$^1P_1$	-	3p4p	$^1D_2$
0.2321	7	1064 612	0.60^{B}	1064 6195	93 9308	3s3d	$^3D_2$	-	3p3d	$^3D_3$
1.7456	7	,,		1064 6212	93 9309	3s3d	$^3D_3$	-	3p3d	$^3D_3$
0.0862	6	1065 544	0.554^{B}	1065 5439	93 8487	3s3d	$^3D_1$	-	3p3d	$^3D_2$
1.0949	6	,,		1065 5447	93 8487	3s3d	$^3D_2$	-	3p3d	$^3D_2$
0.2280	6	,,		1065 5459	93 8483	3s3d	$^3D_3$	-	3p3d	$^3D_2$
0.1174	4	1066 652	0.640^{B}	1066 6421	93 7539	3s3d	$^3D_1$	-	3p3d	$^3D_1$
0.7267	4	,,		1066 6548	93 7515	3s3d	$^3D_2$	-	3p3d	$^3D_1$
0.3225	0	1071656		1071 6570	93 3134	3s4d	$^1D_2$	-	3p4d	$^1P_1$
0.0868	0	1079 416		1079 4139	92 6429	3s4p	$^3P_0$	-	3p4p	$^3S_1$
0.2656	2	1080 096		1080 0972	92 5842	3s4p	$^3P_1$	-	3p4p	$^3S_1$
0.4594		1081 835		1081 8327	92 4358	3s4p	$^3P_2$	-	3p4p	$^3S_1$
0.1852	0	1083 375		1083 3800	92 3036	3s4d	$^3D_1$	-	3p4d	$^3P_0$
0.3817		1084 874		1084 8662	92 1772	3s4d	$^3D_2$	-	3p4d	$^3P_1$

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0.3358	7	1086 944 0.943B	1086 9354	92 0018	3s3d	$^3D_1$	-	3p3d	$^3P_0$
0.7063	2	1087 537	1087 5400	91 9506	3s4d	$^3D_3$	-	3p4d	$^3P_2$
0.8458	8	1088 614 0.608B	1088 5118	91 8686	3s3d	$^3D_1$	-	3p3d	$^3P_1$
0.1573	8	1088 614 0.608B	1088 6164	91 8597	3s3d	$^3D_2$	-	3p3d	$^3P_1$
0.0040	9	1091 442 0.442B	1091 4430	91 6218	3s3d	$^3D_1$	-	3p3d	$^3P_2$
0.1288	9	,,	1091 4430	91 6218	3s3d	$^3D_2$	-	3p3d	$^3P_2$
1.5342	9	,,	1091 4430	91 6218	3s3d	$^3D_3$	-	3p3d	$^3P_2$
1.7216	7	1093 324 0.318B	1093 2758	91 4682	3s4s	$^3S_1$	-	3p4s	$^3P_2$
0.3441	4	1097 790	1097 7867	910924	3s4p	$^3P_1$	-	3p4p	$^3P_2$
0.9940	7	1098 186 0.183B	1098 1851	91 0593	3s4s	$^3S_1$	-	3p4s	$^3P_1$
1.0197	6	1099 581	1099 5780	90 9441	3s4p	$^3P_2$	-	3p4p	$^3P_2$
0.2769	4	1101 070	1101 0719	90 8201	3s4p	$^3P_0$	-	3p4p	$^3P_1$
0.3457	5	1101 599 0.65B	1101 5976	907829	3s4s	$^3S_1$	-	3p4s	$^3P_0$
0.2057	4	1101 784	1101 7666	90 7620	3s4p	$^3P_1$	-	3p4p	$^3P_1$
0.3329	5	1103 590	1103 5868	90 6135	3s4p	$^3P_2$	-	3p4p	$^3P_1$
0.2614	4	1104 108	1104 1083	90 5709	3s4p	$^3P_1$	-	3p4p	$^3P_0$
0.0819	2	1110 126	1110 1255	90 0797	3s4p	$^1P_1$	-	3s6s	$^1S_0$
0.0008	7	1111 167 0.127R*	1111 1691	89 9990	3s3p	$^3P_1$	-	3p2	$^1D_2$
0.0286	1	1112 121	1112 1162	89 9187	3s4p	$^3P_0$	-	3s6s	$^3S_1$
0.0850	2	1112 842	1112 8401	898601	3s4p	$^3P_1$	-	3s6s	$^3S_1$
0.1429	4	1114 685	1114 6800	89 7118	3s4p	$^3P_2$	-	3s6s	$^3S_1$
0.0020	7	1116 985 0.915R*	1116 9269	89 5314	3s3p	$^3P_2$	-	3p2	$^1D_2$
1.0643	15	1118 551 0.586R	1118 5559	89 4010	3s3p	$^1P_1$	-	3p2	$^1S_0$
0.0004	4	1122 376	1122 3567	89 0964	3p3d	$^1P_1$	-	3d2	$^3P_2$
0.0000	4	,,	1122 3708	89 0973	3p3d	$^1P_1$	-	3d2	$^3P_1$
0.0001	4	,,	1122 3815	89 0963	3p3d	$^1P_1$	-	3d2	$^3P_0$
1.0555	4	1126 658	1126 6321	88 7574	3s4d	$^3D_3$	-	3p4d	$^3D_3$
0.9783	3	1129 154	1129 1524	88 5622	3s4d	$^3D_2$	-	3p4d	$^3D_3$
1.7810	7	1131 488	1131 4831	88 3783	3s4p	$^3P_2$	-	3p4p	$^3D_3$
0.9213	6	1134 481	1134 4803	88 1469	3s4p	$^3P_1$	-	3p4p	$^3D_2$
0.6257	4	1136 396	1136 3837	87 9963	3s4d	$^3D_2$	-	3p4d	$^3F_2$
0.3122	4	,,	1136 3939	87 9984	3s4p	$^3P_2$	-	3p4p	$^3D_2$
0.4074	5	1136 528	1136 5363	87 9868	3s4p	$^3P_0$	-	3p4p	$^3D_1$
1.0387	7	1137 281	1137 2731	87 9294	3s3d	$^1D_2$	-	3p3d	$^1P_1$

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0.2893	7	,,	1137 2975	87 9270	$3s4p$	$^3P_1$	-	$3p4p$	$^3D_1$
0.0219	2	1139 222	1139 2183	87 7794	$3s4p$	$^3P_2$	-	$3p4p$	$^3D_1$
0.0084	0	1146 331	1146 3239	87 2352	$3s4p$	$^1P_1$	-	$3p4p$	$^3D_2$
0.0169	1	1149 190	1149 1958	87 0177	$3s4p$	$^1P_1$	-	$3p4p$	$^3D_1$
0.1566	5	1171 316	1171 3138	85 3747	$3p3d$	$^1D_2$	-	$3p4p$	$^1D_2$
0.2051	1 bl P II	1172 996	1173 0141	85 2505	$3s4d$	$^3D_1$	-	$3s7f$	$^3F_2$
0.0380	1 bl	1173 094	1073 0813	85 2456	$3s4d$	$^3D_2$	-	$3s7f$	$^3F_3$
0.3038	1 bl	,,	1073 0813	85 2456	$3s4d$	$^3D_2$	-	$3s7f$	$^3F_2$
0.4394	1 bl	1173 189	1173 1855	85 2370	$3s4d$	$^3D_3$	-	$3s7f$	$^3F_4$
0.0380	1 bl	1173 189	1173 1828	85 2382	$3s4d$	$^3D_3$	-	$3s7f$	$^3F_3$
0.0011	1 bl	,,	1173 1828	852382	$3s4d$	$^3D_3$	-	$3s7f$	$^3F_2$
1.7532	6	1179 022	1179 0237	84 8173	$3s4d$	$^1D_2$	-	$3p4d$	$^1D_2$
0.0244	2	1186 295	1186 2954	84 2969	$3s4p$	$^3P_1$	-	$3p4p$	$^1P_1$
0.0001	3 bl P III	1187 542	1187 5427	84 2075	$3s3p$	$^1P_1$	-	$3s3d$	$^3D_2$
0.0000	3 bl P III	,,	1187 5428	84 2075	$3s3p$	$^1P_1$	-	$3s3d$	$^3D_1$
0.0371	4	1191 055	1191 0522	83 9616	$3s4s$	$^1S_0$	-	$3p4s$	$^3P_1$
1.2598	8	1199 243	1199 2441	83 3847	$3s4p$	$^1P_1$	-	$3p4p$	$^1P_1$
0.3838	2	1201 642	1201 6311	83 2201	$3s4d$	$^1D_2$	-	$3s7f$	$^1F_3$
0.0638	9	1206 422	1206 4112	82 8901	$3p3d$	$^3F_3$	-	$3p4p$	$^3D_3$
0.0628	4	1208 419	1208 4176	82 7534	$3p3d$	$^3F_2$	-	$3p4p$	$^3D_2$
0.7613	7	1211 052	1211 0511	82 5731	$3p3d$	$^3F_4$	-	$3p4p$	$^3D_3$
0.3360	5	1211 612	1211 6231	82 5323	$3p3d$	$^3F_2$	-	$3p4p$	$^3D_1$
0.5131	6	1211 984	1211 9796	82 5096	$3p3d$	$^3F_3$	-	$3p4p$	$^3D_2$
0.0075	4	1219 495	1219 4966	82 0002	$3p3d$	$^3F_2$	-	$3s5g$	$^3G_3$
0.0704	4	1223 098	1223 0997	81 7595	$3p3d$	$^3F_3$	-	$3s5g$	$^3G_4$
0.1487	5	1227 839	1227 8365	81 4429	$3p3d$	$^3F_4$	-	$3s5g$	$^3G_5$
0.0001	6	1238 958	1238 9588	80 7129	$3s4p$	$^3P_1$	-	$3s5d$	$^3D_2$
0.0000	5	1239 276	1239 2792	80 6922	$3s4p$	$^3P_0$	-	$3s5d$	$^3D_1$
0.0000	7	1239 587	1239 5884	80 6712	$3s4p$	$^3P_2$	-	$3s5d$	$^3D_3$
0.0000	4	1240 181	1240 1759	80 6341	$3s4p$	$^3P_1$	-	$3s5d$	$^3D_1$
0.0000	4	1241 246	1241 2473	80 5640	$3s4p$	$^3P_2$	-	$3s5d$	$^3D_2$
0.0037	5	1242 050	1242 0420	805126	$3s4p$	$^1P_1$	-	$3s5d$	$^1D_2$
0.0000	0	1242 456	1242 4555	80 4851	$3s4p$	$^3P_2$	-	$3s5d$	$^3D_1$
0.0000	0	1253 099	1253 0974	79 8022	$3s4p$	$^1P_1$	-	$3s5d$	$^3D_2$

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0.0098	2 b	1278 33	1278 3244	78 2278	$3s4d$	$^3D_1$	-	$3s7p$	$^3P_1$
0.0555	2 b	,,	1278 3254	78 2265	$3s4d$	$^3D_3$	-	$3s7p$	$^3P_2$
0.0132	2 b	,,	1278 3453	78 2259	$3s4d$	$^3D_1$	-	$3s7p$	$^3P_0$
0.0000	2 b	,,	1278 3561	78 2253	$3p4s$	$^3P_1$	-	$3d2$	$^3P_2$
0.0294	2b	1278 38	1278 3813	78 2239	$3s4d$	$^3D_2$	-	$3s7p$	$^3P_1$
0.0000	2 b	,,	1278 3909	78 2226	$3p4s$	$^3P_1$	-	$3d2$	$^3P_1$
0.0441	4	1298 022	1298 0212	77 0402	$3s4f$	$^3F_4$	-	$3d2$	$^3F_4$
0.0300	4	1298 573	1298 5756	77 0074	$3s4f$	$^3F_3$	-	$3d2$	$^3F_3$
0.0224	3	1298 931	1298 9296	76 9866	$3s4f$	$^3F_2$	-	$3d2$	$^3F_2$
0.0410	0	1311 349	1311 3507	76 2571	$3s4d$	$^1D_2$	-	$3s7p$	$^1P_1$
0.0246	3	1327 670	1327 6735	75 3192	$3p3d$	$^3F_2$	-	$3s5d$	$^3D_2$
0.1424	7	,,	1329 0726	75 2409	$3p3d$	$^3F_2$	-	$3s5d$	$^3D_1$
0.0228	3	1330 075	1330 0738	75 1838	$3p3d$	$^3F_3$	-	$3s5d$	$^3D_3$
0.2003	6	1331 981	1331 9787	75 0759	$3p3d$	$^3F_3$	-	$3s5d$	$^3D_2$
0.5586	9 b	1335 705	1335 6849	74 8676	$3s4f$	$^3F_4$	-	$3s7g$	$^3G_5$
0.0005	9 b	,,	1335 7165	74 8661	$3s4f$	$^3F_3$	-	$3s7g$	$^3G_4$
0.2698	9 b	,,	1335 7366	74 8650	$3p3d$	$^3F_4$	-	$3s5d$	$^3D_3$
0.0000	0	1346 945	1346 9463	74 2418	$3p4d$	$^3P_1$	-	$3s5s$	$^1S_0$
0.0010	1	1348 479	1348 4666	74 1583	$3s5p$	$^3P_2$	-	$3s10d$	$^3D_3$
0.0002	1	,,	1348 4666	74 1583	$3s5p$	$^3P_2$	-	$3s10d$	$^3D_2$
0.0000	1	,,	1348 4666	74 1583	$3s5p$	$^3P_2$	-	$3s10d$	$^3D_1$
0.4241	7	1353 303	1353 3028	73 8935	$3p3d$	$^1D_2$	-	$3p4p$	$^1P_1$
1.0788	14	1366 695	1366 6976	73 1686	$3s3d$	$^3D_3$	-	$3p3d$	$^3F_4$
0.0814	4	1368 265	1368 2654	73 0849	$3s4s$	$^1S_0$	-	$3p3d$	$^1P_1$
0.7384	13	1372 674	1372 6745	72 8507	$3s3d$	$^3D_3$	-	$3p3d$	$^3F_3$
0.1008	13	,,	1372 6765	72 8498	$3s3d$	$^3D_2$	-	$3p3d$	$^3F_3$
0.0030	12	1377 282	1377 2758	72 6069	$3s3d$	$^3D_1$	-	$3p3d$	$^3F_2$
0.0976	12	,,	1377 3162	72 6056	$3s3d$	$^3D_2$	-	$3p3d$	$^3F_2$
0.4974	12	,,	1377 3388	72 6037	$3s3d$	$^3D_3$	-	$3p3d$	$^3F_2$
0.4623	9 bl P V	1385 048	1385 0669	72 2006	$3s4d$	$^3D_1$	-	$3s6f$	$^3F_2$
0.6848	9 bl P V	,,	1385 0821	72 1971	$3s4d$	$^3D_2$	-	$3s6f$	$^3F_3$
0.9903	4	1385 192	1385 1929	72 1911	$3s4d$	$^3D_3$	-	$3s6f$	$^3F_4$
0.0091	2	1408 055	1408 0578	71 0191	$3p3d$	$^1D_2$	-	$3s5d$	$^1D_2$
0.8512	3	1412 076	1412 0762	70 8177	$3s4d$	$^1D_2$	-	$3s6f$	$^1F_3$
0.0000	0	1426 180	1426 1779	70 1174	$3s4d$	$^1D_2$	-	$3s6f$	$^3F_3$
0.0000	0	,,	1426 1898	70 1169	$3s4d$	$^1D_2$	-	$3s6f$	$^3F_2$

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0.0014	0	1436 114	1436 1120	69 6327	$3s5p$	$^3P_2$	-	$3s9d$	$^3D_2$
0.0005	0	1436 114	1436 1120	69 6327	$3s5p$	$^3P_2$	-	$3s9d$	$^3D_3$
0.0824	6	1466787	1466 7861	68 1765	$3p3d$	$^3P_2$	-	$3p4p$	$^3S_1$
0.0001	8	1467 427 0.424[R]	1467 4265	68 1465	$3s^2$	$^1S_0$	-	$3s3p$	$^3P_1$
0.0015	6	1467 898	1467 8994	68 1245	$3s3d$	$^3D_2$	-	$3s4p$	$^1P_1$
0.0044	6	1467 898	1467 8994	68 1245	$3s3d$	$^3D_1$	-	$3s4p$	$^1P_1$
0.2064	5	1471 926	1471 9231	67 9383	$3p3d$	$^3P_1$	-	$3p4p$	$^3S_1$
0.1176	4	1475 013	1475 0098	67 7969	$3p3d$	$^3P_0$	-	$3p4p$	$^3S_1$
0.0102	14	1484 507 0.508[B]	1484 5140	67 3621	$3s3d$	$^3D_1$	-	$3s4p$	$^3P_2$
0.1534	14	,,	1484 5141	67 3621	$3s3d$	$^3D_2$	-	$3s4p$	$^3P_2$
0.8592	14	,,	1484 5142	67 3621	$3s3d$	$^3D_3$	-	$3s4p$	$^3P_2$
0.1516	13	1487 788 0.793[B]	1487 7629	6721383	$3s3d$	$^3D_1$	-	$3s4p$	$^3P_1$
0.4549	13	,,	1487 7629	6721383	$3s3d$	$^3D_2$	-	$3s4p$	$^3P_1$
0.2039	11	1489 098 0.093[B]	1489 1039	67 1545	$3s3d$	$^3D_1$	-	$3s4p$	$^3P_0$
0.1977	6	1499 602	1499 6122	66 6833	$3p3d$	$^3P_2$	-	$3p4p$	$^3P_2$
0.0767	2	1504 970	1504 9789	66 4456	$3p3d$	$^3P_1$	-	$3p4p$	$^3P_2$
0.3528	5	1507 067	1507 0693	66 3539	$3p3d$	$^3P_2$	-	$3p4p$	$^3P_1$
0.1176	3	1515 751	1515 7495	65 97406	$3p3d$	$^3P_0$	-	$3p4p$	$^3P_1$
0.1184	1	1516 316	1516 3211	65 9499	$3p3d$	$^3D_2$	-	$3p4p$	$^3S_1$
0.0954	4	1516 879	1516 8874	65 9247	$3p3d$	$^3P_1$	-	$3p4p$	$^3P_0$
0.0588	4	1527 836	1527 8355	65 4521	$3p3d$	$^3P_2$	-	$3s6s$	$^3S_1$
0.0355	2	1533 401	1533 4064	65 2143	$3p3d$	$^3P_1$	-	$3s6s$	$^3S_1$
0.1829	2 b1 P I	1551 420	1551 4165	64 4577	$3p3d$	$^3D_2$	-	$3p4p$	$^3P_2$
0.0016	6	1553 401	1553 4032	64 3742	$3p3d$	$^3D_3$	-	$3p4p$	$^3P_2$
0.0925	5	1557 054	1557 0518	64 2230	$3p3d$	$^3D_1$	-	$3p4p$	$^3P_1$
0.1953	6	1559 407	1559 4026	64 1271	$3p3d$	$^3D_2$	-	$3p4p$	$^3P_1$
0.1347	5	1561 700	1561 6985	64 0323	$3p3d$	$^3D_1$	-	$3p4p$	$^3P_0$
0.0046	6	1589 042	1589 0394	62 9311	$3p^2$	$^1S_0$	-	$3s4p$	$^1P_1$
0.9647	8 bl	1615 078	1615 0578	61 9194	$3s4f$	$^3F_2$	-	$3s6g$	$^3G_3$
0.0467	8 bl	,,	1615 0803	61 9181	3s6g	$^3F_4$	-	$3s6g$	$^3G_4$
1.6507	8 bl	1615 162	1615 1532	61 9136	$3s4f$	$^3F_4$	-	$3s6g$	$^3G_5$
0.0173	8 bl	,,	1615 1764	61 9119	$3s4f$	$^3F_3$	-	$3s6g$	$^3G_3$
0.0013	0	1615 382	1615 3612	61 9059	$3s4f$	$^3F_4$	-	$3s6g$	$^3G_3$
0.0271	0	,,	1615 3876	61 9034	$3s4f$	$^3F_3$	-	$3s6g$	$^1G_4$
0.0194	1	1615 681	1615 6843	61 8932	$3p3d$	$^3D_2$	-	$3p4p$	$^3D_3$
0.1418	1	1617 833	1617 8337	61 8108	$3p3d$	$^3D_3$	-	$3p4p$	$^3D_3$
0.0164	0	1623 155	1623 1645	61 6087	$3p3d$	$^3D_1$	-	$3p4p$	$^3D_2$

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0.0659	5	1625 719	1625 7199	61 5117	3p3d	$^3D_2$	-	3p4p	$^3D_2$
0.0419	3	1628 932	1628 9318	61 3897	3p3d	$^3D_1$	-	3p4p	$^3D_1$
0.0186	1	1631 499	1631 5016	61 2938	3p3d	$^3D_2$	-	3p4p	$^3D_1$
0.0172	1	1635 128	1635 1267	61 1565	3p3d	$^1P_1$	-	3s7s	$^1S_0$
0.0020	4	1653 891	1653 8691	60 4639	3s4d	$^3D_1$	-	3s6p	$^3P_2$
0.0000	4	,,	1653 8884	60 4639	3s3p	$^1P_1$	-	3p2	$^3P_2$
0.1708	3	1654 199	1654 1977	60 4522	3s4d	$^3D_3$	-	3s6p	$^3P_2$
0.0910	3 b	1654 918	1654 9198	60 4261	3s4d	$^3D_2$	-	3s6p	$^3P_1$
0.0406	1	1655 191	1655 1888	60 4161	3s4d	$^3D_1$	-	3s6p	$^3P_0$
0.0002	2	1673 612 0.759[R]	1673 6109	59 7517	3s3p	$^1P_1$	-	3p2	$^3P_0$
0.1207	4	1697 612	1697 6167	58 9059	3s4d	$^1D_2$	-	3s6p	$^1P_1$
0.0381	1	1741 345	1741 3458	57 4268	3s5p	$^3P_2$	-	3s8s	$^3S_1$
0.0001	0	1772 661	1772 6623	56 4128	3p3d	$^3P_2$	-	3s5d	$^3D_3$
0.2393	0	1797 638	1797 6375	55 6285	3s5d	$^3D_3$	-	3s9f	$^3F_4$
0.0207	0	,,	1797 6377	55 6285	3s5d	$^3D_3$	-	3s9f	$^3F_3$
0.0006	0	,,	1797 6380	55 6284	3s5d	$^3D_3$	-	3s9f	$^3F_2$
0.0007	0	1831 568	1831 5206	54 5994	3s5p	$^3P_1$	-	3s7d	$^3D_2$
0.0002	0	1831 568	1831 6857	54 5945	3s5p	$^3P_1$	-	3s7d	$^3D_1$
0.0052	0	1832 466	1832 4720	54 5711	3s4p	$^3P_1$	-	3s5s	$^1S_0$
0.0002	1	1834 621	1834 6215	54 5072	3s5p	$^3P_2$	-	3s7d	$^3D_3$
0.0261	2	1848 318	1848 3195	54 1032	3p3d	$^3D_3$	-	3s5d	$^3D_3$
0.0102	0	1848 579	1848 5788	54 0956	3p3d	$^3D_1$	-	3s5d	$^3D_1$
0.0148	lb	1849 176	1849 1788	54 0780	3p3d	$^3D_2$	-	3s5d	$^3D_2$
0.4468	9	1863 580	1863 5762	53 6603	3s4p	$^1P_1$	-	3s5s	$^1S_0$
0.1198	16	1888 523 0.652[R*]	1888 5204	52 9515	3s3p	$^1P_1$	-	3p2	$^1D_2$
0.2265	4	1900 244	1900 2322	52 6255	3p3d	$^1P_1$	-	3p4p	$^1S_0$
0.1865	6	1902 649 0.62[Q]	1902 6316	52 5588	3s4p	$^3P_0$	-	3s5s	$^3S_1$
0.5537	8	1904 777 0.80[B]	1904 8054	52 4988	3s4p	$^3P_1$	-	3s5s	$^3S_1$
0.9290	9	1910 183 0.18[B]	1910 1777	52 3512	3s4p	$^3P_2$	-	3s5s	$^3S_1$
0.0052	1 d	1938 403	1938 4101	51 5887	3s4p	$^1P_1$	-	3s5s	$^3S_1$
1.5050	7	1985 682	1985 6854	50 3604	3s4d	$^3D_1$	-	3s5f	$^3F_2$
2.2296	8	1985 851	1985 8545	50 3562	3s4d	$^3D_2$	-	3s5f	$^3F_3$
3.2250	9	1986 114	1986 1132	50 3499	3s4d	$^3D_3$	-	3s5f	$^3F_4$
2.9997	8	1987 022	1987 0209	50 3266	3s4d	$^1D_2$	-	3s5f	$^1F_3$

Abbreviations used for the intensities [11]: b = broad, bl = blended, h = hazy, m = masked by, d = diffuse. References: R = Robinson; B = Bowen; R* Robinson's identification revised; Q = Queney.

Table 2. PIV semi-empirical oscillator strengths calculated in the region above 2000 Å.

gf	Intensity and shape	$\lambda_{Obs.}$ (Å)	$\lambda_{Calc.}$ (Å)	$\sigma_{Calc.}$ (cm^{-1})	Lower			Upper	
0.1552		2088 705	2088 7072	47 7733	3s3d	$^1D_2$	-	3p3d	$^1D_2$
1.0985		2094 301	2094 2953	47 7336	3p4p	$^1P_1$	-	3p4d	$^1P_1$
0.0144	4 bl P IV	2206 502	2206 5146	45 3075	3p3d	$^1P_1$	-	3p4p	$^1D_2$
0.2783	3	2242 442	2242 4311	44 5810	3s5d	$^3D_3$	-	3p4d	$^3D_3$
0.1954	2	2247 264	2247 2617	44 4848	3s5d	$^3D_2$	-	3p4d	$^3D_2$
0.4550	0 h	2302 62	2302 5577	43 4143	3s5g	$^3G_3$	-	3s8h	$^3H_4$
0.3899	0 h	,,	2302 6212	43 4160	3s5g	$^3G_4$	-	3s8h	$^3H_5$
0.0162	0 h	,,	2302 6213	43 4159	3s5g	$^3G_4$	-	3s8h	$^3H_4$
0.0234	0 h	,,	2302 6314	43 4158	3s5g	$^3G_5$	-	3s8h	$^3H_5$
0.6912	0 h	2302 81	2302 8088	43 4122	3s5g	$^3G_5$	-	3s8h	$^3H_6$
0.0171	0 h	,,	2302 8192	43 4119	3s5g	$^1G_4$	-	3s8h	$^3H_5$
0.1717	0 h	,,	2302 8193	43 4119	3s5g	$^1G_4$	-	3s8h	$^3H_4$
0.0049	1	2462 048	2462 0481	40 6022	3s5p	$^3P_1$	-	3s6d	$^3D_2$
0.0016	1	2462 159	2462 1597	40 5188	3s5p	$^3P_1$	-	3s6d	$^3D_1$
0.0086	1	2467 860	2467 8611	40 5008	3s5p	$^3P_2$	-	3s6d	$^3D_3$
0.0647	9	2477 823	2477 8220	40 3413	3s4f	$^3F_3$	-	3s5g	$^1G_4$
5.9869	9	,,	2477 8231	40 3400	3s4f	$^3F_2$	-	3s5g	$^3G_3$
8.0121	8	2478 070	2478 0659	40 3406	3s4f	$^3F_3$	-	3s5g	$^3G_4$
10.2426	10	2478 256	2478 2622	40 3384	3s4f	$^3F_4$	-	3s5g	$^3G_5$
2.8408	6	2547 880	2547 8844	39 2359	3p4p	$^1P_1$	-	3p4d	$^1D_2$
0.0316	5	2582 092	2582 0953	38 7158	3s4p	$^3P_1$	-	3s4d	$^1D_2$
0.2559	10	2605 506	2605 5056	38 2753	3s3d	$^1D_2$	-	3s4p	$^1P_1$
0.2541	2	2614 144	2614 1444	38 2418	3p4p	$^3P_0$	-	3p4d	$^3P_1$
0.3499	2	2618 897	2618 8996	38 1725	3p4p	$^3P_1$	-	3p4d	$^3P_0$
0.3342	2 bl P II	2627 308	2627 2812	38 0503	3p4p	$^3P_1$	-	3p4d	$^3P_1$
0.2046	2	2642 491	2642 4841	37 8318	3p4p	$^3P_1$	-	3p4d	$^3P_2$
3.3736	13	2644 295	2644 2984	37 8056	3s4p	$^1P_1$	-	3s4d	$^1D_2$
1.3272	2	2665 769	2665 7697	37 5014	3p4p	$^3P_2$	-	3p4d	$^3P_2$
0.3215	3	2696 449	2696 4487	37 0748	3p4p	$^3D_1$	-	3p4d	$^3D_1$
0.9121	5	2698 144	2698 1443	37 0515	3p4p	$^3D_2$	-	3p4d	$^3D_2$
0.1057	6	2711 245	2711 2443	36 8732	3p4p	$^3D_3$	-	3p4d	$^3D_2$

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0.0951	3	2712 404	2712 4034	36 8577	3p4p	$^3D_2$	-	3p4d	$^3D_1$
3.4331	0	2723 455	2723 4560	36 7068	3p4p	$^3D_1$	-	3p4d	$^3F_2$
1.1785	11	2724 764 0.86 B*	2724 7669	36 6882	3s4p	$^3P_0$	-	3s4d	$^3D_1$
4.8530	3 b	2726 251	2726 2301	36 6703	3p4p	$^3D_2$	-	3p4d	$^3F_3$
0.1057	3 b	,,	2726 2521	36 6688	3p4p	$^3D_3$	-	3p4d	$^3D_2$
2.6241	13	2728 770 0.80 B*	2728 7711	36 6351	3s4p	$^3P_1$	-	3s4d	$^3D_2$
0.8741	9	2729 120 0.19 B*	2729 1787	36 6411	3s4p	$^3P_1$	-	3s4d	$^3D_1$
7.4019	4	2732 236	2732 2356	36 6001	3p4p	$^3D_3$	-	3p4d	$^3F_4$
4.9237	14	2739 309 0.32 B*	2739 3123	36 5055	3s4p	$^3P_2$	-	3s4d	$^3D_3$
0.8790	10	2739 872 0.90 B*	2739 8782	36 4980	3s4p	$^3P_2$	-	3s4d	$^3D_2$
0.0586	9	2740 223	2740 2242	36 4934	3s4p	$^3P_2$	-	3s4d	$^3D_1$
0.4344	2	2750 198	2750 1978	36 3610	3p4p	$^3S_1$	-	3p4d	$^3P_0$
1.3369	4	2759 421	2759 4217	36 2395	3p4p	$^3S_1$	-	3p4d	$^3P_1$
2.3512	5	2776 210	2776 2003	36 0204	3p4p	$^3S_1$	-	3p4d	$^3P_2$
0.0082	3	2798 330	2798 3298	35 7356	3s4p	$^1P_1$	-	3s4d	$^3D_2$
0.0229	2	2798 704	2798 7034	35 7308	3s4p	$^1P_1$	-	3s4d	$^3D_1$
2.8408	0	2849 909	2849 9103	35 0888	3p4d	$^1D_2$	-	3p5p	$^1P_1$
1.4888	4 h bl P III	2856 96	2856 9588	35 0022	3s5g	$^3G_3$	-	3s7h	$^3H_4$
1.2759	4 h bl P III	,,	2856 9597	35 0022	3s5g	$^3G_4$	-	3s7h	$^3H_4$
0.5833	4 h bl P III	,,	2856 9603	35 0021	3s5g	$^3G_4$	-	3s7h	$^3H_5$
0.0766	4 h	2857 23	2857 2306	34 9886	3s5g	$^3G_5$	-	3s7h	$^3H_6$
2.2620	4 h	,,	2857 2312	34 9886	3s5g	$^3G_5$	-	3s7h	$^3H_5$
1.3246	4 h	,,	2857 2317	34 9885	3s5g	$^1G_4$	-	3s7h	$^1H_5$
1.8781	3	2861 435	2861 4345	34 9475	3s5f	$^3F_4$	-	3s7g	$^3G_5$
1.0971	m P III	2862 053	2862 0533	34 9399	3s5f	$^3F_3$	-	3s7g	$^3G_4$
0.8010	2	2862 882	2862 8819	34 9298	3s5f	$^3F_3$	-	3s7g	$^3G_3$
0.0960	2	,,	2862 8819	34 9298	3s5f	$^3F_3$	-	3s7g	$^3G_4$
0.5479	4	2919 642	2919 6412	34 2507	3p4p	$^3P_1$	-	3p4d	$^3D_1$
0.0646	2	2921 117	2921 1159	34 2234	3s5d	$^3D_1$	-	3s7p	$^3P_0$
0.1459	3 bl P III	2927 690	2927 6921	34 1565	3s5d	$^3D_2$	-	3s7p	$^3P_1$
0.4160	6	2931 240	2931 2405	34 1152	3p4p	$^3P_2$	-	3p4d	$^3D_2$
0.2701	2 b	2935 978	2935 9769	34 0602	3s5d	$^3D_3$	-	3s7p	$^3P_2$

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0.0266	4 bl P II	2948 091	2948 0920	33 9202	$3p4p$	$^3P_2$	-	$3p4d$	$^3D_1$
0.1098	5	2955 513	2955 5138	33 8350	$3p3d$	$^1P_1$	-	$3p4p$	$^1P_1$
0.0008	2	2960 205	2960 2043	33 7814	$3s4f$	$^3F_2$	-	$3s5d$	$^3D_3$
0.3352	9	2961 242	2961 2422	33 7696	$3s4f$	$^3F_4$	-	$3s5d$	$^3D_3$
0.0284	2	2969 638	2969 6376	33 6741	$3s4f$	$^3F_2$	-	$3s5d$	$^3D_2$
0.2057	7	2970 089	2970 0898	33 6690	$3s4f$	$^3F_3$	-	$3s5d$	$^3D_2$
0.1557	5	2976 649	2976 6478	33 5948	$3s4f$	$^3F_2$	-	$3s5d$	$^3D_1$
0.8374	3	3042 981	3042 9867	32 8624	$3s5f$	$^1F_3$	-	$3s7g$	$^1G_4$
0.0008	3	3199 858	3199 8572	31 2514	$3p3d$	$^3F_2$	-	$3s4d$	$^3D_2$
0.0705	4	3200 216	3200 2170	31 2479	$3p4s$	$^3P_1$	-	$3p4p$	$^3S_1$
0.0042	6	3200 332	3200 3326	31 2467	$3p3d$	$^3F_2$	-	$3s4d$	$^3D_1$
0.0000	3	3224 160	3224 1593	31 0158	$3p3d$	$^3F_2$	-	$3s4d$	$^3D_3$
0.0061	6	3224 954	3224 9549	31 0081	$3p3d$	$^3F_3$	-	$3s4d$	$^3D_2$
0.4765	3	3229 910	3229 9109	30 9606	$3p3d$	$^1P_1$	-	$3s5d$	$^1D_2$
1.0852	6	3242 267	3242 2659	30 8426	$3p4s$	$^3P_2$	-	$3p4p$	$^3S_1$
0.0085	7	3257 652	3257 6528	30 6969	$3p3d$	$^3F_4$	-	$3s4d$	$^3D_3$
0.0107	5	3264 424	3264 4235	30 6332	$3s4s$	$^3S_1$	-	$3s4p$	$^1P_1$
1.8650	16	3347 736 0.73[B*]	3347 7334	29 8709	$3s4s$	$^3S_1$	-	$3s4p$	$^3P_2$
0.4112	5	3360 718	3360 7177	30 2373	$3p4s$	$^3P_1$	-	$3p4p$	$^3P_2$
1.1046	15	3364 467 0.45[B*]	3364 4619	29 7224	$3s4s$	$^3S_1$	-	$3s4p$	$^3P_1$
0.4998	5	3366 176	3366 1747	29 7073	$3p4s$	$^3P_0$	-	$3p4p$	$^3P_1$
0.3702	13	3371 122 0.12[B*]	3371 1231	29 6637	$3s4s$	$^3S_1$	-	$3s4p$	$^3P_0$
0.5995	6	3398 470	3398 4681	29 4250	$3p4s$	$^3P_1$	-	$3p4p$	$^3P_1$
1.4737	8	3407 125	3407 1236	29 3502	$3p4s$	$^3P_2$	-	$3p4p$	$^3P_2$
0.0187	4	3412 105	3412 1053	29 3074	$3s4d$	$^3D_1$	-	$3s5p$	$^3P_2$
0.2801	7	3412 653	3412 6521	29 3027	$3s4d$	$^3D_2$	-	$3s5p$	$^3P_2$
1.5686	9	3413 543	3413 5440	29 2950	$3s4d$	$^3D_3$	-	$3s5p$	$^3P_2$
0.3597	4	3420 686	3420 6859	29 2339	$3p4s$	$^3P_1$	-	$3p4p$	$^3P_0$
0.2847	6	3424 138	3424 1383	29 2044	$3s4d$	$^3D_1$	-	$3s5p$	$^3P_1$
0.8540	7	3424 702	3424 7014	29 1996	$3s4d$	$^3D_2$	-	$3s5p$	$^3P_1$
0.3825	7	3430 182	3430 1817	29 1529	$3s4d$	$^3D_1$	-	$3s5p$	$^3P_0$
0.0398	6	3445 928	3445 9274	29 0197	$3p4s$	$^3P_2$	-	$3p4p$	$^3P_1$
0.8007	4	3455 158	3455 1565	28 9422	$3p4p$	$^1S_0$	-	$3p4d$	$^1P_1$
1.3311	4	3545 109	3545 1080	28 2079	$3s5d$	$^3D_1$	-	$3s6f$	$^3F_2$

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1.9371	6 bl P III	3555 021	3555 0221	28 1292	$3s5d$	$^3D_2$	-	$3s6f$	$^3F_3$
2.8329	7	3568 537	3568 5362	28 0226	$3s5d$	$^3D_3$	-	$3s6f$	$^3F_4$
0.3947	4	3601 843	3601 8435	27 7635	$3p4p$	$^1D_2$	-	$3p4d$	$^1D_2$
0.6586	0 h	3675 01	3675 0112	27 2108	$3s6h$	$^3H_5$	-	$3s9i$	$^3I_5$
0.5543	0 h	,,	3675 0112	27 2108	$3s6h$	$^3H_5$	-	$3s9i$	$^3I_6$
0.7817	0 h	,,	3675 0112	27 2108	$3s6h$	$^3H_6$	-	$3s9i$	$^3I_6$
0.6773	0 h	,,	3675 0112	27 2108	$3s6h$	$^1H_5$	-	$3s9i$	$^1I_6$
0.2916	6	3721 304	3721 3036	26 8723	$3p4s$	$^3P_0$	-	$3p4p$	$^3D_1$
0.6095	7	3730 188	3730 1874	26 8083	$3p4s$	$^3P_1$	-	$3p4p$	$^3D_2$
1.1245	9	3733 393	3733 3932	26 7853	$3p4s$	$^3P_2$	-	$3p4p$	$^3D_3$
0.0145	3	3736 241	3736 2407	26 7648	$3s5p$	$^3P_1$	-	$3p4p$	$^3S_1$
0.1729	4	3760 792	3760 7923	26 5901	$3p4s$	$^3P_1$	-	$3p4p$	$^3D_1$
0.1523	5	3787 446	3787 4458	26 4030	$3p4s$	$^3P_2$	-	$3p4p$	$^3D_2$
0.0431	4	3980 574	3980 5732	25 1220	$3s4d$	$^3D_2$	-	$3p4s$	$^3P_2$
0.2414	6	3981 779	3981 7802	25 1144	$3s4d$	$^3D_3$	-	$3p4s$	$^3P_2$
0.0267	m P III	3997 217	3997 2174	25 0174	$3s6s$	$^3S_1$	-	$3s7p$	$^3P_2$
0.0158	0	3998 951	3998 9503	25 0065	$3s6s$	$^3S_1$	-	$3s7p$	$^3P_1$
0.0053	0	3999 341	3999 3413	25 0041	$3s6s$	$^3S_1$	-	$3s7p$	$^3P_0$
0.1108	5	4045 838	4045 8370	24 7167	$3s4d$	$^3D_2$	-	$3p4s$	$^3P_1$
0.2589	4	4150 854	4150 8545	24 0914	$3s5p$	$^3P_0$	-	$3s6s$	$^3S_1$
0.7710	5	4159 755	4159 7546	24 0398	$3s5p$	$^3P_1$	-	$3s6s$	$^3S_1$
1.2662	7	4177 648	4177 6479	23 9369	$3s5p$	$^3P_2$	-	$3s6s$	$^3S_1$
0.7688	11	4249 656 0.58[B*]	4249 6234	23 5331	$3s4s$	$^1S_0$	-	$3s4p$	$^1P_1$
0.0893	11	4516 515	4516 5147	22 1410	$3s5g$	$^1G_4$	-	$3s6f$	$^1F_3$
11.5025	11	4540 288	4540 2699	22 0251	$3s5g$	$^3G_3$	-	$3s6h$	$^3H_4$
0.4107	10	,,	4540 2732	22 0251	$3s5g$	$^3G_4$	-	$3s6h$	$^3H_4$
9.8570	10	,,	4540 2744	22 0251	$3s5g$	$^3G_4$	-	$3s6h$	$^3H_5$
4.5423	10	,,	4540 2776	22 0250	$3s5g$	$^3G_4$	-	$3s6h$	$^1H_5$
0.0060	10	,,	4540 2789	22 0250	$3s5g$	$^3G_5$	-	$3s6h$	$^3H_4$
0.5915	10	,,	4540 2886	22 0250	$3s5g$	$^3G_5$	-	$3s6h$	$^3H_5$
17.4747	10	,,	4540 2893	22 0249	$3s5g$	$^3G_5$	-	$3s6h$	$^3H_6$
0.1808	10	4541 112	4541 1117	22 0210	$3s5g$	$^1G_4$	-	$3s6h$	$^3H_4$

Continued

4.3393	10	,,	4541 1125	22 0209	$3s5g$	$^1G_4$	-	$3s6h$	$^1H_5$
7.9981	8	4548 056	4548 0552	21 9874	$3s5f$	$^3F_4$	-	$3s6g$	$^3G_5$
3.3931	9 bl P III	4548 449	4548 4479	21 9954	$3s5f$	$^3F_3$	-	$3s6g$	$^3G_4$
4.6721	6	4549 457	4549 4576	21 9806	$3s5f$	$^3F_2$	-	$3s6g$	$^3G_3$
2.7403	2 d	4551 299	4551 3005	21 9717	$3s5f$	$^3F_3$	-	$3s6g$	$^1G_4$
0.0438	0 h	4574 52	4574 5192	21 8602	$3s6g$	$^1G_4$	-	$3s8h$	$^3H_4$
1.0523	0 h	,,	4574 5194	21 8602	$3s6g$	$^1G_4$	-	$3s8h$	$^3H_5$
1.3567	0 h	,,	4574 5199	21 8601	$3s6g$	$^1G_4$	-	$3s8h$	$^1H_5$
1.9081	1 h	4576 35	4576 3521	21 8515	$3s6g$	$^3G_3$	-	$3s8h$	$^3H_4$
0.0543	1 h	4577 39	4577 3907	21 8465	$3s6g$	$^3G_4$	-	$3s8h$	$^3H_4$
1.3023	1 h	,,	4577 3910	21 8465	$3s6g$	$^3G_4$	-	$3s8h$	$^3H_5$
1.0973	1 h	,,	4577 3914	21 8465	$3s6g$	$^3G_4$	-	$3s8h$	$^1H_5$
0.0010	1 h	4578 06	4578 0621	21 8433	$3s6g$	$^3G_5$	-	$3s8h$	$^3H_5$
0.0981	1 h	,,	4578 0622	21 8433	$3s6g$	$^3G_5$	-	$3s8h$	$^3H_6$
2.4297	3 h	4663 02	4663 0205	21 4453	$3s6h$	$^1H_5$	-	$3s8i$	$^1I_6$
2.8040	3 h	,,	4663 0205	21 4453	$3s6h$	$^3H_5$	-	$3s8i$	$^3I_5$
1.9883	3 h	,,	4663 0205	21 4453	$3s6h$	$^3H_6$	-	$3s8i$	$^3I_6$
2.3627	3 h	,,	4663 0205	21 4453	$3s6h$	$^3H_6$	-	$3s8i$	$^3I_7$
2.9709	2 d	5016 718	5016 7173	19 9333	$3s5f$	$^1F_3$	-	$3s6g$	$^3G_4$
3.6816	7	5020 132	5020 1319	19 9198	$3s5f$	$^1F_3$	-	$3s6g$	$^1G_4$
0.1041	4	5108 367	5108 3671	19 5757	$3p4s$	$^3P_0$	-	$3s5d$	$^3D_1$
0.2893	5	5161 858	5161 8578	19 3729	$3p4s$	$^3P_1$	-	$3s5d$	$^3D_2$
0.0833	2	5183 065	5183 0656	19 2936	$3p4s$	$^3P_1$	-	$3s5d$	$^3D_1$
0.5587	7	5242 452	5242 4512	19 0750	$3p4s$	$^3P_2$	-	$3s5d$	$^3D_3$
0.0976	3	5272 118	5272 1101	18 9668	$3p4s$	$^3P_2$	-	$3s5d$	$^3D_2$
0.5498	3	6085 609	6085 6087	16 3221	$3s5d$	$^3D_1$	-	$3s6p$	$^3P_1$
0.7353	4	6090 907	6090 9073	16 4179	$3s5d$	$^3D_1$	-	$3s6p$	$^3P_0$
1.6475	6	6115 136	6115 1365	16 3553	$3s5d$	$^3D_2$	-	$3s6p$	$^3P_1$
3.0702	8	6142 605	6142 6058	16 2797	$3s5d$	$^3D_3$	-	$3s6p$	$^3P_2$
1.8865	7	6171 245	6171 2455	16 2004	$3s5d$	$^1D_2$	-	$3s6p$	$^1P_1$
5.2390	8	6713 939	6713 9384	14 8944	$3s5p$	$^3P_2$	-	$3s5d$	$^3D_3$
2.7848	7	6715 906	6715 9056	14 8900	$3s5p$	$^3P_1$	-	$3s5d$	$^3D_2$

Continued

1.2696	6	6728 466	6728 4652	14 8618	3s5p	$^3P_0$	-	3s5d	$^3D_1$
0.9429	4	6751 855	6751 8558	14 8107	3s5p	$^3P_1$	-	3s5d	$^3D_1$
0.9136	5	6762 686	6762 6854	14 7870	3s5p	$^3P_2$	-	3s5d	$^3D_2$
0.0616	1	6799 150	6799 1489	14 7077	3s5p	$^3P_2$	-	3s5d	$^3D_1$
2.9277	0 h	7050 70	7050 7011	14 1843	3s7i	$^3I_6$		3s9k	$^3K_6$
3.3871	0 h	,,	7050 7005	14 1843	3s7i	$^3I_6$		3s9k	$^3K_7$
2.5289	0 h	,,	7050 7005	14 1843	3s7i	$^3I_7$		3s9k	$^3K_8$
2.9886	0 h	,,	7050 7000	14 1843	3s7i	$^1I_7$		3s9k	$^1K_8$
4.6762	1	7267 038	7267 0389	13 7607	3p4p	$^1D_2$	-	3s6f	$^1F_3$
0.2305	9	7443 657	7443 6562	13 4342	3s6g	$^1G_4$	-	3s7h	$^3H_5$
7.2032	9	,,	7443 6572	13 4341	3s6g	$^1G_4$	-	3s7h	$^1H_5$
2.4272	9	,,	7443 6576	13 4340	3s5s	$^3S_1$	-	3s5p	$^3P_2$
10.0339	1 h	7448 39	7448 3879	13 4257	3s6g	$^3G_3$	-	3s7h	$^3H_4$
6.8485	2 h	7451 13	7451 1305	13 4208	3s6g	$^3G_4$	-	3s7h	$^3H_5$
5.8279	2 h	,,	7451 1324	13 4207	3s6g	$^1G_4$	-	3s7h	$^1H_5$
15.2336	2 h	7452 86	7452 8593	13 4177	3s6g	$^3G_5$	-	3s7h	$^3H_5$
0.5156	2 h	,,	7452 8595	13 4177	3s6g	$^3G_5$	-	3s7h	$^3H_6$
1.4674	7	7501 194	7501 1943	13 3312	3s5s	$^3S_1$	-	3s5p	$^3P_1$
0.4908	4	7530 261	7530 2616	13 2797	3s5s	$^3S_1$	-	3s5p	$^3P_0$
6.9412	1 h	7634 28	7634 2816	13 0988	3s6f	$^3F_4$	-	3s7g	$^3G_5$
2.9585	1 h	7639 71	7639 7093	13 0895	3s6f	$^3F_3$	-	3s7g	$^3G_4$
4.0521	1 h	7644 46	7644 4629	13 0813	3s6f	$^3F_2$	-	3s7g	$^3G_3$
22.0093	6 h	7670 23	7670 2287	13 0374	3s6h	$^1H_5$	-	3s7i	$^1I_6$
25.3914	6 h	,,	7670 2292	13 0374	3s6h	$^3H_6$	-	3s7i	$^3I_7$
18.0048	6 h	,,	7670 2304	13 0374	3s6h	$^3H_6$	-	3s7i	$^3I_6$
21.3946	6 h	,,	7670 2307	13 0373	3s6h	$^3H_5$	-	3s7i	$^3I_5$
0.0006	1	8504 89	8504 8906	11 7579	3s4d	$^1D_2$	-	3p3d	$^1P_1$
0.9955	4 b, d	9596 29	8504 8912	11 7578	3s4d	$^3D_2$	-	3s4f	$^3F_3$
0.8430	4 b, d	,,	9596 2912	10 4200	3s4d	$^3D_1$	-	3s4f	$^3F_2$
1.8062	4 b, d	,,	9596 2887	10 4206	3s4d	$^3D_3$	-	3s4f	$^3F_4$
0.1560	2 d	9600 76	9600 7483	10 4158	3s4d	$^3D_2$	-	3s4f	$^3F_2$
0.1240	2 d	9602 98	9602 9659	10 4134	3s4d	$^3D_3$	-	3s4f	$^3F_3$

Abbreviations used for the intensities [11]: b = broad, bl = blended, h = hazy, m = masked by, d = diffuse. Ref. [11]: B* - Line taken from Geuter's measurements and classified by Bowen and Millikan or Bowen.

Table 3. P IV energy levels and lifetimes for the even configurations.

Lifetimes (10^{-10} s^{-1})	Levels (cm^{-1}) Referenced	Fitted	Config.	Term	Percentage Composition[1]				
	0.00	0.0000	$3s^2$	$^1S_0$					
0.7116	158 141.82	158 1422	$3p^2$	$^1D_2$	69%	+	$3s3d$	^1D	31%
2.751	164 941.44	164 9427	$3p^2$	$^3P_0$					
2.740	165 185.39	165 1850	$3p^2$	$^3P_1$					
2.723	165 654.04	165 6536	$3p^2$	$^3P_2$					
1.762	194 591.75	194 5918	$3p^2$	$^1S_0$	94%	+	$3d^2$	^1S	4%
1.964	189 398.13	189 3979	$3s3d$	$^3D_1$					
1.976	189 398.13	189 3980	$3s3d$	$^3D_2$					
1.993	189 398.13	189 3981	$3s3d$	$^3D_3$					
0.9364	219 153.88	219 1540	$3s3d$	$^1D_2$	68%	+	$3p^2$	^1D	29%
1.919	226 898.14	226 8977	$3s4s$	$^3S_1$					
4.156	233 997.96	233 9984	$3s4s$	$^1S_0$					
11.24	293 242.94	293 2426	$3s4d$	$^3D_1$					
11.29	293 247.69	293 2476	$3s4d$	$^3D_2$					
11.37	293 255.27	293 2551	$3s4d$	$^3D_3$					
14.92	295 328.63	295 3283	$3s4d$	$^1D_2$	95%	+	$3p4p$	^1D	4%
3.532	309 111.44	309 1092	$3s5s$	$^3S_1$					
4.679	311 183.04	311 1834	$3s5s$	$^1S_0$					
19.48	337 245.64	337 2479	$3s5d$	$^3D_1$	77%	+	$3p4p$	^3D	22%
19.61	337 324.91	337 3258	$3s5d$	$^3D_2$	78%	+	$3p4p$	^3D	21%
19.44	337 432.26	337 4325	$3s5d$	$^3D_3$	80%	+	$3p4p$	^3D	19%
34.64	338 035.09	338 0353	$3s5d$	$^1D_2$	86%	+	$3p4p$	^1D	13%
9.598	344 006.44	344 0092	$3s5g$	$^3G_3$					
9.412	344 007.66	344 0094	$3s5g$	$^3G_4$					
9.602	344 011.21	344 0096	$3s5g$	$^3G_5$					
9.189	344 011.61	344 0116	$3s5g$	$^1G_4$					

Continued

6.180	340 908.55	340 9078	$3p4p$	$^1P_1$									
11.25	344 540.00	344 5306	$3p4p$	$^3D_1$	75%	+	$3s5d$	^3D	23%				
11.03	344 758.07	344 7567	$3p4p$	$^3D_2$	76%	+	$3s5d$	^3D	22%				
10.66	345 140.16	345 1305	$3p4p$	$^3D_3$	78%	+	$3s5d$	^3D	20%				
8.871	349 196.23	349 1962	$3p4p$	$^3S_1$	76%	+	$3s6s$	^3S	19%				
6.677	347 182.92	347 1794	$3p4p$	$^3P_0$	94%	+	$3s6s$	^1S	5%				
7.247	347 373.99	347 3719	$3p4p$	$^3P_1$									
6.651	347 704.36	347 6957	$3p4p$	$^3P_2$									
14.92	352 389.40	352 3900	$3p4p$	$^1D_2$	70%	+	$3s6d$	^1D	12%		3s5d	^1D	12%
6.057	359 708.14	359 7082	$3p4p$	$^1S_0$	79%	+	$3s7s$	^1S	8%	+	3s6s	^1S	6%
7.237	347 602.39	347 6024	$3s6s$	$^1S_0$	88%	+	$3p4p$	^1S	6%	+	3p4p	^3P	6%
6.178	346 472.11	346 4712	$3s6s$	$^3S_1$	79%	+	$3p4p$	^3S	20%				
25.69	363 041.47	363 0414	$3s6d$	$^3D_1$									
25.76	363 043.30	363 0451	$3s6d$	$^3D_2$									
25.89	363 050.67	363 0508	$3s6d$	$^3D_3$									
32.54	363 751.86	363 7496	$3s6d$	$^1D_2$	87%	+	$3p4p$	^1D	10%				
16.65	365 569.46	365 5695	$3s6g$	$^1G_4$	90%	+	$3s6g$	^3G	10%				
15.99	365 578.07	365 5781	$3s6g$	$^3G_3$									
16.53	365 582.98	365 5830	$3s6g$	$^3G_4$	90%	+	$3s6g$	^1G	10%				
15.99	365 586.13	365 5862	$3s6g$	$^3G_5$									
8.762	367 535.64	367 5361	$3s7s$	$^3S_1$									
1.016	368 240.73	368 2394	$3s7s$	$^1S_0$	92%	+	$3p4p$	^1S	6%				
38.38	377 035.10	377 0337	$3s7d$	$^3D_1$									
38.53	377 037.03	377 0396	$3s7d$	$^3D_2$									
38.55	377 049.14	377 0487	$3s7d$	$^3D_3$									
44.63	377 179.98	377 1802	$3s7d$	$^1D_2$									
26.13	378 508.15	378 5080	$3s7g$	$^1G_4$	86%	+	$3s7g$	^3G	14%				
24.49	378 523.25	378 5231	$3s7g$	$^3G_3$									
25.81	378 531.99	378 5353	$3s7g$	$^3G_4$	86%	+	$3s7g$	^1G	14%				
24.46	378 542.15	378 5420	$3s7g$	$^3G_5$									
52.14	379 060.00	379 0600	$3s7i$	$^3I_5$									
52.13	379 060.00	379 0600	$3s7i$	$^3I_6$	55%	+	$3s7i$	^1I	45%				
52.14	379 060.00	379 0600	$3s7i$	$^3I_7$									
52.14	379 060.00	379 0600	$3s7i$	$^1I_6$	55%	+	$3s7i$	^3I	45%				

Continued

15.15	379 968.82	379 9688	$3s8s$	$^3S_1$									
14.13	380 315.60	380 3167	$3s8s$	$^1S_0$									
176.5	386 083.50	386 0818	$3s8d$	$^3D_1$									
176.5	386 083.50	386 0825	$3s8d$	$^3D_2$	66%	+	$3s8d$	^1D	33%				
148.6	386 083.50	386 0834	$3s8d$	$^3D_3$									
51.13	385 802.40	385 8023	$3s8d$	$^1D_2$	67%	+	$3s8d$	^3D	32%				
36.85	N.I.	*389 3433	$3s8g$	$^1G_4$									
34.17	N.I.	*389 4254	$3s8g$	$^3G_3$									
34.18	N.I.	*389 4254	$3s8g$	$^3G_4$									
34.18	N.I.	*389 4254	$3s8g$	$^3G_5$									
77.28	387 465.5	387 4655	$3s8i$	$^3I_5$									
138.7	387 465.5	387 4655	$3s8i$	$^3I_6$	55%	+	$3s8i$	^1I	45%				
77.28	387 465.5	387 4655	$3s8i$	$^3I_7$									
137.8	387 465.5	387 4655	$3s8i$	$^1I_6$	55%	+	$3s8i$	^3I	45%				
2.170	388 078.6	388 0786	$3s9s$	$^3S_1$									
1.837	388 287.3	388 2882	$3s9s$	$^1S_0$									
1.223	380 647.21	380 6480	$3d^2$	$^3F_2$									
1.229	380 673.19	380 6777	$3d^2$	$^3F_3$									
1.237	380 712.65	380 7126	$3d^2$	$^3F_4$									
0.9209	396 179.60	396 1800	$3d^2$	$^3P_0$									
0.9222	396 180.67	396 1800	$3d^2$	$^3P_1$									
0.9248	396 179.60	396 1800	$3d^2$	$^3P_2$									
1.037	389 296.50	389 2970	$3d^2$	$^1D_2$									
2.115	N.I.	*400 9415	$3d^2$	$^1G_4$									
0.8456	N.I.	*428 4735	$3d^2$	$^1S_0$	82%	+	3p5p	^1S	12%	+	$3p^2$	^1S	4%
618.7	392 174.5	392 1734	$3s9d$	$^3D_1$									
274.4	392 174.5	392 1740	$3s9d$	$^3D_2$	71%	+	$3s9d$	^1D	28%				
274.4	392 174.5	392 1755	$3s9d$	$^3D_3$									
50.36	N.I.	*392 1750	$3s9d$	$^1D_2$	71%	+	$3s9d$	^3D	28%				
41.72	N.I.	*395 0978	$3s9g$	$^1G_4$									
38.60	N.I.	*395 2372	$3s9g$	$^3G_3$									
38.60	N.I.	*395 2372	$3s9g$	$^3G_4$									
38.61	N.I.	*395 2372	$3s9g$	$^3G_5$									

Continued

109.3	393 229.2	393 2290	*3s9i*	$^3I_5$									
109.3	393 229.2	393 2290	*3s9i*	$^3I_6$	96%	+	*3s9i*	^1H	4%				
109.3	393 229.2	393 2290	*3s9i*	$^3I_7$									
109.3	393 229.2	393 2290	*3s9i*	$^1I_6$	96%	+	*3s9i*	^3H	4%				
32.58	393 662.8	393 6629	*3s10s*	$^3S_1$									
21.42	393 799.0	393 7989	*3s10s*	$^1S_0$									
82.91	396 700.0	396 7000	*3s10d*	$^3D_1$									
53.39	396 700.0	396 7000	*3s10d*	$^3D_2$	92%	+	3s10d	^1D	7%				
84.30	396 700.0	396 7000	*3s10d*	$^3D_3$									
34.66	N.I.	*396 7000	*3s10d*	$^1D_2$	88%	+	3s10d	^3D	8%				

[1]Percentage composition lower than 3% were omitted. N.I.: Level no identified. *As suggested by the fitting.

Table 4. P IV energy levels and lifetimes for the odd configurations.

Lifetimes (10^{-10} s^{-1})	Levels (cm^{-1})		Config.	Term	Percentage Composition[1]								
	Referenced	Fitted											
	67 918.03	67 9175	*3s3p*	$^3P_0$									
1433-5	68 146.48	68 1471	*3s3p*	$^3P_1$									
	68 615.17	68 6150	*3s3p*	$^3P_2$									
2702	105 190.42	105 1901	*3s3p*	$^1P_1$	95%	+	*3p3d*	^1P	4%				
11.93	256 553.36	256 5530	*3s4p*	$^3P_0$									
11.63	256 611.97	256 6133	*3s4p*	$^3P_1$									
11.78	256 760.46	256 7606	*3s4p*	$^3P_2$									
3.515	257 522.66	257 5226	*3s4p*	$^1P_1$	94%	+	*3p4s*	^1P	5%				
13.42	262 005.27	262 0062	*3p3d*	$^3F_2$									
13.32	262 248.46	262 2460	*3p3d*	$^3F_3$									
13.15	262 567.20	262 5647	*3p3d*	$^3F_4$									
2.246	267 015.23	267 0152	*3p3d*	$^1D_2$									
5.212	281 020.00	281 0215	*3p3d*	$^3P_2$									
5.190	281 257.85	281 2578	*3p3d*	$^3P_1$									
5.274	281 399.92	281 3975	*3p3d*	$^3P_0$									
1.195	283 150.04	283 1460	*3p3d*	$^3D_1$									
1.201	283 246.87	283 2450	*3p3d*	$^3D_2$									
1.197	283 329.08	283 3345	*3p3d*	$^3D_3$									
	314 423.69	N.I.	*3p3d*	$^1F_3$	53%	+	*3s4f*	^1F	30%	+	*3s5f*	^1F	14%
0.8946	307 083.34	307 0833	*3p3d*	$^1P_1$	92%	+	*3s3p*	^1P	4%				

Continued

2.133	303 660.64	303 6532	$3s4f$	$^3F_2$									
2.037	303 665.80	303 6598	$3s4f$	$^3F_3$									
2.132	303 672.49	303 6687	$3s4f$	$^3F_4$									
	290 327.71	N.I.	$3s4f$	$^1F_3$	68%	+	$3p3d$	^1F	30%				
1.811	317 675.35	317 6673	$3p4s$	$^3P_0$	99%								
1.821	317 957.41	317 9563	$3p4s$	$^3P_1$	94%								
1.817	318 362.54	318 3619	$3p4s$	$^3P_2$	99%								
	327 873.54	N.I.	$3p4s$	$^1P_1$	55%	+	$3s5p$	^1P	35%	+	$3p4s$	^3P	6%
0.1267	322 387.52	322 3882	$3s5p$	$^3P_0$									
0.1220	322 438.99	322 4390	$3s5p$	$^3P_1$									
0.1130	322 541.98	322 5425	$3s5p$	$^3P_2$									
	316 888.79	N.I.	$3s5p$	$^1P_1$	60%	+	$3p4s$	^1P	34%				
3.978	343 603.59	343 6044	$3s5f$	$^3F_2$									
3.979	343 603.90	343 6047	$3s5f$	$^3F_3$									
3.979	343 604.88	343 6050	$3s5f$	$^3F_4$									
3.363	345 655.20	345 6555	$3s5f$	$^1F_3$									
0.2501	353 659.02	353 6585	$3s6p$	$^3P_0$									
0.2486	353 673.27	353 6736	$3s6p$	$^3P_1$									
0.2504	353 707.50	353 7071	$3s6p$	$^3P_2$									
0.1080	354 234.79	354 2340	$3s6p$	$^1P_1$									
6.772	365 445.49	365 4446	$3s6f$	$^3F_2$									
6.778	365 446.09	365 4456	$3s6f$	$^3F_3$									
6.787	365 446.95	365 4469	$3s6f$	$^3F_4$									
5.819	366 146.37	366 1464	$3s6f$	$^1F_3$									
0.2300	366 026.17	366 0262	$3s6h$	$^3H_4$									
0.2301	366 026.17	366 0262	$3s6h$	$^3H_5$									
0.2290	366 026.17	366 0262	$3s6h$	$^1H_5$									
0.2301	366 026.17	366 0262	$3s6h$	$^3H_6$									
0.4011	371 469.13	371 4684	$3s7p$	$^3P_0$									
0.3947	371 471.60	371 4726	$3s7p$	$^3P_1$									
0.4013	371 482.50	371 4822	$3s7p$	$^3P_2$									
0.1685	371 585.76	371 5861	$3s7p$	$^1P_1$									

Continued

0.1079	378 493.37	378 4942	$3s7f$	$^3F_2$	92%	+	$3p4d$	^3F	8%				
0.1080	378 493.37	378 4937	$3s7f$	$^3F_3$	89%	+	$3p4d$	^3F	6%	+	$3s7f$	^1F	4%
0.1081	378 493.37	378 4932	$3s7f$	$^3F_4$	95%	+	$3p4d$	^3F	5%				
9.534	378 548.10	378 5483	$3s7f$	$^1F_3$	88%		$3p4d$	$^1F_3$	7%		$3s7f$	^3F	5%
0.3532	379 000.09	379 0000	$3s7h$	$^3H_4$									
0.3534	379 000.09	379 0000	$3s7h$	$^3H_5$	55%	+	$3s7h$	^1H	45%				
0.3522	379 000.09	379 0000	$3s7h$	$^1H_5$	55%	+	$3s7h$	^3H	45%				
0.3537	379 000.09	379 0000	$3s7h$	$^3H_6$									
4.188	380 145.04	380 1471	$3p4d$	$^1D_2$									
5.523	381 247.18	381 2464	$3p4d$	$^3F_2$	77%	+	$3p4d$	^3D	13%	+	$3s7f$	^3F	7%
5.445	381 426.02	381 4263	$3p4d$	$^3F_3$	74%	+	$3p4d$	^3D	18%	+	$3s7f$	^3F	6%
6.185	381 729.38	381 7289	$3p4d$	$^3F_4$	92%	+	$3s7f$	^3F	5%	+			
3.356	381 614.80	381 6153	$3p4d$	$^3D_1$	82%	+	$3s8p$	^3P	16%	+			
3.571	381 809.62	381 8103	$3p4d$	$^3D_2$	79%	+	$3p4d$	^3F	10%	+	$3s8p$	^3F	9%
3.655	362 012.68	362 0127	$3p4d$	$^3D_3$	82%	+	$3p4d$	^3F	17%	+			
3.057	385 205.91	385 2050	$3p4d$	$^3P_2$									
3.028	385 424.96	385 4231	$3p4d$	$^3P_1$									
3.023	38554660	385 5458	$3p4d$	$^3P_0$									
	38598004	N.I.	$3p4d$	$^1F_3$	32%	+	$3s8f$	^1F	31%	+	$3s9f$	^1F	31%
1.305	388 64207	388 6429	$3p4d$	$^1P_1$	74%	+	$3s9p$	^1P	10%	+	$3p5s$	^1P	10%
0.6476	381 7151	3817150	$3s8p$	$^3P_0$									
0.6483	381 7151	3817150	$3s8p$	$^3P_1$	82%	+	$3p4d$	^3D	17%				
0.6497	381 7151	3817150	$3s8p$	$^3P_2$	90%	+	$3p4d$	^3D	6%				
0.2182	382 4508	382 4492	$3s8p$	$^1P_1$									
0.1731	387 2681	3872681	$3s8f$	$^3F_2$									
0.1732	387 2681	3872681	$3s8f$	$^3F_3$									
0.1734	387 2681	3872681	$3s8f$	$^3F_4$									
	388 12417	N.I.	$3s8f$	$^1F_3$	62%	+	$3p4d$	^1F	33%				
0.5103	387 4234	3874234	$3s8h$	$^3H_4$									
0.7256	387 4234	3874234	$3s8h$	$^3H_5$									
0.1554	387 4234	3874234	$3s8h$	$^1H_5$									
0.5115	387 4234	3874234	$3s8h$	$^3H_6$									

Continued

0.8356	389 8106	3898115	$3s9p$	$^3P_0$								
0.8362	389 8106	3898109	$3s9p$	$^3P_1$								
0.8373	389 8106	3898104	$3s9p$	$^3P_2$								
0.2475	389 9350	3899352	$3s9p$	$^1P_1$	88%	+	$3p4d$	^1P	11%			
0.2400	393 0608	3930602	$3s9f$	$^3F_2$								
0.2402	393 0608	3930608	$3s9f$	$^3F_3$								
0.2404	393 0608	3930618	$3s9f$	$^3F_4$								
0.1823	393 4443	393 4440	$3s9f$	$^1F_3$	66%	+	$3p4d$	^1F	20%	$3s8f$	$^1F_3$	5%
0.7388	N.I.	*3952990	$3s9h$	$^3H_4$								
0.7392	N.I.	*3952990	$3s9h$	$^3H_5$								
0.7363	N.I.	*3953000	$3s9h$	$^1H_5$								
0.7397	N.I.	*3952990	$3s9h$	$^3H_6$								
0.0148	393 2391	3932391	$3s9k$	$^3K_6$								
0.0148	393 2391	3932391	$3s9k$	$^3K_7$	54%	+	$3s9k$	^1K	46%			
0.0148	393 2391	3932391	$3s9k$	$^1K_7$	54%	+	$3s9k$	^3K	46%			
0.0148	393 2391	3932391	$3s9k$	$^3K_8$								
0.0115	N.I.	*3969723	$3s10p$	$^3P_0$								
0.0115	N.I.	*3969777	$3s10p$	$^3P_1$								
0.0115	N.I.	*3969875	$3s10p$	$^3P_2$								
0.0162	N.I.	*3958734	$3s10p$	$^1P_1$	94%							
0.3281	397 2219	3972218	$3s10f$	$^3F_2$								
0.3283	397 2219	3972220	$3s10f$	$^3F_3$								
0.1900	397 2219	3972225	$3s10f$	$^3F_4$								
0.3286	397 4736	3974744	$3s10f$	$^1F_3$								

[1]Percentage composition lower than 3% were omitted. N.I.: Level no identified. *As suggested by the fitting.

trum of the ion P IV are presented by the method of attempting to reproduce as much as possible the observed values and extracting information about the values of *gf* and lifetimes that are closer to the experimental ones. Phosphorus is an astrophysically important element. The present work is part of an ongoing program, whose goal is to obtain oscillator strength and lifetimes for elements of astrophysical importance. Phosphorus occupies the fifteenth place with respect to cosmic distribution [17].

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