Astronomy & Astrophysics manuscript no. aa15126-10
September 3, 2010

New Fe II energy levels from stellar spectra⋆

F. Castelli[1] and R. L. Kurucz[2]

[1] Istituto Nazionale di Astrofisica – Osservatorio Astronomico di Trieste, via Tiepolo 11, 34131 Trieste, Italy
e-mail: castelli@oats.inaf.it
[2] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

Received 1 June 2010 / Accepted 29 June 2010

ABSTRACT

Aims. The spectra of B-type and early A-type stars show numerous unidentified lines in the whole optical range, especially in the 5100−5400 Å interval. Because Fe II transitions to high energy levels should be observed in this region, we used semiempirical predicted wavelengths and gf-values of Fe II to identify unknown lines.
Methods. Semiempirical line data for Fe II computed by Kurucz are used to synthesize the spectrum of the slow-rotating, Fe -overabundant CP star HR 6000.
Results. We determined a total of 109 new 4f levels for Fe II with energies ranging from 122 324 cm^{-1} to 128 110 cm^{-1}. They belong to the Fe II subconfigurations $3d^6(^3P)4f$ (10 levels), $3d^6(^3H)4f$ (36 levels), $3d^6(^3F)4f$ (37 levels), and $3d^6(^3G)4f$ (26 levels). We also found 14 even levels from 4d (3 levels), 5d (7 levels), and 6d (4 levels) configurations. The new levels have allowed us to identify more than 50% of the previously unidentified lines of HR 6000 in the wavelength region 3800−8000 Å. Tables listing the new energy levels are given in the paper; tables listing the spectral lines with $\log gf \geq -1.5$ that are transitions to the 4f energy levels are given in the Online Material. These new levels produce 18 000 lines throughout the spectrum from the ultraviolet to the infrared.

Key words. line: identification – atomic data – stars: atmospheres – stars: chemically peculiar – stars: individual: HR 6000

1. Introduction

In a previous paper (Castelli et al. 2009) (Paper I) we have determined 21 new $3d^6(^3H)4f$ high energy levels of Fe II on the basis of predicted energy levels, computed $\log gf$ values for Fe II, and unidentified lines in UVES high resolution, high signal-to-noise spectra of HR 6000 and 46 Aql. Both stars are iron overabundant CP stars and have rotational velocity $v \sin i$ of the order of 1.5 km s^{-1} and 1.0 km s^{-1}, respectively.

In this paper we continue the effort to determine new high-energy levels of Fe II. We used the same spectra and models for HR 6000 that we adopted in Paper I, together with Fe II line lists which include transitions between observed-observed, observed-predicted, and predicted-predicted energy levels. In this paper we increase the number of the new energy levels from the 21 listed in Paper I, to a total of 109 energy levels, which belong to the Fe II subconfigutations: $3d^6(^3P)4f$ (10 levels), $3d^6(^3H)4f$ (36 levels), $3d^6(^3F)4f$ (37 levels), and $3d^6(^3G)4f$ (26 levels), and 14 levels from the even configurations 4d (3 levels), 5d (7 levels), and 6d (4 levels). The new levels have allowed us to identify more than the 50% of the previously unidentified lines in the wavelength region 3800−8000 Å of HR 6000 (Castelli & Hubrig 2007). The method that we adopted to determine the new energy levels is the same as described in Paper I. It is recalled here in Sect. 3. The comparison of the observed spectrum of HR 6000 with the synthetic spectrum which includes the new Fe II lines is available on the Castelli web site[1].

⋆ Tables 6–9 are also available in electronic form at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsweb.u-strasbg.fr/cgi-bin/qcat?J/A+A/vol/page

[1] http://wwwuser.oat.ts.astro.it/castelli/hr6000new/hr6000.html

2. The star HR 6000

According to Paper I, the CP star HR 6000 (HD 144667) has an estimated rotational velocity of 1.5 km s^{-1}. The model stellar parameters for an individual abundance ATLAS12 (Kurucz 2005) model are $T_{\rm eff}$ = 13 450 K, $\log g$ = 4.3. In addition to the large iron overabundance [+0.9], overabundances of Xe ([+4.6]), P (>[+1.5]), Ti ([+0.55]), Cr ([+0.2]), Mn ([+1.5]), Y ([+1.2]), and Hg ([+2.7]) were observed. This peculiar chemical composition, together with the underabundances of He, C, N, O, Al, Mg, Si, S, Cl, Sc, V, Co, Ni, and Sr gives rise to an optical line spectrum very rich in Fe II lines, with transitions involving upper energy levels close to the ionization limit (Johansson 2009). Also numerous Fe I and Fe III lines are observable in the spectrum.

3. The method

To determine the new energy levels we used high-resolution UVES spectra of HR 6000 (see Paper I), the corresponding synthetic spectrum, and the list of the computed transitions with predicted values for levels with no experimentally available energies. Predicted energy levels and $\log gf$ values were computed by Kurucz with his version of the Cowan (1981) code (Kurucz 2009). The calculation included 46 even configurations d^7, d^64s-9s, d^64d-9d, d^65g-9g, d^67i-9i, d^69l, d^54s^2, $d^54s5s-9s$, $d^54s4d-9d$, $d^54s5g-9g$, $d^54s7i-9i$, d^54s9l, d^44s^24d, and d^54p^2 with 19 771 levels least-squares fitted to 418 known levels. The 39 odd configurations included d^64p-9p, d^64f-9f, d^66h-9h, d^68k-9k, $d^54s4p-9p$, $d^54s4f-9f$, $d^54s6h-9h$, $d^54s8k-9k$, d^44s^24p-5p, and d^44s^24f with 19 652 levels least-squares fitted to 596 known levels. The calculations were done in LS coupling with all configuration interactions included, with scaled Hartree-Fock start-

Table 1. Fe II energy levels for the $3d^6$ (^{3}P)4f subconfiguration.

Design-ation	J	Energy cm^{-1}	c−o cm^{-1}	Design-ation	J	Energy cm^{-1}	c−o cm^{-1}	Design-ation	J	Energy cm^{-1}	c−o cm^{-1}
2[5]	11/2	122 351.810	−20.236								
	9/2	122 324.142	−18.980								
2[4]	9/2	122 355.116	−6.685	1[4]	9/2	123 629.520	−4.606				
	7/2	122 355.553	−6.801		7/2	123 637.833	−6.417				
2[3]	7/2	122 351.488	−18.489	1[3]	7/2	123 615.875	−2.642	0[3]	7/2	(124 167.229)	
	5/2	(122 353.541)			5/2	123 649.493	−5.687		5/2	124 157.060	+15.841
2[2]	5/2	(122 342.921)		1[2]	5/2	(123 637.063)					
	3/2	(122 336.098)			3/2	(123 646.360)					
2[1]	3/2	(122 358.405)									
	1/2	(122 332.608)									

Notes. Energies between parentheses are predicted values.

ing guesses, and with Hartree-Fock transition integrals. A total of 7 080 169 lines were saved from the transition array of which 102 833 lines are between known levels and have good wavelengths.

The computed line list was sorted into tables of all the strong lines connected to every predicted level. When a given predicted level gives rise to at least two Fe II lines having $\log gf \geq -1.0$, we selected one of these transitions and searched in the spectrum for those unidentified lines which have wavelength within ±50 Å and residual flux within about ±5% of those of the selected predicted line. From the observed wavelength of one of these unidentified lines and from the known energy of the lower or upper level of the predicted transition, we derived a possible energy for the predicted level. If most of transitions obtained with this energy correspond to lines observed in the spectrum, we kept the tentative energy value as a real value, otherwise we repeated the procedure using another line taken from the unidentified ones, and continued the searching until we found that energy for which most of the predicted lines correspond to the observed lines. Whenever one or more new levels were found, the whole semiempirical calculation was repeated to produce improved predicted wavelengths and $\log gf$-values. Because all configuration interactions were included, and because the mixing is exceptionally strong in the 4d and 5d configurations, every new level changed the predictions. Mixing between close levels can produce large uncertainties in the $\log gf$ values for lines that involve those levels.

This procedure is very successfull for levels which produce two or more transitions with $\log gf > 0.0$, but becomes more and more difficult as the intensity of the predicted lines decreases. In fact, weak lines are usually blended with stronger components, so that the method may fail in these cases.

4. The new energy levels

The new energy levels of the $3d^6(^3P)4f$, $3d^6(^3H)4f$, $3d^6(^3F)4f$, and $3d^6(^3G)4f$ subconfigurations and from the even configurations $3d^64d$, $3d^65d$, and $3d^66d$ are listed in Tables 1−5. Because the $3d^64f$ states of Fe II tend to appear in pairs we have used the $j_c[K]_j$ notation of jK coupling for them, where j_c is the total angular momentum of the core and $K = {}_c + l$ is the coupling of J_c with the orbital angular momentum l of the active electron. The level pairs correspond to the two separate values of the total angular momentum J obtained when the spin $s = \pm 1/2$ of the active electron is added to K. The positive energies are those obtained by comparing observed and predicted line profiles, as described in Sect. 3 and shown in Fig. 2. The energies between parentheses in Tables 1−4 are predicted values for which we have been not able to find the corresponding observed level. The reason for the failure is that either all the lines from the energy level are weak or, even if some of the transitions are predicted as moderately strong ($\log gf > 0.0$), they are blended with other stronger components, so that their identification is uncertain. The columns with label "c−o" in Tables 1−5 show the difference between the predicted and observed energy levels.

The 4d even energy levels listed in Table 5 give rise to some of the transitions listed in the Online Material. The strongest transitions related with the 5d, and 6d even energy levels occur in the 6000−8000 Å region and in the 4000−5000 Å region, respectively. The transitions to the odd energy levels are discussed in Sect. 5

The observed energy levels, the least squares fits, the predicted energy levels, and the line lists can be found on the Kurucz web site[2]. The observed levels come from the following sources: Johansson (1978), Sugar & Corliss (1985), Adam et al. (1987), Johansson & Baschek (1988), Johansson (1988, private communication), Rosberg & Johansson (1992), Castelli et al. (2008), Castelli et al. (2009), and this work. The calculations on the web site are updated whenever there are improvements to the energy levels.

5. The new Fe II lines

The new Fe II lines in the 3800−8000 Å region, produced by transitions to the Fe II subconfigurations (^{3}P)4f, (^{3}H)4f, (^{3}F)4f, and (^{3}G)4f, are shown in Tables 6−9, respectively. Only lines with $\log gf \geq -1.50$ are listed, because lines with lower $\log gf$ values are not observable in this wavelength region of HR 6000. The new Fe II lines are mostly concentrated in the 5100−5400 Å interval. The upper energy levels (Cols. 1−4) were derived as described in Sect. 3, the lower energy levels (Cols. 5−6) are those described in Sect. 4, the calculated wavelength (Col. 7) is the Ritz wavelength in air, the $\log gf$ values (Col. 8) were computed by Kurucz, the observed wavelengths (Col. 9) are the

[2] http://kurucz.harvard.edu/atoms/2601

Table 2. Fe II energy levels for the $3d^6$ (^{3}H)4f subconfiguration.

Design-ation	J	Energy cm^{-1}	c−o cm^{-1}	Design-ation	J	Energy cm^{-1}	c−o cm^{-1}	Design-ation	J	Energy cm^{-1}	c−o cm^{-1}
6[9]	19/2	122 954.180	+14.465								
	17/2	122 952.730	+20.251								
6[8]	17/2	123 007.910	+26.752	5[8]	17/2	123 219.200	−10.198				
	15/2	122 910.920	−16.531		15/2	123 193.090	−17.864				
6[7]	15/2	123 018.430	+34.439	5[7]	15/2	123 238.440	−6.653	4[7]	15/2	123 396.250	−33.027
	13/2	123 015.400	+40.333		13/2	123 168.680	−33.645		13/2	123 355.490	−36.436
6[6]	13/2	122 990.620	−2.720	5[6]	13/2	123 249.650	−6.519	4[6]	13/2	123 414.730	−32.244
	11/2	123 037.430	+26.878		11/2	123 270.340	+0.899		11/2	123 427.119	−33.418
6[5]	11/2	123 002.288	+33.455	5[5]	11/2	123 251.470	−1.320	4[5]	11/2	123 441.100	−26.889
	9/2	123 026.350	+18.587		9/2	123 269.378	+2.937		9/2	123 435.468	−17.705
6[4]	9/2	122 988.215	+30.836	5[4]	9/2	123 258.994	−1.556	4[4]	9/2	123 460.690	−26.898
	7/2	122 980.408	+26.752		7/2	123 258.021	−1.362		7/2	123 435.277	−16.103
6[3]	7/2	122 946.419	+21.403	5[3]	7/2	123 235.165	+3.471	4[3]	7/2	123 451.449	−21.115
	5/2	(122 967.896)			5/2	(123 248.017)			5/2	123 430.181	−16.906
				5[2]	5/2	123 211.159	−1.017	4[2]	5/2	(123 401.927)	
					3/2	123 213.323	−12.585		3/2	(123 384.857)	
								4[1]	3/2	(123 356.410)	
									1/2	(123 343.705)	

Notes. Energies between parentheses are predicted values.

Table 3. Fe II energy levels for the $3d^6$ (^{3}F)4f subconfiguration. Energies between parentheses are predicted values.

Design-ation	J	Energy cm^{-1}	c−o cm^{-1}	Design-ation	J	Energy cm^{-1}	c−o cm^{-1}	Design-ation	J	Energy cm^{-1}	c−o cm^{-1}
4[7]	15/2	124 421.468	+12.238								
	13/2	124 436.436	+36.895								
4[6]	13/2	124 400.107	+4.567	3[6]	13/2	124 661.274	+15.827				
	11/2	124 402.557	−3.593		11/2	124 656.535	+7.092				
4[5]	11/2	124 388.840	+3.174	3[5]	11/2	124 626.900	+3.179	2[5]	11/2	124 803.873	+20.054
	9/2	124 385.706	+2.938		9/2	124 636.116	+3.120		9/2	124 809.727	+15.721
4[4]	9/2	124 401.939	+4.674	3[4]	9/2	124 623.120	+3.085	2[4]	9/2	124 793.905	+12.624
	7/2	124 385.010	+0.698		7/2	124 620.914	+7.289		7/2	124 783.748	+15.272
4[3]	7/2	124 416.110	+13.187	3[3]	7/2	124 641.989	+9.092	2[3]	7/2	(124 814.025)	
	5/2	124 403.474	+1.243		5/2	124 653.022	−8.651		5/2	(124 808.178)	
4[2]	5/2	124 434.563	+23.142	3[2]	5/2	(124 670.316)		2[2]	5/2	(124 835.676)	
	3/2	124 460.410	−11.802		3/2	(124 678.325)			3/2	(124 833.418)	
4[1]	3/2	(124 487.989)		3[1]	3/2	(124 697.077)		2[1]	3/2	(124 876.972)	
	1/2	(124 484.721)			1/2	(124 708.453)			1/2	(124 874.375)	
				3[0]	1/2	124 731.762	−4.875				

Notes. Energies between parentheses are predicted values.

wavelengths of lines well observable in the HR 6000 spectrum. Most of them were listed as unidentified lines in Castelli & Hubrig (2007)[3]. In the last column, comments derived from the comparison of the observed and computed spectra are added for most lines. In a few cases, both computed and observed stellar lines correspond to lines measured by Johansson in laboratory works (Johansson 1978; Castelli et al. 2008). The notes "J78" and "lab" are added for these lines. When lines are computed

[3] http://wwwuser.oat.ts.astro.it/castelli/hr6000/unidentified.txt

Table 4. Fe II energy levels for the $3d^6$ (^{3}G)4f subconfiguration. Energies between parentheses are predicted values.

Design-ation	J	Energy cm^{-1}	c−o cm^{-1}	Design-ation	J	Energy cm^{-1}	c−o cm^{-1}	Design-ation	J	Energy cm^{-1}	c−o cm^{-1}
5[8]	17/2	127 507.241	−5.657								
	15/2	127 524.1227	+14.501								
5[7]	15/2	127 484.653	−1.445	4[7]	15/2	127 892.981	+4.313				
	13/2	127 515.235	+2.816		13/2	127 895.260	+3.367				
5[6]	13/2	127 489.429	−4.823	4[6]	13/2	127 875.000	+2.236	3[6]	13/2	128 110.214	−2.182
	11/2	127 489.977	−0.294		11/2	127 880.436	+1.216		11/2	(128 076.012)	
5[5]	11/2	127 482.748	+3.147	4[5]	11/2	127 869.158	+0.993	3[5]	11/2	128 071.171	−10.517
	9/2	(127 484.561)			9/2	127 855.952	−16.898		9/2	128 055.658	−16.898
5[4]	9/2	127 485.362	−15.194	4[4]	9/2	127 869.892	−4.920	3[4]	9/2	128 062.710	−15.669
	7/2	127 485.699	+9.404		7/2	(127 871.098)			7/2	128 066.823	−22.228
5[3]	7/2	(127 476.624)		4[3]	7/2	(127 877.776)		3[3]	7/2	(128 047.849)	
	5/2	127 510.913	+9.552		5/2	127 874.745	+5.549		5/2	128 063.103	−8.192
5[2]	5/2	(127 499.343)		4[2]	5/2	(127 868.807)		3[2]	5/2	128 089.313	+10.032
	3/2	127 487.681	−0.341		3/2	(127 895.930)			3/2	(128 069.044)	
				4[1]	3/2	(127 876.787)		3[1]	3/2	(128 099.051)	
					1/2	(127 898.510)			1/2	(128 099.237)	
								3[0]	1/2	(128 161.312)	

Notes. Energies between parentheses are predicted values.

Table 5. Fe II new levels from $3d^6$4d, $3d^6$5d, and $3d^6$6d configurations.

Designation		J	Energy cm^{-1}	c−o cm^{-1}
$3d^6(^3P)4d$	^2F	7/2	103 191.917	+27.014
$3d^6(^3P)4d$	^2D	5/2	103 597.402	−5.701
$3d^6(^3F)4d$	^2F	7/2	105 775.491	−42.697
$3d^6(^3H)5d$	^4H	13/2	124 208.725	+47.495
$3d^6(^3H)5d$	^4G	11/2	124 251.805	+44.041
$3d^6(^3H)5d$	^4K	15/2	124 297.017	−5.220
$3d^6(^3H)5d$	^4I	15/2	124 357.304	+12.292
$3d^6(^3H)5d$	^4K	13/2	124 415.353	−14.256
$3d^6(^3H)5d$	^2I	11/2	124 976.008	−38.096
$3d^6(^3F)5d$	^4H	13/2	125 732.991	+9.243
$3d^6(^5D)6d$	^6D	5/2	113 934.466	−58.836
$3d^6(^5D)6d$	^4D	7/2	114 009.934	−3.477
$3d^6(^5D)6d$	^6G	7/2	114 428.399	+51.787
$3d^6(^5D)6d$	^6G	5/2	114 619.007	+22.415

weaker than the observed ones the disagreement can be due either to a too low log gf value or to some unknown component which increases the line intensity. When lines are computed much stronger than the observed ones, some problem with the energy levels or/and log gf computations is very probably present. When we observed a very good agreement between the observed and computed lines, either isolated or blends, we added the note "good agreement".

Figure 1 shows the Fe II spectrum in the 5185−5196 Å interval, computed before and after the determination of the new energy levels. Figure 2 compares the observed spectrum of HR 6000 with the synthetic spectrum computed with the line list including the new Fe II lines. When the two figures are considered together, the improvement in the comparison between the observed and computed spectra is evident.

6. Conclusions

Computed atomic data and stellar spectra observed at high resolution and high signal-to-noise ratio of the iron−overabundant, slow−rotating star HR 6000 were used to extend laboratory studies on Fe II energy levels and line transitions. We identified as Fe II about 500 unidentified spectral lines in the 3800−8000 Å region. A few of these lines were already identified as iron from laboratory analyses (Johansson 2007, private communication), but they were never classified. Because numerous other new lines are components of blends they contribute to improve the agreement between observed and computed spectra. On the other hand, there is a small number of new lines which are not observed in the spectrum. We believe that they are due to computational problems related with the mixing of the even energy levels rather than to incorrect energy values for the new 4f odd levels.

In spite of the large number of the new identified lines, several medium-strong lines and a conspicuous number of weak lines remain still unidentified in the spectral region we analyzed. If we examine the list of the Fe II lines which correspond to transitions from predicted energy levels, we can count about 4600 lines with log $gf \geq -1.0$, where about 400 of them have log $gf \geq 0.0$. Because the transitions producing these lines occur between high-excitation energy levels that are not strongly

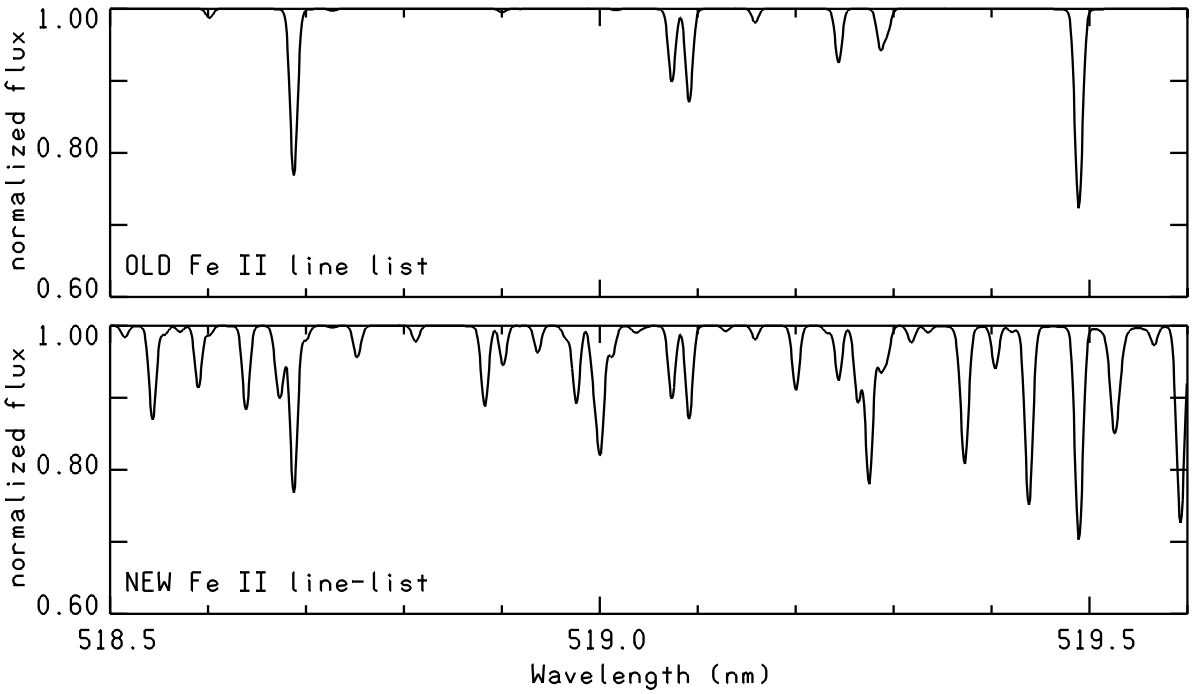

Fig. 1. Upper panel shows the Fe II synthetic spectrum for the parameters of HR 6000 ($T_{\rm eff}$ = 13 450 K, log g = 4.3, $v \sin i$ = 1.5 km^{-1}, [Fe/H] = +0.9) computed with the line list availble before this work. The lower panel is the same, but with the new Fe II lines added in the line list.

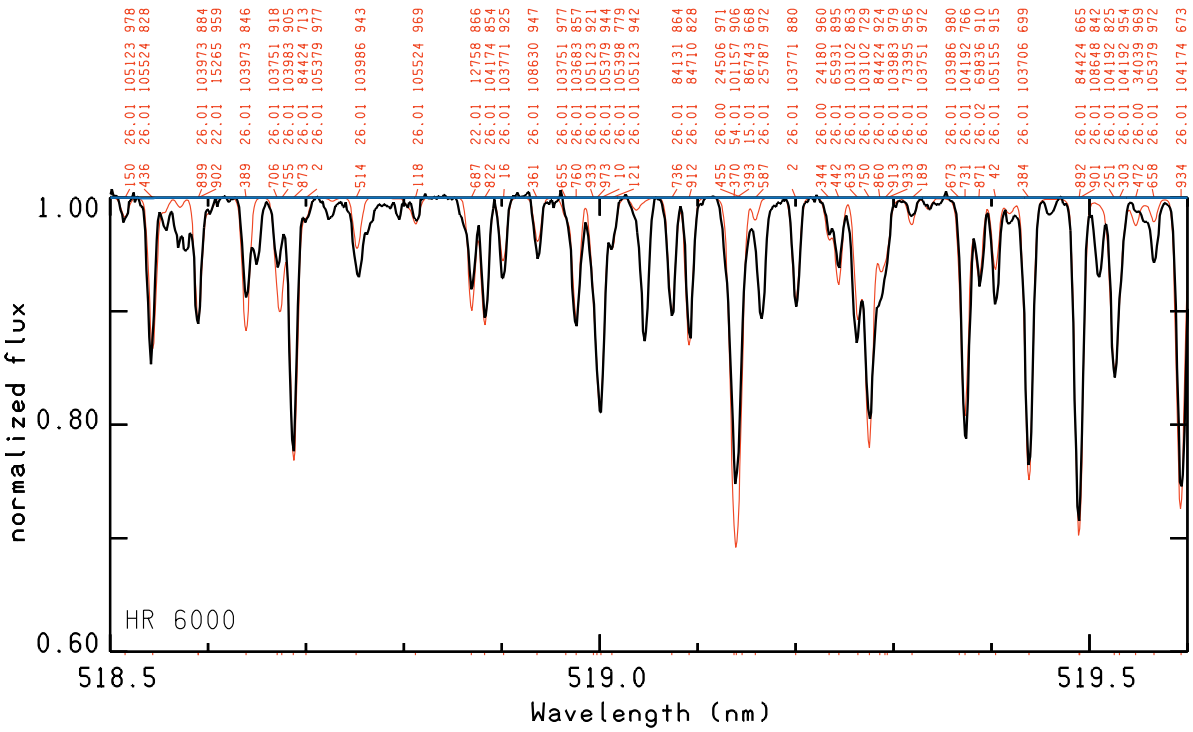

Fig. 2. Comparison of the UVES spectrum of HR 6000 (black line) with a synthetic spectrum (red line) computed with a line list including the new Fe II lines. The line identification can be decoded as follows: for the first line, 150 last 3 digits of wavelength 518.5150 nm; 26 atomic number of iron; .01 charge/100, i.e. 26.01 identifies the line as Fe II; 105 123 is the energy of the lower level in cm^{-1}; 970 is the residual central intensity in per mil.

populated, most of the lines are weak in a star like HR 6000. This large number of weak predicted lines could explain the spectrum of HR 6000 longward of about 5800 Å. The spectrum looks like it is affected by a noise larger than that due to the instrumental effects. Castelli & Hubrig (2007) explained this "noise" with the presence of a T-Tauri star affecting the HR 6000 spectrum. After this study, we prefer to state that the spectrum shows the presence of numerous weak Fe II lines from high-excitation levels, probably 4d, 5d, 6d – 4f, 5f, 6f transitions, which still have to be identified. The hypothesis of the presence of the T-Tauri star affecting the HR 6000 spectrum is an example of an incorrect conclusion that can be drawn owing to the use of incomplete line lists. We will extend this study of the Fe II spectrum to the near infrared region in the near future using CRIRES (CRyogenic high-resolution InfraRed Echelle Spectrograph) observations of HR 6000 and 46 Aql. The observations are scheduled in summer 2010 (ESO proposal 41380, P.I. S. Hubrig).

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Table 6. Fe II lines in the 3800-8000 Å region with log $gf \geq -1.5$ and $3d^6(^3P)4f$ energy levels as upper levels.

Upper level				Lower level		λ(calc)	log gf	λ(obs)	Notes
cm^{-1}			J	cm^{-1}		Å	KUR	Å	
122 351.810	$(^3P)4f$	2[5]	11/2	103 165.320	$(^3P)4d\ ^4F_{9/2}$	5210.550	+0.795	5210.55	good agreement
				103 683.070	$(^5D)5d\ ^4F_{9/2}$	5355.059	+0.164	5355.06	computed too strong
				103 771.320	$(^3H)4d\ ^4G_{9/2}$	5380.493	−1.047		at the noise level
				104 807.210	$(^3H)4d\ ^2G_{9/2}$	5698.178	−0.539		blend with a telluric line
				104 916.550	$(^3H)4d\ ^4F_{9/2}$	5733.913	−0.635	5733.90	computed too weak
				106 722.170	$(^3F)4d\ ^4F_{9/2}$	6396.332	−0.741	6396.32	computed too weak
				109 811.920	$(^3G)4d\ ^4F_{9/2}$	7972.359	−0.985		at the noise level
122 324.142	$(^3P)4f$	2[5]	9/2	103 102.860	$(^3P)4d\ ^4D_{7/2}$	5201.118	−0.056		wrong,not observed
				103 191.917	$(^3P)4d\ ^2F_{7/2}$	5225.329	+0.634		blend, good agreement
				103 986.330	$(^3H)4d\ ^4H_{7/2}$	5451.698	−1.133		blend, good agreement
				104 107.950	$(^3P)4d\ ^4F_{7/2}$	5488.097	−0.362		blend, good agreement
				104 481.590	$(^3H)4d\ ^2F_{7/2}$	5603.024	−0.170	5603.05	
				105 123.000	$(^3H)4d\ ^2G_{7/2}$	5811.956	−1.441		blend,good agreement
				105 775.491	$(^3F)4d\ ^2F_{7/2}$	6041.116	−0.837	6041.1	weak,good agreement
122 355.116	$(^3P)4f$	2[4]	9/2	102 394.718	$(^5D)6s\ ^4D_{7/2}$	5008.523	−0.809		weak, computed too strong
				103 102.860	$(^3P)4d\ ^4D_{7/2}$	5192.750	+0.657	5192.75	lab, good agreement
				103 165.320	$(^3P)4d\ ^4F_{9/2}$	5209.652	−0.035	5209.66	lab, good agreement
				103 191.917	$(^3P)4d\ ^2F_{7/2}$	5216.883	−0.404		blend
				103 683.070	$(^5D)5d\ ^4F_{9/2}$	5354.110	−0.637	5354.1	weak
				104 107.950	$(^3P)4d\ ^4F_{7/2}$	5478.781	−1.319		at the continuum level
				104 807.210	$(^3H)4d\ ^2G_{9/2}$	5697.105	−1.443		at the continuum level
				106 767.210	$(^3F)4d\ ^4F_{7/2}$	6413.457	−1.407		blend
122 355.550	$(^3P)4f$	2[4]	7/2	102 394.718	$(^5D)6s\ ^4D_{7/2}$	5008.414	−1.258		good agreement
				102 802.312	$(^5D)6s\ ^4D_{5/2}$	5112.818	−0.959	5112.82	computed too weak
				103 002.670	$(^3P)4d\ ^4D_{5/2}$	5165.751	+0.441	5165.75	lab, good agreement
				103 102.860	$(^3P)4d\ ^4D_{7/2}$	5192.633	+0.155	5192.62	lab, computed too weak
				103 165.320	$(^3P)4d\ ^4F_{9/2}$	5209.534	−1.105		blend, good agreement
				103 191.917	$(^3P)4d\ ^2F_{7/2}$	5216.765	−0.764		blend
				106 796.660	$(^3F)4d\ ^4P_{5/2}$	6425.418	−1.436		at the continuum level
122 351.488	$(^3P)4f$	2[3]	7/2	103 102.860	$(^3P)4d\ ^4D_{7/2}$	5193.729	−1.320		blend
				103 191.917	$(^3P)4d\ ^2F_{7/2}$	5217.871	−0.250	5217.870	lab
				103 597.402	$(^3P)4d\ ^2D_{5/2}$	5330.689	+0.525	5330.680	lab
				104 023.910	$(^3H)4d\ ^4G_{5/2}$	5454.742	−1.327		at the continuum level
				104 107.950	$(^3P)4d\ ^4F_{7/2}$	5479.870	−1.320		at the continuum level
				104 481.590	$(^3H)4d\ ^2F_{7/2}$	5594.450	−1.116	5594.42	computed too weak?
				104 569.230	$(^3P)4d\ ^4F_{5/2}$	5622.022	−0.573	5622.02	computed too weak?
				105 234.237	$(^3H)4d\ ^4F_{5/2}$	5840.440	−1.282		at the continuum level
				107 407.800	$(^3F)4d\ ^2D_{5/2}$	6689.941	−0.330	6689.91	
123 629.520	$(^3P)4f$	1[4]	9/2	103 102.860	$(^3P)4d\ ^4D_{7/2}$	4870.353	−1.402		at the continuum level
				104 000.810	$(^5D)5d\ ^6P_{7/2}$	5093.159	−0.981		blend
				104 107.950	$(^3P)4d\ ^4F_{7/2}$	5121.112	+0.327	5121.1	lab, good agreement
				104 481.590	$(^3H)4d\ ^2F_{7/2}$	5221.043	+0.408	5221.04	lab, good agreement
				104 873.230	$(^5D)5d\ ^4D_{7/2}$	5330.062	−1.183		blend
				104 993.860	$(^3F)4d\ ^4D_{7/2}$	5364.564	−0.118	5364.55	computed too strong
				105 123.000	$(^3H)4d\ ^2G_{7/2}$	5401.999	−0.418		blend
				105 220.600	$(^3H)4d\ ^4F_{7/2}$	5430.640	−1.066	5430.64	computed too weak
				105 775.491	$(^3F)4d\ ^2F_{7/2}$	5599.422	−0.624	5599.42	good agreement
				106 767.210	$(^3F)4d\ ^4F_{7/2}$	5928.743	−0.677	5928.72	at the noise level
				110 167.280	$(^3G)4d\ ^4F_{7/2}$	7426.139	−1.173		

Table 6. continued.

Upper level				Lower level		λ(calc)	log gf	λ(obs)	Notes
cm^{-1}			J	cm^{-1}		Å	KUR	Å	
123 637.833	(^{3}P)4f	1[4]	7/2	102 802.312	(^{5}D)6s ^{4}D$_{5/2}$	4798.155	−1.297		at the continuum level
				103 002.670	(^{3}P)4d ^{4}D$_{5/2}$	4844.743	−0.954		computed too strong
				103 597.402	(^{3}P)4d ^{2}D$_{5/2}$	4988.521	−0.339	4988.51	lab
				104 107.950	(^{3}P)4d ^{4}F$_{7/2}$	5118.932	−0.819	5118.95	lab, computed too weak
				104 120.270	(^{5}D)5d ^{6}P$_{5/2}$	5122.163	−1.282		
				104 481.590	(^{3}H)4d ^{2}F$_{7/2}$	5218.777	−0.644		blend
				104 569.230	(^{3}P)4d ^{4}F$_{5/2}$	5242.763	+0.180	5242.775	lab
				104 993.860	(^{3}F)4d ^{4}D$_{7/2}$	5362.172	−1.268		at the continuum level
				105 127.770	(^{5}D)5d ^{4}D$_{5/2}$	5400.965	−1.143		at the continuum level
				105 234.237	(^{3}H)4d ^{4}F$_{5/2}$	5432.211	−0.531		wrong, not observed
				105 379.430	(^{3}F)4d ^{4}D$_{5/2}$	5475.409	−0.552	5475.42	computed too strong
				105 711.730	(^{5}D)5d ^{6}S$_{5/2}$	5576.909	−1.432		at the continuum level
				106 208.560	(^{3}F)4d ^{2}F$_{5/2}$	5735.883	−1.221		at the continuum level
				106 796.660	(^{3}F)4d ^{4}P$_{5/2}$	5936.184	−1.317		at the level of the noise
				106 866.760	(^{3}F)4d ^{4}F$_{5/2}$	5960.996	−0.565	5961.00	
				107 407.800	(^{3}F)4d ^{2}D$_{5/2}$	6159.712	−0.665	6179.75	blend?
				110 428.280	(^{3}G)4d ^{4}F$_{5/2}$	7568.195	−1.229		no spectrum
123 615.875	(^{3}P)4f	1[3]	7/2	103 597.402	(^{3}P)4d ^{2}D$_{5/2}$	4993.993	−1.435		
				104 023.910	(^{3}H)4d ^{4}G$_{5/2}$	5102.711	−0.526	5102.7	lab, good agreement
				104 107.950	(^{3}P)4d ^{4}F$_{7/2}$	5124.694	−1.046	5124.69	good agreement
				104 120.270	(^{5}D)5d ^{6}P$_{5/2}$	5127.932	−0.244		wrong, not obs
				104 209.610	(^{3}H)4d ^{2}F$_{5/2}$	5151.540	−0.081	5151.52	J78, lab, computed too weak
				104 481.590	(^{3}H)4d ^{2}F$_{7/2}$	5224.766	−0.973	5227.77	good agreement
				104 569.230	(^{3}P)4d ^{4}F$_{5/2}$	5248.807	−0.232	5248.801	computed too strong
				105 127.770	(^{5}D)5d ^{4}D$_{5/2}$	5407.380	−1.391	5407.37	computed too weak
				105 234.237	(^{3}H)4d ^{4}F$_{5/2}$	5438.700	−0.416	5438.70	computed too strong
				106 208.560	(^{3}F)4d ^{2}F$_{5/2}$	5743.118	−0.454	5743.10	good agreement
123 649.493	(^{3}P)4f	1[3]	5/2	104 209.610	(^{3}H)4d ^{2}F$_{5/2}$	5142.631	−1.288		at the continuum level
				104 569.230	(^{3}P)4d ^{4}F$_{5/2}$	5239.559	−1.150	5239.56	good agreement
				104 572.920	(^{3}P)4d ^{4}F$_{3/2}$	5240.573	+0.071	5240.587	lab, good agreement
				104 588.710	(^{5}D)5d ^{6}D$_{3/2}$	5244.914	−1.288		blend
				104 839.998	(^{3}P)4d ^{2}D$_{3/2}$	5314.985	−0.441		blend,computed too strong
				105 234.237	(^{3}H)4d ^{4}F$_{5/2}$	5428.771	−1.471		blend
				105 317.440	(^{3}P)4d ^{2}P$_{3/2}$	5453.411	+0.082	5453.42	lab, computed too strong
				105 518.140	(^{3}H)4d ^{4}F$_{3/2}$	5513.777	−0.591		wrong, not observed
				106 846.650	(^{3}F)4d ^{4}F$_{3/2}$	5949.725	−1.358		at the continuum level
				107 430.250	(^{3}F)4d ^{2}D$_{3/2}$	6163.810	−0.253		wrong, not observed
				108 105.900	(^{3}F)4d ^{2}P$_{3/2}$	6431.741	−0.724		blend
124 157.060	(^{3}P)4f	0[3]	5/2	104 569.230	(^{3}P)4d ^{4}F$_{5/2}$	5103.788	−1.191	5103.8	good agreement
				104 572.920	(^{3}P)4d ^{4}F$_{3/2}$	5104.750	+0.094	5104.75	lab, good agreement
				104 588.710	(^{5}D)5d ^{6}D$_{3/2}$	5108.869	−1.369		
				104 839.998	(^{3}P)4d ^{2}D$_{3/2}$	5175.329	−1.125		blend
				105 234.237	(^{3}H)4d ^{4}F$_{5/2}$	5283.154	−0.937		blend
				105 317.440	(^{3}P)4d ^{2}P$_{3/2}$	5306.486	−1.020	5306.49	computed too weak
				105 460.230	(^{3}F)4d ^{4}D$_{3/2}$	5347.013	−0.482	5347.05	blend
				105 518.140	(^{3}H)4d ^{4}F$_{3/2}$	5363.626	+0.082	5363.61	computed too strong
				106 846.650	(^{3}F)4d ^{4}F$_{3/2}$	5775.269	−0.286	5775.25	good agreement
				107 430.250	(^{3}F)4d ^{2}D$_{3/2}$	5976.771	−0.922		blend
				108 105.900	(^{3}F)4d ^{2}P$_{3/2}$	6228.356	−0.686	6228.34	good agreement
				110 609.540	(^{3}G)4d ^{4}F$_{3/2}$	7379.392	−1.370		at the continuum level

Table 7. Fe II lines in the 3800-8000 Å region with log $gf \geq -1.5$ and $3d^6(^3H)4f$ energy level as upper levels.

Upper level				Lower level		λ(calc)	log gf	λ(obs)	Notes
cm^{-1}			J	cm^{-1}		Å	KUR	Å	
122 954.180	$(^3H)4f$	6[9]	19/2	103 644.800	$(^3H)4d\ ^4K_{17/2}$	5177.388	+1.169	5177.394	J78, lab, good agreement
122 952.730	$(^3H)4f$	6[9]	17/2	103 644.800	$(^3H)4d\ ^4K_{17/2}$	5177.777	−0.930		blend
				103 706.530	$(^3H)4d\ ^4K_{15/2}$	5194.384	+0.798	5194.387	lab, good agreement
				103 878.370	$(^3H)4d\ ^4I_{15/2}$	5241.181	+0.558	5241.183	J78, lab, good agreement
				104 119.710	$(^3H)4d\ ^2K_{15/2}$	5308.346	+0.518	5308.350	J78,lab, good agreement
123 007.910	$(^3H)4f$	6[8]	17/2	103 644.800	$(^3H)4d\ ^4K_{17/2}$	5163.021	+0.498	5163.018	J78,lab, good agreement
				103 706.530	$(^3H)4d\ ^4K_{15/2}$	5179.534	+0.534	5179.540	J78, lab, good agreement
				103 878.370	$(^3H)4d\ ^4I_{15/2}$	5226.062	+0.820	5226.070	lab, good agreement
				104 119.710	$(^3H)4d\ ^2K_{15/2}$	5292.838	−1.419		
				108 337.860	$(^3G)4d\ ^4I_{15/2}$	6814.729	−1.183		at the noise level
122 910.920	$(^3H)4f$	6[8]	15/2	103 706.530	$(^3H)4d\ ^4K_{15/2}$	5205.693	−0.207	5205.70	blend
				103 832.050	$(^3H)4d\ ^4K_{13/2}$	5239.942	+0.015	5239.948	J78, lab, computed too weak
				103 878.370	$(^3H)4d\ ^4I_{15/2}$	5252.695	−0.107	5252.702	lab, computed too weak
				104 064.670	$(^3H)4d\ ^4I_{13/2}$	5304.620	−0.357	5304.60	lab, computed too weak
				104 119.710	$(^3H)4d\ ^2K_{15/2}$	5320.157	+0.082	5320.18	lab, good agreement
				104 315.370	$(^3H)4d\ ^2K_{13/2}$	5376.136	+0.132	5376.12	lab, computed too weak
				104 622.300	$(^3H)4d\ ^2I_{13/2}$	5466.362	+0.698	5466.38	good agreement
				108 463.910	$(^3G)4d\ ^4I_{13/2}$	6919.939	−0.887		at the continuum level
				108 648.695	$(^1I)5s\ e^2I_{13/2}$	7009.596	−1.436	7009.6?	computed too weak?
				109 049.600	$(^3G)4d\ ^2I_{13/2}$	7212.332	−1.456	7212.33?	computed too weak?
123 018.430	$(^3H)4f$	6[7]	15/2	103 617.580	$(^3H)4d\ ^4H_{13/2}$	5152.978	+0.761	5152.985	lab, good agreement
				103 644.800	$(^3H)4d\ ^4K_{17/2}$	5160.218	−0.354	5160.213	lab, good agreement
				103 706.530	$(^3H)4d\ ^4K_{15/2}$	5176.713	+0.364	5176.722	J78,lab, good agreement
				103 832.050	$(^3H)4d\ ^4K_{13/2}$	5210.580	−1.104	5210.65?	computed too weak?
				103 878.370	$(^3H)4d\ ^4I_{15/2}$	5223.190	+0.447	5223.25	blend, good agreement
				104 064.670	$(^3H)4d\ ^4I_{13/2}$	5274.530	−1.138	5274.53	good agreement
				104 119.710	$(^3H)4d\ ^2K_{15/2}$	5289.892	−0.894	5289.899	lab, good agreement
				104 622.300	$(^3H)4d\ ^2I_{13/2}$	5434.415	−1.378		at the noise level
				108 337.860	$(^3G)4d\ ^4I_{15/2}$	6809.845	−1.228		at the noise level
123 015.400	$(^3H)4f$	6[7]	13/2	103 600.430	$(^3H)4d\ ^4G_{11/2}$	5149.230	+0.424	5149.243	lab, good agreement
				103 617.580	$(^3H)4d\ ^4H_{13/2}$	5153.783	+0.761	5153.786	lab, good agreement
				103 706.530	$(^3H)4d\ ^4K_{15/2}$	5177.525	−0.341		blend
				103 751.660	$(^3H)4d\ ^4H_{11/2}$	5189.655	−0.783		blend, good agreement
				103 878.370	$(^3H)4d\ ^4I_{15/2}$	5224.017	−0.132	5224.025	lab, good agreement
				104 119.710	$(^3H)4d\ ^2K_{15/2}$	5290.740	−1.258	5290.730	computed too weak
				104 765.450	$(^3H)4d\ ^2I_{11/2}$	5477.945	−1.275	5477.95	good agreement
				105 063.550	$(^3F)4d\ ^4G_{11/2}$	5568.910	−1.164	5568.92	good agreement
				105 288.850	$(^3F)4d\ ^4H_{13/2}$	5639.690	−1.357		blend
				106 045.690	$(^3H)4d\ ^2H_{11/2}$	5891.220	−1.302		blend
				108 181.550	$(^3G)4d\ ^4G_{11/2}$	6739.478	−1.459		at the noise level
122 990.620	$(^3H)4f$	6[6]	13/2	103 706.530	$(^3H)4d\ ^4K_{15/2}$	5184.178	−0.976		blend
				103 751.660	$(^3H)4d\ ^4H_{11/2}$	5196.339	−0.126	5196.32	computed too weak
				103 832.050	$(^3H)4d\ ^4K_{13/2}$	5218.143	−0.028	5218.149	lab, good agreement
				103 878.370	$(^3H)4d\ ^4I_{15/2}$	5230.790	−1.208	5230.80	good agreement
				103 973.780	$(^3H)4d\ ^4K_{11/2}$	5257.034	−0.940		blend
				104 064.670	$(^3H)4d\ ^4I_{13/2}$	5282.281	−1.039	5282.29	blend,computed too weak
				104 119.710	$(^3H)4d\ ^2K_{15/2}$	5297.687	−1.010	5297.7	blend
				104 174.270	$(^3H)4d\ ^4I_{11/2}$	5313.049	−0.954		blend
				104 315.370	$(^3H)4d\ ^2K_{13/2}$	5353.192	+0.205	5353.22	blend, computed too strong
				104 622.300	$(^3H)4d\ ^2I_{13/2}$	5442.643	+0.049	5442.65	J78, lab, good agreement
				104 765.450	$(^3H)4d\ ^2I_{11/2}$	5485.393	+0.141	5485.40	computed too strong

Table 7. continued.

Upper level				Lower level		λ(calc)	log gf	λ(obs)	Notes
cm^{-1}			J	cm^{-1}		Å	KUR	Å	
122 990.620	cont.			105 063.550	$(^3F)4d\ ^4G_{11/2}$	5576.608	−0.487	5576.60	computed too strong
				105 763.270	$(^3F)4d\ ^2H_{11/2}$	5803.114	−0.380	5803.12	computed too weak
				106 045.690	$(^3H)4d\ ^2H_{11/2}$	5899.835	+0.277	5899.82	good agreement
				108 630.429	$(^1I)5s\ e^2I_{11/2}$	6961.775	−1.168		at the continuum level
				109 049.600	$(^3G)4d\ ^2I_{13/2}$	7171.100	−1.477		at the continuum level
				109 389.880	$(^3G)4d\ ^2I_{11/2}$	7350.516	−1.297	7350.49?	computed too weak?
				109 683.280	$(^3G)4d\ ^2H_{11/2}$	7512.581	−0.706		blend, computed too weak?
123 037.430	$(^3H)4f$	6[6]	11/2	103 751.660	$(^3H)4d\ ^4H_{11/2}$	5183.727	+0.242	5183.713	J78, lab, blend
				103 771.320	$(^3H)4d\ ^4G_{9/2}$	5189.016	−0.187	5189.013	lab
				103 832.050	$(^3H)4d\ ^4K_{13/2}$	5205.425	−0.558	5205.427	lab, blend
				103 874.260	$(^3H)4d\ ^4H_{9/2}$	5216.891	−0.503		blend
				104 064.670	$(^3H)4d\ ^4I_{13/2}$	5269.248	−0.797	5269.235	
				104 315.370	$(^3H)4d\ ^2K_{13/2}$	5339.807	−0.759		
				104 622.300	$(^3H)4d\ ^2I_{13/2}$	5428.808	−0.405	5428.80	lab
				104 765.450	$(^3H)4d\ ^2I_{11/2}$	5471.340	−0.934		
				104 807.210	$(^3H)4d\ ^2G_{9/2}$	5483.874	−0.019	5483.85	lab
				104 916.550	$(^3H)4d\ ^4F_{9/2}$	5516.963	−0.234		wrong, not obs
				105 063.550	$(^3F)4d\ ^4G_{11/2}$	5562.084	−1.223		
				105 398.850	$(^3F)4d\ ^4H_{11/2}$	5667.818	−1.176		
				105 763.270	$(^3F)4d\ ^2H_{11/2}$	5787.389	−0.146	5787.35	
				106 045.690	$(^3H)4d\ ^2H_{11/2}$	5883.582	+0.287	5883.58	J78
				106 097.520	$(^3H)4d\ ^2H_{9/2}$	5901.584	−0.581		blend
				106 924.430	$(^3F)4d\ ^2G_{9/2}$	6204.452	−1.391		
				109 683.280	$(^3G)4d\ ^2H_{11/2}$	7486.247	−0.596		
123 002.288	$(^3H)4f$	6[5]	11/2	103 165.320	$(^3P)4d\ ^4F_{9/2}$	5039.690	−0.526		
				103 600.430	$(^3H)4d\ ^4G_{11/2}$	5152.712	+0.662	5152.70	lab
				103 617.580	$(^3H)4d\ ^4H_{13/2}$	5157.271	+0.380		blend
				103 683.070	$(^3H)4d\ ^4F_{9/2}$	5174.754	−0.491	5174.75	lab
				103 751.660	$(^3H)4d\ ^4H_{11/2}$	5193.192	−0.719	5193.191	blend
				103 771.320	$(^3H)4d\ ^4G_{9/2}$	5198.501	−1.338		
				104 765.450	$(^3H)4d\ ^2I_{11/2}$	5481.886	−1.256		
				104 807.210	$(^3H)4d\ ^2G_{9/2}$	5494.468	−0.835		
				104 916.550	$(^3H)4d\ ^4F_{9/2}$	5527.686	−1.221	5527.68	computed too weak
				105 063.550	$(^3F)4d\ ^4G_{11/2}$	5572.983	−0.697	5572.98	
				106 045.690	$(^3H)4d\ ^2H_{11/2}$	5895.778	−1.407		
				106 722.170	$(^3F)4d\ ^4F_{9/2}$	6140.765	−0.940		
				108 181.550	$(^3G)4d\ ^4G_{11/2}$	6745.444	−1.310		
				109 811.920	$(^3G)4d\ ^4F_{9/2}$	7579.208	−1.201		
123 026.350	$^3H)4f$	6[5]	9/2	103 102.860	$(^3P)4d\ ^4D_{7/2}$	5017.801	−1.092		
				103 751.660	$(^3H)4d\ ^4H_{11/2}$	5186.706	−0.152	5186.722	lab
				103 771.320	$(^3H)4d\ ^4G_{9/2}$	5192.002	+0.073	5192.010	lab
				103 874.260	$(^3H)4d\ ^4H_{9/2}$	5219.909	−0.488		blend
				104 107.950	$(^3P)4d\ ^4F_{7/2}$	5284.389	−0.355		
				104 481.590	$(^3H)4d\ ^2F_{7/2}$	5390.860	−1.184		
				104 807.210	$(^3H)4d\ ^2G_{9/2}$	5487.209	+0.186	5487.21	lab
				104 916.550	$(^3H)4d\ ^4F_{9/2}$	5520.339	−0.063		wrong, not observed
				104 993.860	$(^3F)4d\ ^4D_{7/2}$	5544.006	−1.091		
				105 763.270	$(^3F)4d\ ^2H_{11/2}$	5791.103	−0.522	5791.05	
				106 045.690	$(^3H)4d\ ^2H_{11/2}$	5887.421	−0.109	5887.42	
				106 097.520	$(^3H)4d\ ^2H_{9/2}$	5905.446	−0.710		
				106 722.170	$(^3F)4d\ ^4F_{9/2}$	6131.699	−1.253		
				106 767.210	$(^3F)4d\ ^4F_{7/2}$	6148.685	−1.351		
				106 924.430	$(^3F)4d\ ^2G_{9/2}$	6208.722	−0.916		
				109 683.280	$(^3G)4d\ ^2H_{11/2}$	7492.464	−1.002		

Table 7. continued.

Upper level				Lower level		λ(calc)	$log\,gf$	λ(obs)	Notes
cm^{-1}			J	cm^{-1}		Å	KUR	Å	
122 988.215	(^{3}H)4f	6[4]	9/2	103 165.320	(^{3}P)4d ^{4}F$_{9/2}$	5043.266	−0.030		
				103 600.430	(^{3}H)4d ^{4}G$_{11/2}$	5156.450	+0.529	5156.45	lab
				103 683.070	(^{3}H)4d ^{4}F$_{9/2}$	5178.524	−0.018	5178.53	lab
				103 751.660	(^{3}H)4d ^{4}H$_{11/2}$	5196.989	−0.773		
				103 771.320	(^{3}H)4d ^{4}G$_{9/2}$	5202.306	−0.787		
				104 765.450	(^{3}H)4d ^{2}I$_{11/2}$	5486.117	−1.286		
				104 807.210	(^{3}H)4d ^{2}G$_{9/2}$	5498.718	−0.382	5498.72	
				104 916.550	(^{3}H)4d ^{4}F$_{9/2}$	5531.988	−1.028		
				105 063.550	(^{3}F)4d ^{4}G$_{11/2}$	5577.356	−0.785	5577.35	
				106 045.690	(^{3}H)4d ^{2}H$_{11/2}$	5900.673	−1.342		
				106 722.170	(^{3}F)4d ^{4}F$_{9/2}$	6146.075	−0.412	6146.08	
				106 924.430	(^{3}F)4d ^{2}G$_{9/2}$	6223.461	−1.178		
				108 181.550	(^{3}G)4d ^{4}G$_{11/2}$	6751.852	−1.421		
				109 811.920	(^{3}G)4d ^{4}F$_{9/2}$	7587.298	−0.695		
122 980.408	(^{3}H)4f	6[4]	7/2	103 102.860	(^{3}P)4d ^{4}D$_{7/2}$	5029.399	−0.735		
				103 165.320	(^{3}P)4d ^{4}F$_{9/2}$	5045.253	−0.962		
				103 683.070	(^{3}H)4d ^{4}F$_{9/2}$	5180.619	−1.116		
				103 771.320	(^{3}H)4d ^{4}G$_{9/2}$	5204.420	−0.034	5204.419	
				103 874.260	(^{3}H)4d ^{4}H$_{9/2}$	5232.461	−0.656		
				103 921.630	(^{3}H)4d ^{4}G$_{7/2}$	5245.466	−1.235		
				104 107.950	(^{3}P)4d ^{4}F$_{7/2}$	5297.253	+0.049	5297.26	
				104 481.590	(^{3}H)4d ^{2}F$_{7/2}$	5404.248	−0.598		
				104 807.210	(^{3}H)4d ^{2}G$_{9/2}$	5501.081	−0.147		
				104 916.550	(^{3}H)4d ^{4}F$_{9/2}$	5534.379	−0.071		
				104 993.860	(^{3}F)4d ^{4}D$_{7/2}$	5558.167	−0.731		
				106 097.520	(^{3}H)4d ^{2}H$_{9/2}$	5921.516	−0.986		
				106 722.170	(^{3}F)4d ^{4}F$_{9/2}$	6149.026	−0.728		
				106 767.210	(^{3}F)4d ^{4}F$_{7/2}$	6166.108	−1.069		
				106 924.430	(^{3}F)4d ^{2}G$_{9/2}$	6226.487	−1.380		
122 946.419	(^{3}H)4f	6[3]	7/2	103 102.860	(^{3}P)4d ^{4}D$_{7/2}$	5038.014	−1.413		
				103 165.320	(^{3}P)4d ^{4}F$_{9/2}$	5053.922	+0.160		
				103 683.070	(^{3}H)4d ^{4}F$_{9/2}$	5189.760	+0.167	5189.763	lab.
				103 771.320	(^{3}H)4d ^{4}G$_{9/2}$	5213.645	−0.746		
				104 107.950	(^{3}P)4d ^{4}F$_{7/2}$	5306.811	−0.814		
				104 807.210	(^{3}H)4d ^{2}G$_{9/2}$	5511.388	−0.043	5511.40	
				105 155.090	(^{3}F)4d ^{4}G$_{9/2}$	5619.156	−1.229		
				105 211.062	(^{5}D)5d ^{4}G$_{9/2}$	5636.890	−1.411		
				106 097.520	(^{3}H)4d ^{2}H$_{9/2}$	5933.462	−1.332		
				106 722.170	(^{3}F)4d ^{4}F$_{9/2}$	6161.908	−0.227	6161.90	
				106 924.430	(^{3}F)4d ^{2}G$_{9/2}$	6239.696	−0.856		
				109 811.920	(^{3}G)4d ^{4}F$_{9/2}$	7611.442	−0.504		
123 219.200	(^{3}H)4f	5[8]	17/2	103 644.800	(^{3}H)4d ^{4}K$_{17/2}$	5107.290	−0.983		
				103 706.530	(^{3}H)4d ^{4}K$_{15/2}$	5123.448	+0.347	5123.45	lab
				103 878.370	(^{3}H)4d ^{4}I$_{15/2}$	5168.969	+0.064		blend
				104 119.710	(^{3}H)4d ^{2}K$_{15/2}$	5234.285	+0.991	5234.283	lab
123 193.090	(^{3}H)4f	5[8]	15/2	103 706.530	(^{3}H)4d ^{4}K$_{15/2}$	5130.313	−0.507		
				103 832.050	(^{3}H)4d ^{4}K$_{13/2}$	5163.574	+0.908	5163.55	lab
				103 878.370	(^{3}H)4d ^{4}I$_{15/2}$	5175.957	−0.540	5175.95	
				104 064.670	(^{3}H)4d ^{4}I$_{13/2}$	5226.368	−0.216		blend
				104 119.710	(^{3}H)4d ^{2}K$_{15/2}$	5241.450	−0.301	5241.465	lab
				104 315.370	(^{3}H)4d ^{2}K$_{13/2}$	5295.776	−0.452	5295.773	
				104 622.300	(^{3}H)4d ^{2}I$_{13/2}$	5383.304	+0.146	5383.32	blend

Table 7. continued.

Upper level				Lower level		λ(calc)	$log\,gf$	λ(obs)	Notes
cm^{-1}			J	cm^{-1}		Å	KUR	Å	
123 238.440	(^{3}H)4f	5[7]	15/2	103 617.580	(^{3}H)4d ^{4}H$_{13/2}$	5095.196	−0.836	5095.19	
				103 706.530	(^{3}H)4d ^{4}K$_{15/2}$	5118.401	−0.254	5118.40	lab
				103 832.050	(^{3}H)4d ^{4}K$_{13/2}$	5151.507	−0.716		blend
				103 878.370	(^{3}H)4d ^{4}I$_{15/2}$	5163.831	−0.599	5163.82	lab
				104 064.670	(^{3}H)4d ^{4}I$_{13/2}$	5214.007	+0.873	5214.99	blend
				104 119.710	(^{3}H)4d ^{2}K$_{15/2}$	5229.017	−0.045	5229.030	lab
				104 315.370	(^{3}H)4d ^{2}K$_{13/2}$	5283.085	+0.323	5283.093	lab
				105 288.850	(^{3}F)4d ^{4}H$_{13/2}$	5569.611	−1.005		blend
123 168.680	(^{3}H)4f	5[7]	13/2	103 600.430	(^{3}H)4d ^{4}G$_{11/2}$	5108.895	−1.165		
				103 706.530	(^{3}H)4d ^{4}K$_{15/2}$	5136.747	−1.256		
				103 751.660	(^{3}H)4d ^{4}H$_{11/2}$	5148.687	+0.010	5148.7	lab
				103 832.050	(^{3}H)4d ^{4}K$_{11/2}$	5170.092	−1.170		
				103 973.780	(^{3}H)4d ^{4}K$_{11/2}$	5208.267	−0.275	5208.268	computed too weak
				104 064.670	(^{3}H)4d ^{4}I$_{13/2}$	5233.046	+0.138	5233.041	
				104 174.270	(^{3}H)4d ^{4}I$_{11/2}$	5263.242	−0.600		
				104 315.370	(^{3}H)4d ^{2}K$_{13/2}$	5302.633	−0.581		
				104 622.300	(^{3}H)4d ^{2}I$_{13/2}$	5390.389	+0.010	5390.38	computed too strong
				104 765.450	(^{3}H)4d ^{2}I$_{11/2}$	5432.319	+0.495	5432.31	lab
				105 063.550	(^{3}F)4d ^{4}G$_{11/2}$	5521.763	−0.481	5521.78	
				105 398.850	(^{3}F)4d ^{4}H$_{11/2}$	5625.954	−1.425		
				105 763.270	(^{3}F)4d ^{2}H$_{11/2}$	5743.747	−0.321	5743.75	computed too strong
				106 045.690	(^{3}H)4d ^{2}H$_{11/2}$	5838.483	−0.311		
				108 630.429	(^{1}I)5s e^{2}I$_{11/2}$	6876.509	−1.228		
				109 683.280	(^{3}G)4d ^{2}H$_{11/2}$	7413.385	−0.848		
123 249.650	(^{3}H)4f	5[6]	13/2	103 600.430	(^{3}H)4d ^{4}G$_{11/2}$	5087.842	−0.510	5087.85	lab
				103 706.530	(^{3}H)4d ^{4}K$_{15/2}$	5115.465	−1.027		
				103 751.660	(^{3}H)4d ^{4}H$_{11/2}$	5127.305	+0.392	5127.32	lab, blend
				103 832.050	(^{3}H)4d ^{4}K$_{13/2}$	5148.533	+0.357	5148.52	lab
				103 973.780	(^{3}H)4d ^{4}K$_{11/2}$	5186.389	+0.210	5186.396	lab
				104 064.670	(^{3}H)4d ^{4}I$_{13/2}$	5210.960	−0.403	5210.964	
				104 119.710	(^{3}H)4d ^{2}K$_{15/2}$	5225.953	−0.742		blend
				104 174.270	(^{3}H)4d ^{4}I$_{11/2}$	5240.901	−0.464	5240.911	
				104 315.370	(^{3}H)4d ^{2}K$_{13/2}$	5279.957	−0.647		blend
				104 622.300	(^{3}H)4d ^{2}I$_{13/2}$	5366.958	+0.032	5366.95	lab
				105 063.550	(^{3}F)4d ^{4}G$_{11/2}$	5497.178	−1.156		
				105 288.850	(^{3}F)4d ^{4}H$_{13/2}$	5566.135	−1.260		
				105 763.270	(^{3}F)4d ^{2}H$_{11/2}$	5717.150	−0.553	5717.18	
				106 045.690	(^{3}H)4d ^{2}H$_{11/2}$	5811.004	−0.182	5811.00	
				109 049.600	(^{3}G)4d ^{2}I$_{13/2}$	7040.287	−1.496		
				109 683.280	(^{3}G)4d ^{2}H$_{11/2}$	7369.139	−1.023		
123 270.340	(^{3}H)4f	5[6]	11/2	103 600.430	(^{3}H)4d ^{4}G$_{11/2}$	5082.491	−0.827		blend
				103 683.070	(^{3}H)4d ^{4}F$_{9/2}$	5103.934	−1.365		
				103 751.660	(^{3}H)4d ^{4}H$_{11/2}$	5121.871	+0.373	5121.89	lab
				103 771.320	(^{3}H)4d ^{4}G$_{9/2}$	5127.035	−0.542	5127.05	
				103 832.050	(^{3}H)4d ^{4}K$_{11/2}$	5143.054	−0.456	5143.05	
				103 874.260	(^{3}H)4d ^{4}H$_{9/2}$	5154.246	+0.127	5154.25	lab
				103 973.780	(^{3}H)4d ^{4}K$_{11/2}$	5180.829	−0.529	5180.84	lab
				104 064.670	(^{3}H)4d ^{4}I$_{13/2}$	5205.347	−0.844	5235.225	
				104 174.270	(^{3}H)4d ^{4}I$_{11/2}$	5235.223	−0.536		
				104 192.480	(^{3}H)4d ^{4}I$_{9/2}$	5240.220	−1.229		
				104 315.370	(^{3}H)4d ^{2}K$_{13/2}$	5274.195	−1.310		
				104 622.300	(^{3}H)4d ^{2}I$_{13/2}$	5361.004	−0.422	5361.00	lab

Table 7. continued.

Upper level				Lower level		λ(calc)	log gf	λ(obs)	Notes
cm^{-1}			J	cm^{-1}		Å	KUR	Å	
123 270.340	cont.			104 807.210	(^{3}H)4d ^{2}G$_{9/2}$	5414.696	−0.589	5414.7	blend
				104 916.550	(^{3}H)4d ^{4}F$_{9/2}$	5446.953	−0.182	5446.95	
				105 063.550	(^{3}F)4d ^{4}G$_{11/2}$	5490.931	−1.162		
				105 155.090	(^{3}F)4d ^{4}G$_{9/2}$	5518.678	−0.927		wrong,not observed
				105 763.270	(^{3}F)4d ^{2}H$_{11/2}$	5710.394	−0.287	5710.40	
				106 045.690	(^{3}H)4d ^{2}H$_{11/2}$	5804.025	−0.029	5804.02	
				106 722.170	(^{3}F)4d ^{4}F$_{9/2}$	6041.291	−1.018		
				106 924.430	(^{3}F)4d ^{2}G$_{9/2}$	6116.045	−1.092		
				109 683.280	(^{3}G)4d ^{2}H$_{11/2}$	7357.917	−0.867		
123 251.470	(^{3}H)4f	5[5]	11/2	103 751.660	(^{3}H)4d ^{4}H$_{11/2}$	5126.827	−0.236		blend
				103 771.320	(^{3}H)4d ^{4}G$_{9/2}$	5132.001	+0.078	5132.0	lab
				103 874.260	(^{3}H)4d ^{4}H$_{9/2}$	5159.265	+0.007	5159.29	lab, blend
				103 973.780	(^{3}H)4d ^{4}K$_{11/2}$	5185.899	+0.058	5185.901	lab
				104 064.670	(^{3}H)4d ^{4}I$_{13/2}$	5210.466	−0.583		
				104 174.270	(^{3}H)4d ^{4}I$_{11/2}$	5240.401	−0.177	5240.405	lab
				104 192.480	(^{3}H)4d ^{4}I$_{9/2}$	5245.408	−1.139		blend
				104 315.370	(^{3}H)4d ^{2}K$_{13/2}$	5279.449	−1.308		
				104 765.450	(^{3}H)4d ^{2}I$_{11/2}$	5407.990	+0.040	5407.99	lab
				104 807.210	(^{3}H)4d ^{2}G$_{9/2}$	5420.234	−1.131		
				104 916.550	(^{3}H)4d ^{4}F$_{9/2}$	5452.558	−0.967	5452.55	
				105 063.550	(^{3}F)4d ^{4}G$_{11/2}$	5496.628	−0.739	5496.62	
				105 155.090	(^{3}F)4d ^{4}G$_{9/2}$	5524.433	−1.032		
				105 524.460	(^{3}F)4d ^{4}H$_{9/2}$	5639.544	−1.347		
				106 018.640	(^{3}F)4d ^{2}H$_{9/2}$	5801.269	−0.770		computed too strong
				106 045.690	(^{3}H)4d ^{2}H$_{11/2}$	5810.389	−1.328		
				106 097.520	(^{3}H)4d ^{2}H$_{9/2}$	5827.945	−0.015	5827.95	computed too weak
				106 924.430	(^{3}F)4d ^{2}G$_{9/2}$	6123.114	−0.236		
				109 625.200	(^{3}G)4d ^{2}G$_{9/2}$	7336.744	−1.064		
				110 008.300	(^{3}G)4d ^{2}H$_{9/2}$	7548.984	−1.185		
123 269.378	(^{3}H)4f	5[5]	9/2	103 751.660	(^{3}H)4d ^{4}H$_{11/2}$	5122.123	−1.173		blend
				103 771.320	(^{3}H)4d ^{4}G$_{9/2}$	5127.287	−0.734		blend
				103 874.260	(^{3}H)4d ^{4}H$_{9/2}$	5154.501	+0.418	5154.50	lab
				103 921.630	(^{3}H)4d ^{4}G$_{7/2}$	5167.121	−0.470	5167.1	computed too weak
				103 973.780	(^{3}H)4d ^{4}K$_{11/2}$	5181.086	−0.545	5181.1	blend, computed too weak
				103 983.510	(^{3}G)5s ^{2}G$_{7/2}$	5183.700	−0.079		blend
				103 986.330	(^{3}H)4d ^{4}H$_{7/2}$	5184.458	−0.485	5184.463	computed too strong
				104 107.950	(^{3}P)4d ^{4}F$_{7/2}$	5217.365	−1.017		
				104 174.270	(^{3}H)4d ^{4}I$_{11/2}$	5235.486	−0.560		
				104 765.450	(^{3}H)4d ^{2}I$_{11/2}$	5402.756	−0.812		
				104 807.210	(^{3}H)4d ^{2}G$_{9/2}$	5414.977	−0.955		
				104 993.860	(^{3}F)4d ^{4}D$_{7/2}$	5470.281	−1.409		
				105 123.000	(^{3}H)4d ^{2}G$_{7/2}$	5509.211	−0.290	5509.2	
				105 220.600	(^{3}H)4d ^{4}F$_{7/2}$	5539.003	−1.382		
				105 524.460	(^{3}F)4d ^{4}H$_{9/2}$	5633.853	−1.381		
				106 018.640	(^{3}F)4d ^{2}H$_{9/2}$	5795.246	−0.974		
				106 097.520	(^{3}H)4d ^{2}H$_{9/2}$	5821.868	−0.325	5821.88	
				106 722.170	(^{3}F)4d ^{4}F$_{9/2}$	6041.643	−1.431		
				106 900.370	(^{3}F)4d ^{2}G$_{7/2}$	6107.415	−0.980		
				106 924.430	(^{3}F)4d ^{2}G$_{9/2}$	6116.405	−0.472		blend
				109 625.200	(^{3}G)4d ^{2}G$_{9/2}$	7327.115	−1.238		
123 258.994	(^{3}H)4f	5[4]	9/2	103 165.320	(^{3}P)4d ^{4}F$_{9/2}$	4975.303	−1.479		
				103 191.917	(^{3}P)4d ^{2}F$_{7/2}$	4981.898	−0.587		
				103 600.430	(^{3}H)4d ^{4}G$_{11/2}$	5085.425	−1.404		
				103 683.070	(^{3}H)4d ^{4}F$_{9/2}$	5106.894	−0.960		
				103 751.660	(^{3}H)4d ^{4}H$_{11/2}$	5124.850	+0.047	5124.82	lab

Table 7. continued.

Upper level				Lower level		λ(calc)	$log\,gf$	λ(obs)	Notes
cm^{-1}			J	cm^{-1}		Å	KUR	Å	
123 258.994	cont.			103 771.320	$(^3H)4d\ ^4G_{9/2}$	5130.020	+0.269	5130.0	lab
				103 874.260	$(^3H)4d\ ^4H_{9/2}$	5157.263	−0.663		blend
				104 481.590	$(^3H)4d\ ^2F_{7/2}$	5324.070	−0.506		blend
				104 807.210	$(^3H)4d\ ^2G_{9/2}$	5418.025	−0.657	5418.02	lab
				104 916.550	$(^3H)4d\ ^4F_{9/2}$	5450.323	+0.051	5450.30	wrong, computed too strong
				105 063.550	$(^3F)4d\ ^4G_{11/2}$	5494.356	−1.301		
				105 123.000	$(^3H)4d\ ^2G_{7/2}$	5512.367	−0.848		
				105 155.090	$(^3F)4d\ ^4G_{9/2}$	5522.138	−0.450	5522.10	computed too strong
				105 211.062	$(^5D)5d\ ^4G_{9/2}$	5539.264	−1.434		
				105 763.270	$(^3F)4d\ ^2H_{11/2}$	5714.098	−0.740	5714.10	
				106 045.690	$(^3H)4d\ ^2H_{11/2}$	5807.851	−0.440	5807.85	blend
				106 097.520	$(^3H)4d\ ^2H_{9/2}$	5825.392	−0.814		
				106 722.170	$(^3F)4d\ ^4F_{9/2}$	6045.483	−0.970		
				106 767.210	$(^3F)4d\ ^4F_{7/2}$	6061.948	−1.148		
				106 900.370	$(^3F)4d\ ^2G_{7/2}$	6111.293	−1.488		
				108 391.500	$(^3G)4d\ ^4G_{9/2}$	6724.229	−1.436		
				109 683.280	$(^3G)4d\ ^2H_{11/2}$	7364.069	−1.370		
				110 167.280	$(^3G)4d\ ^4F_{7/2}$	7636.319	−1.343		
123 258.021	$(^3H)4f$	5[4]	7/2	102 802.312	$(^5D)6s\ ^4D_{5/2}$	4887.246	−1.497		blend
				103 002.670	$(^3P)4d\ ^4D_{5/2}$	4935.589	−1.223		blend
				103 102.860	$(^3P)4d\ ^4D_{7/2}$	4960.124	−1.397		at the continuum level
				103 771.320	$(^3H)4d\ ^4G_{9/2}$	5130.276	−0.633		blend
				103 874.260	$(^3H)4d\ ^4H_{9/2}$	5157.521	−0.254		blend
				103 921.630	$(^3H)4d\ ^4G_{7/2}$	5170.156	−0.375		blend
				103 983.510	$(^3G)5s\ ^2G_{7/2}$	5186.755	−0.078		blend
				103 986.330	$(^3H)4d\ ^4H_{7/2}$	5187.514	−0.396	5187.52	
				104 107.950	$(^3P)4d\ ^4F_{7/2}$	5220.459	−1.202		computed too strong
				104 120.270	$(^5D)5d\ ^6P_{5/2}$	5223.820	−0.829		blend
				104 209.610	$(^3H)4d\ ^2F_{5/2}$	5248.321	−0.898		blend
				104 569.230	$(^3P)4d\ ^4F_{5/2}$	5349.313	−0.940		wrong, not observed
				104 916.550	$(^3H)4d\ ^4F_{9/2}$	5450.611	−1.412		blend
				104 993.860	$(^3F)4d\ ^4D_{7/2}$	5473.683	−0.926		blend
				105 123.000	$(^3H)4d\ ^2G_{7/2}$	5512.661	+0.003	5512.65	
				105 220.600	$(^3H)4d\ ^4F_{7/2}$	5542.490	−1.205		blend
				106 018.640	$(^3F)4d\ ^2H_{9/2}$	5799.064	−1.320		blend
				106 097.520	$(^3H)4d\ ^2H_{9/2}$	5825.721	−0.559	5825.73	
				106 866.760	$(^3F)4d\ ^4F_{5/2}$	6099.124	−1.189		blend
				106 900.370	$(^3F)4d\ ^2G_{7/2}$	6111.655	−0.698		blend
				106 924.430	$(^3F)4d\ ^2G_{9/2}$	6120.658	−0.942		at the continuum level
				110 167.280	$(^3G)4d\ ^4F_{7/2}$	7636.885	−1.434		no spectrum
123 235.165	$(^3H)4f$	5[3]	7/2	103 191.917	$(^3P)4d\ ^2F_{7/2}$	4987.820	−0.173		
				103 771.320	$(^3H)4d\ ^4G_{9/2}$	5136.300	−0.037	5136.30	
				103 874.260	$(^3H)4d\ ^4H_{9/2}$	5163.610	−0.154		blend
				103 921.630	$(^3H)4d\ ^4G_{7/2}$	5176.274	−0.716	5176.25	
				103 983.510	$(^3G)5s\ ^2G_{7/2}$	5192.913	−0.799		blend
				103 986.330	$(^3H)4d\ ^4H_{7/2}$	5193.673	−0.887		blend
				104 107.950	$(^3P)4d\ ^4F_{7/2}$	5226.698	−1.309		
				104 481.590	$(^3H)4d\ ^2F_{7/2}$	5330.834	−0.226	5330.81	computed too strong
				104 807.210	$(^3H)4d\ ^2G_{9/2}$	5425.030	−0.825	5425.01	
				104 916.550	$(^3H)4d\ ^4F_{9/2}$	5457.411	−0.238	5457.40	
				105 123.000	$(^3H)4d\ ^2G_{7/2}$	5519.618	−1.438		
				105 155.090	$(^3F)4d\ ^4G_{9/2}$	5529.415	−0.668	5529.40	wrong, computed too strong
				105 220.600	$(^3H)4d\ ^4F_{7/2}$	5549.523	−1.242		
				105 291.010	$(^3F)4d\ ^4G_{7/2}$	5571.298	−1.482		
				106 722.170	$(^3F)4d\ ^4F_{9/2}$	6054.160	−1.224		

Table 7. continued.

Upper level				Lower level		λ(calc)	log gf	λ(obs)	Notes
cm^{-1}			J	cm^{-1}		Å	KUR	Å	
123 235.165	cont.			106 767.210	(^{3}F)4d ^{4}F$_{7/2}$	6070.719	−0.626	6070.71	
				110 167.280	(^{3}G)4d ^{4}F$_{7/2}$	7650.242	−0.970		
				110 570.300	(^{3}G)4d ^{2}F$_{7/2}$	7893.688	−1.448		
123 211.159	(^{3}H)4f	5[2]	5/2	103 193.917	(^{3}P)4d ^{2}F$_{7/2}$	4993.801	−0.145	4993.80	computed too strong
				103 921.630	(^{3}H)4d ^{4}G$_{7/2}$	5182.716	−1.163	5182.707	good agreement
				103 986.330	(^{3}G)5s ^{2}G$_{7/2}$	5200.159	−1.442		
				104 481.590	(^{3}H)4d ^{2}F$_{7/2}$	5337.666	−0.236		blend
				104 993.860	(^{3}F)4d ^{4}D$_{7/2}$	5487.763	−1.396		blend
				105 123.000	(^{3}H)4d ^{2}G$_{7/2}$	5526.943	−0.560	5526.92	computed too strong
				105 291.010	(^{3}F)4d ^{4}G$_{7/2}$	5578.762	−1.365		at the level of the noise
				106 767.210	(^{3}F)4d ^{4}F$_{7/2}$	6079.581	−0.532	6709.60	good agreement
				106 900.370	(^{3}F)4d ^{2}G$_{7/2}$	6129.215	−1.126		blend
				110 167.280	(^{3}G)4d ^{4}F$_{7/2}$	7664.321	−0.703		in telluric
				110 570.300	(^{3}G)4d ^{2}F$_{7/2}$	7908.679	−1.384		in telluric
123 213.323	(^{3}H)4f	5[2]	3/2	102 802.312	(^{5}D)6s ^{4}D$_{5/2}$	4897.949	−1.090	4897.90	at the level of the noise
				103 597.402	(^{3}P)4d ^{2}D$_{5/2}$	5096.480	−1.325		at the level of the noise
				104 120.270	(^{5}D)5d ^{6}P$_{5/2}$	5236.050	−0.269	5236.046	computed too strong
				104 209.610	(^{3}H)4d ^{2}F$_{5/2}$	5260.666	−0.338	5260.682	lab, good agreement
				104 569.230	(^{3}P)4d ^{4}F$_{5/2}$	5362.139	−0.684		wrong, not observed
				105 234.237	(^{3}H)4d ^{4}F$_{5/2}$	5560.475	−1.142		
				105 414.180	(^{3}F)4d ^{4}G$_{5/2}$	5616.690	−1.055		blend
				106 796.660	(^{3}F)4d ^{4}P$_{5/2}$	6089.687	−1.322		blend
				106 866.760	(^{3}F)4d ^{4}F$_{5/2}$	6115.802	−0.758	6115.80	good agreement
				110 428.280	(^{3}G)4d ^{4}F$_{5/2}$	7819.490	−1.269		at the continuum level
123 396.250	(^{3}H)4f	4[7]	15/2	103 706.530	(^{3}H)4d ^{4}K$_{15/2}$	5077.377	−1.404		
				103 832.050	(^{3}H)4d ^{4}K$_{13/2}$	5109.953	−0.102	5109.95	lab
				104 064.670	(^{3}H)4d ^{4}I$_{13/2}$	5171.443	+0.259	5171.45	lab
				104 315.370	(^{3}H)4d ^{2}K$_{13/2}$	5239.390	+0.861	5239.394	J78
				104 622.300	(^{3}H)4d ^{2}I$_{13/2}$	5325.048	+0.257	5325.05	J78, lab
123 355.490	(^{3}H)4f	4[7]	13/2	103 600.430	(^{3}H)4d ^{4}G$_{11/2}$	5060.583	−1.409		
				103 751.660	(^{3}H)4d ^{4}H$_{11/2}$	5099.623	−0.221	5099.6	lab
				103 832.050	(^{3}H)4d ^{4}K$_{13/2}$	5120.621	−1.170	5120.62	lab, computed too weak
				103 973.780	(^{3}H)4d ^{4}K$_{11/2}$	5158.067	+0.788	5158.05	J78, lab
				104 064.670	(^{3}H)4d ^{4}I$_{13/2}$	5182.370	+0.034	5182.371	lab
				104 119.710	(^{3}H)4d ^{2}K$_{15/2}$	5197.198	−1.475		
				104 315.370	(^{3}H)4d ^{2}K$_{13/2}$	5250.606	−0.778	5250.609	computed too weak
				104 622.300	(^{3}H)4d ^{2}I$_{13/2}$	5336.635	−0.215	5336.62	
				104 765.450	(^{3}H)4d ^{2}I$_{11/2}$	5377.729	−0.165	5377.71	J78, lab, computed too weak
				105 763.270	(^{3}F)4d ^{2}H$_{11/2}$	5682.754	−0.574	5682.75	
				106 045.690	(^{3}H)4d ^{2}H$_{11/2}$	5775.473	−0.674		
				109 683.280	(^{3}G)4d ^{2}H$_{11/2}$	7312.092	−1.277		
123 414.730	(^{3}H)4f	4[6]	13/2	103 751.660	(^{3}H)4d ^{4}H$_{11/2}$	5084.259	−0.750		
				103 832.050	(^{3}H)4d ^{4}K$_{13/2}$	5105.131	−0.704		
				103 973.780	(^{3}H)4d ^{4}K$_{11/2}$	5142.349	−0.245	5142.35	lab
				104 064.670	(^{3}H)4d ^{4}I$_{13/2}$	5166.504	−0.525		blend
				104 174.270	(^{3}H)4d ^{4}I$_{11/2}$	5195.934	+0.922	5195.942	lab
				104 315.370	(^{3}H)4d ^{2}K$_{13/2}$	5234.320	−0.791		blend
				104 622.300	(^{3}H)4d ^{2}I$_{13/2}$	5319.812	−1.134		
				104 765.450	(^{3}H)4d ^{2}I$_{11/2}$	5360.646	−0.638	5360.65	computed too weak
				105 063.550	(^{3}F)4d ^{4}G$_{11/2}$	5447.727	−1.416		
				105 398.850	(^{3}F)4d ^{4}H$_{11/2}$	5549.118	−1.185		
				106 045.690	(^{3}H)4d ^{2}H$_{11/2}$	5755.774	−1.242		

Table 7. continued.

Upper level				Lower level		λ(calc)	log gf	λ(obs)	Notes
cm^{-1}			J	cm^{-1}		Å	KUR	Å	
123 427.119	(^{3}H)4f	4[6]	11/2	103 771.320	(^{3}H)4d ^{4}G$_{9/2}$	5086.139	−0.441	5086.15	
				103 874.260	(^{3}H)4d ^{4}H$_{9/2}$	5112.917	−0.423		blend
				103 973.780	(^{3}H)4d ^{4}K$_{11/2}$	5139.074	+0.124	5139.10	
				104 192.480	(^{3}H)4d ^{4}I$_{9/2}$	5197.506	+0.465	5197.56	blend
				104 315.370	(^{3}H)4d ^{2}K$_{13/2}$	5230.927	−1.051		
				104 622.300	(^{3}H)4d ^{2}I$_{13/2}$	5316.307	−1.253		
				104 765.450	(^{3}H)4d ^{2}I$_{11/2}$	5357.088	+0.165	5357.10	J78,lab
				104 807.210	(^{3}H)4d ^{2}G$_{9/2}$	5369.102	−1.260		
				105 063.550	(^{3}F)4d ^{4}G$_{11/2}$	5444.051	−0.902		
				105 763.270	(^{3}F)4d ^{2}H$_{11/2}$	5659.712	−0.911		
				106 018.640	(^{3}F)4d ^{2}H$_{9/2}$	5742.735	−0.704		computed too strong
				106 045.690	(^{3}H)4d ^{2}H$_{11/2}$	5751.672	−1.454		
				106 097.520	(^{3}H)4d ^{2}H$_{9/2}$	5768.874	−0.115	5768.90	J78, computed too weak
				106 722.170	(^{3}F)4d ^{4}F$_{9/2}$	5984.595	−1.089		
				106 924.430	(^{3}F)4d ^{2}G$_{9/2}$	6057.941	−0.358	6057.92	blend
				109 625.200	(^{3}G)4d ^{2}G$_{9/2}$	7243.378	−1.142		
				110 008.300	(^{3}G)4d ^{2}H$_{9/2}$	7450.174	−1.329		
123 441.100	(^{3}H)4f	4[5]	11/2	103 771.320	(^{3}H)4d ^{4}G$_{9/2}$	5082.524	−0.439	5082.51	computed too strong
				103 874.260	(^{3}H)4d ^{4}H$_{9/2}$	5109.263	+0.037	5109.29	lab
				103 973.780	(^{3}H)4d ^{4}K$_{11/2}$	5135.383	−1.089		
				104 174.270	(^{3}H)4d ^{4}I$_{11/2}$	5188.822	+0.224	5188.831	lab
				104 192.480	(^{3}H)4d ^{4}I$_{9/2}$	5193.731	+0.573	5193.74	J78, lab
				104 315.370	(^{3}H)4d ^{2}K$_{13/2}$	5227.103	−1.390		
				104 765.450	(^{3}H)4d ^{2}I$_{11/2}$	5353.077	−0.299		blend
				105 063.550	(^{3}F)4d ^{4}G$_{11/2}$	5439.910	−1.230		
				105 524.460	(^{3}F)4d ^{4}H$_{9/2}$	5579.854	−1.306		
				106 018.640	(^{3}F)4d ^{2}H$_{9/2}$	5738.126	−1.011		computed too strong, not obs
				106 097.520	(^{3}H)4d ^{2}H$_{9/2}$	5764.224	−0.455	5764.20	
				106 722.170	(^{3}F)4d ^{4}F$_{9/2}$	5979.588	−1.109		
				106 924.430	(^{3}F)4d ^{2}G$_{9/2}$	6052.813	−0.460	6052.8	
				109 625.200	(^{3}G)4d ^{2}G$_{9/2}$	7236.043	−1.361		
123 435.468	(^{3}H)4f	4[5]	9/2	103 921.630	(^{3}H)4d ^{4}G$_{7/2}$	5123.141	+0.119	5123.190	blend
				103 973.780	(^{3}H)4d ^{4}K$_{11/2}$	5136.869	−0.836		blend
				103 983.510	(^{3}G)5s ^{2}G$_{7/2}$	5139.439	+0.314		blend
				103 986.330	(^{3}H)4d ^{4}H$_{7/2}$	5140.184	−0.208	5140.2	lab
				104 107.950	(^{3}P)4d ^{4}F$_{7/2}$	5172.529	−1.242		
				104 174.270	(^{3}H)4d ^{4}I$_{11/2}$	5190.340	−1.319		
				104 192.480	(^{3}H)4d ^{4}I$_{9/2}$	5195.251	+0.450	5195.26	lab
				105 589.670	(^{3}F)4d ^{4}H$_{7/2}$	5602.005	−1.242		
123 460.690	(^{3}H)4f	4[4]	9/2	103 191.917	(^{3}P)4d ^{2}F$_{7/2}$	4932.321	−1.442		
				103 771.320	(^{3}H)4d ^{4}G$_{9/2}$	5077.467	−0.602	5077.5	lab
				103 874.260	(^{3}H)4d ^{4}H$_{9/2}$	5104.153	−0.047	5104.15	
				103 921.630	(^{3}H)4d ^{4}G$_{7/2}$	5116.528	−0.613	5116.52	
				103 973.780	(^{3}H)4d ^{4}K$_{11/2}$	5130.220	−1.289		
				103 983.510	(^{3}G)5s ^{2}G$_{7/2}$	5132.783	−0.961		
				103 986.330	(^{3}H)4d ^{4}H$_{7/2}$	5133.527	−0.989		
				104 174.27	(^{3}H)4d ^{4}I$_{11/2}$	5183.552	−0.937		
				104 481.590	(^{3}H)4d ^{2}F$_{7/2}$	5267.488	−0.494	5267.47	
				104 765.450	(^{3}H)4d ^{2}I$_{11/2}$	5347.468	−0.307	5347.45	lab
				104 807.210	(^{3}H)4d ^{2}G$_{9/2}$	5359.439	−1.442		
				104 993.860	(^{3}F)4d ^{4}D$_{7/2}$	5413.610	−0.234	5413.60	lab
				105 063.550	(^{3}F)4d ^{4}G$_{11/2}$	5434.117	−1.217		
				105 123.000	(^{3}H)4d ^{2}G$_{7/2}$	5451.734	−0.292	5451.72	
				105 220.600	(^{3}H)4d ^{4}F$_{7/2}$	5480.906	−0.700		blend
				105 291.010	(^{3}F)4d ^{4}G$_{7/2}$	5502.146	−0.769		
				105 449.540	(^{5}D)5d ^{4}G$_{7/2}$	5550.575	−1.270		

Table 7. continued.

Upper level				Lower level		λ(calc)	log gf	λ(obs)	Notes
cm^{-1}			J	cm^{-1}		Å	KUR	Å	
123 460.690	cont.			106 018.640	$(^3F)4d\ ^2H_{9/2}$	5731.681	−0.446		wrong, not observed
				106 097.520	$(^3H)4d\ ^2H_{9/2}$	5757.720	+0.118	5757.72	J78, computed too low
				106 722.170	$(^3F)4d\ ^4F_{9/2}$	5972.589	−0.946		
				106 767.210	$(^3F)4d\ ^4F_{7/2}$	5988.704	−1.212		
				106 900.370	$(^3F)4d\ ^2G_{7/2}$	6036.859	−0.912		
				106 924.430	$(^3F)4d\ ^2G_{9/2}$	6045.643	−0.124	6045.65	
				109 625.200	$(^3G)4d\ ^2G_{9/2}$	7225.797	−0.960		
				110 008.300	$(^3G)4d\ ^2H_{9/2}$	7431.576	−1.109		
123 435.277	$(^3H)4f$	4[4]	7/2	103 921.630	$(^3H)4d\ ^4G_{7/2}$	5123.191	−0.068		blend
				103 983.510	$(^3G)5s\ ^2G_{7/2}$	5139.489	+0.217	5139.45	lab, blend
				103 986.330	$(^3H)4d\ ^4H_{7/2}$	5140.234	−0.435	5140.20	blend
				104 023.910	$(^3H)4d\ ^4G_{5/2}$	5150.186	+0.144	5150.15	lab
				104 120.270	$(^5D)5d\ ^6P_{5/2}$	5175.880	−1.206		blend
				104 192.480	$(^3H)4d\ ^4I_{9/2}$	5195.303	−0.325		blend
				104 209.610	$(^3H)4d\ ^2F_{5/2}$	5199.932	−1.066	5199.95	computed too weak
				104 569.230	$(^3P)4d\ ^4F_{5/2}$	5299.053	−0.753		computed too strong
				105 414.180	$(^3F)4d\ ^4G_{5/2}$	5547.511	−1.009		at the level of the noise
				105 589.670	$(^3F)4d\ ^4H_{7/2}$	5602.065	−1.328		blend
				105 630.750	$(^5D)5d\ ^4G_{5/2}$	5614.990	−1.423		at the continuum level
				107 407.800	$(^3F)4d\ ^2D_{5/2}$	6237.560	−1.471		at the continuum level
123 451.449	$(^3H)4f$	4[3]	7/2	103 191.917	$(^3P)4d\ ^2F_{7/2}$	4934.571	−1.453		
				103 597.402	$(^3P)4d\ ^2D_{5/2}$	5035.352	−0.856		
				103 771.320	$(^3H)4d\ ^4G_{9/2}$	5079.851	−1.218		
				103 874.260	$(^3H)4d\ ^4H_{9/2}$	5106.563	−0.583	5106.55	
				103 921.630	$(^3H)4d\ ^4G_{7/2}$	5118.949	−1.061		
				103 983.510	$(^3G)5s\ ^2G_{7/2}$	5135.220	−0.335		
				103 986.330	$(^3H)4d\ ^4H_{7/2}$	5135.964	−1.420	5135.95	
				104 023.910	$(^3H)4d\ ^4G_{5/2}$	5145.899	−0.764		
				104 107.950	$(^3P)4d\ ^4F_{7/2}$	5168.256	−1.230		
				104 120.270	$(^5D)5d\ ^6P_{5/2}$	5171.550	−1.408		
				104 481.590	$(^3H)4d\ ^2F_{7/2}$	5270.054	−0.654		blend
				104 569.230	$(^3P)4d\ ^4F_{5/2}$	5294.515	−1.314		
				104 993.860	$(^3F)4d\ ^4D_{7/2}$	5416.320	−0.276	5416.32	lab
				105 123.000	$(^3H)4d\ ^2G_{7/2}$	5454.483	−0.324	5454.50	blend
				105 220.600	$(^3H)4d\ ^4F_{7/2}$	5483.684	−0.695		
				105 291.010	$(^3F)4d\ ^4G_{7/2}$	5504.945	−0.792	5504.95	
				105 449.540	$(^5D)5d\ ^4G_{7/2}$	5553.424	−1.292		
				106 018.640	$(^3F)4d\ ^2H_{9/2}$	5734.719	−1.053		
				106 097.520	$(^3H)4d\ ^2H_{9/2}$	5760.786	−0.536	5760.78	computed too weak
				106 767.210	$(^3F)4d\ ^4F_{7/2}$	5992.021	−1.212		
				106 900.370	$(^3F)4d\ ^2G_{7/2}$	6040.230	−1.110		
				106 924.430	$(^3F)4d\ ^2G_{9/2}$	6049.023	−0.751		
123 430.181	$(^3H)4f$	4[3]	5/2	103 597.402	$(^3P)4d\ ^2D_{5/2}$	5040.752	−1.238		blend
				103 921.630	$(^3H)4d\ ^4G_{7/2}$	5124.529	−0.535	5124.52	
				103 983.510	$(^3G)5s\ ^2G_{7/2}$	5140.836	−0.648	5140.83	
				103 986.330	$(^3H)4d\ ^4H_{7/2}$	5141.582	−0.884		blend
				104 023.910	$(^3H)4d\ ^4G_{5/2}$	5151.538	+0.030	5151.52	J78, lab
				104 120.270	$(^5D)5d\ ^6P_{5/2}$	5177.246	−0.906		blend
				104 209.610	$(^3H)4d\ ^2F_{5/2}$	5201.311	−0.851		blend, wrong?
				104 569.230	$(^3P)4d\ ^4F_{5/2}$	5300.485	−0.786		blend, computed too strong
				104 572.920	$(^3P)4d\ ^4F_{3/2}$	5301.522	−0.742		wrong, not observed
				104 993.860	$(^3F)4d\ ^4D_{7/2}$	5422.568	−1.395		at the continuum level
				105 317.440	$(^3P)4d\ ^2P_{3/2}$	5519.442	−1.271	5519.43	at the level of the noise

Table 7. continued.

Upper level			Lower level		λ(calc)	log gf	λ(obs)	Notes
cm^{-1}		J	cm^{-1}		Å	KUR	Å	
123 430.181	cont.		105 379.430	(^{3}F)4d ^{4}D$_{5/2}$	5538.397	−1.442		at the level of the noise
			105 414.180	(^{3}F)4d ^{4}G$_{5/2}$	5549.080	−0.905		blend
			105 630.750	(^{5}D)5d ^{4}G$_{5/2}$	5616.598	−1.451		blend
			106 846.650	(^{3}F)4d ^{4}F$_{3/2}$	6028.409	−1.085	6028.40	at the level of the noise
			106 866.760	(^{3}F)4d ^{4}F$_{5/2}$	6035.729	−1.269		
			107 407.800	(^{3}F)4d ^{2}D$_{5/2}$	6239.544	−1.446		
			110 428.280	(^{3}G)4d ^{4}F$_{5/2}$	7689.067	−1.409		
			110 609.540	(^{3}G)4d ^{4}F$_{3/2}$	7797.776	−1.406		

Table 8. Fe II lines in the 3800−8000 Å region with log $gf \geq -1.5$ and $3d^6(^3F)4f$ energy levels as upper levels.

Upper level				Lower level		λ(calc)	log gf	λ(obs)	Notes
cm^{-1}			J	cm^{-1}		Å	K09	Å	
124 421.468	$(^3F)4f$	4[7]	15/2	103 617.580	$(^3H)4d\ ^4H_{13/2}$	4805.451	−0.972	4805.42	
				104 064.670	$(^3H)4d\ ^4I_{13/2}$	4910.993	−1.090		at the continuum level
				104 119.710	$(^3H)4d\ ^2K_{15/2}$	4924.307	−1.174		not obs
				104 622.300	$(^3H)4d\ ^2I_{13/2}$	5049.309	−1.258	5049.3	very weak
				105 288.847	$(^3F)4d\ ^4H_{13/2}$	5225.221	+0.974	5225.229	lab, J78
124 436.436	$(^3F)4f$	4[7]	13/2	103 600.430	$(^3H)4d\ ^4G_{11/2}$	4798.043	−1.190		at the continuum level
				103 751.660	$(^3H)4d\ ^4H_{11/2}$	4833.123	−1.441		
				104 315.370	$(^3H)4d\ ^2K_{13/2}$	4968.529	−1.078	4968.53	very weak
				104 765.450	$(^3H)4d\ ^2I_{11/2}$	5082.213	−1.265		blend
				105 063.550	$(^3F)4d\ ^4G_{11/2}$	5160.416	−0.003	5160.4	lab
				105 288.847	$(^3F)4d\ ^4H_{13/2}$	5221.136	−0.831		blend,weak component
				105 398.852	$(^3F)4d\ ^4H_{11/2}$	5251.306	+0.664	5251.321	blend
				105 763.270	$(^3F)4d\ ^2H_{11/2}$	5353.789	+0.076	5353.80	
				106 045.690	$(^3H)4d\ ^2H_{11/2}$	5436.006	−0.154	5436.12	
				108 630.429	$(^1I)5s\ e^2I_{11/2}$	6324.960	−1.433		at the continuum level
124 400.107	$(^3F)4f$	4[6]	13/2	103 600.430	$(^3H)4d\ ^4G_{11/2}$	4806.424	−0.542	4806.4	
				104 174.270	$(^3H)4d\ ^4I_{11/2}$	4942.792	−1.458		very weak
				104 765.450	$(^3H)4d\ ^2I_{11/2}$	5091.616	−0.517	5091.6	
				105 063.550	$(^3F)4d\ ^4G_{11/2}$	5170.111	+0.742	5170.10	J78,lab, blended
				105 288.850	$(^3F)4d\ ^4H_{13/2}$	5231.062	+0.278	5231.067	lab
				105 398.850	$(^3F)4d\ ^4H_{11/2}$	5261.345	+0.080	5261.339	shifted?
				105 763.270	$(^3F)4d\ ^2H_{11/2}$	5364.226	−0.538	5364.22	
				106 045.690	$(^3H)4d\ ^2H_{11/2}$	5446.766	−0.314	5446.75	blend
124 402.557	$(^3F)4f$	4[6]	11/2	103 683.070	$(^5D)5d\ ^4F_{9/2}$	4825.028	−1.407		
				104 765.450	$(^3H)4d\ ^2I_{11/2}$	5090.983	−1.256		blend
				104 807.210	$(^3H)4d\ ^2G_{9/2}$	5101.830	−1.382	5101.82	
				104 916.550	$(^3H)4d\ ^4F_{9/2}$	5130.460	+0.158		
				105 063.550	$(^3F)4d\ ^4G_{11/2}$	5169.456	−0.871		computed too strong
				105 155.090	$(^3F)4d\ ^4G_{9/2}$	5194.042	−0.084	5194.047	
				105 211.062	$(^5D)5d\ ^4G_{9/2}$	5209.193	−0.494	5209.199	
				105 398.852	$(^3F)4d\ ^4H_{11/2}$	5260.668	−0.049	5260.682	
				105 524.461	$(^3F)4d\ ^4H_{9/2}$	5295.671	−1.274	5295.662	computed too weak
				105 763.270	$(^3F)4d\ ^2H_{11/2}$	5363.520	−0.269	5363.51	
				106 018.643	$(^3F)4d\ ^2H_{9/2}$	5438.027	−0.914		blend
				106 045.690	$(^3H)4d\ ^2H_{11/2}$	5446.039	−0.626	5446.05	
				106 097.520	$(^3H)4d\ ^2H_{9/2}$	5461.459	+0.179	5461.48	
				106 722.170	$(^3F)4d\ ^4F_{9/2}$	5654.418	−0.044		computed too strong
				106 924.430	$(^3F)4d\ ^2G_{9/2}$	5719.850	+0.097	5719.85	lab,J78
				109 925.200	$(^3G)4d\ ^2G_{9/2}$	6765.246	−1.049		
				110 008.300	$(^3G)4d\ ^2H_{9/2}$	6945.303	−1.190		
124 388.840	$(^3F)4f$	4[5]	11/2	103 600.430	$(^3H)4d\ ^4G_{11/2}$	4809.029	−0.852	4809.02	
				103 683.070	$(^5D)5d\ ^4F_{9/2}$	4828.222	−0.829		
				103 771.320	$(^3H)4d\ ^4G_{9/2}$	4848.889	−0.699		weak, on the H_β wing
				104 765.450	$(^3H)4d\ ^2I_{11/2}$	5094.540	−0.517	5094.55	lab
				104 807.210	$(^3H)4d\ ^2G_{9/2}$	5105.404	+0.158	5105.4	
				104 868.500	$(^5D)5d\ ^6G_{9/2}$	5121.435	−0.968	5121.45	weak
				104 916.550	$(^3H)4d\ ^4F_{9/2}$	5134.072	−0.161		blend
				105 063.550	$(^3F)4d\ ^4G_{11/2}$	5173.126	+0.425	5173.12	lab
				105 155.090	$(^3F)4d\ ^4G_{9/2}$	5197.747	−0.166	5197.756	
				105 211.062	$(^5D)5d\ ^4G_{9/2}$	5212.916	−0.199		blend
				105 288.847	$(^3F)4d\ ^4H_{13/2}$	5234.147	−0.630		blend
				105 398.852	$(^3F)4d\ ^4H_{11/2}$	5264.468	−0.717	5264.45	
				106 045.690	$(^3H)4d\ ^2H_{11/2}$	5450.112	−1.282		blend
				106 722.170	$(^3F)4d\ ^4F_{9/2}$	5658.806	−0.643		blend
				106 924.430	$(^3F)4d\ ^2G_{9/2}$	5724.343	−0.429		blend, computed too strong
				109 811.920	$(^3G)4d\ ^4F_{9/2}$	6858.267.	−0.903		at the continuum level

Table 8. continued.

Upper level				Lower level		λ(calc)	log gf	λ(obs)	Notes
cm^{-1}			J	cm^{-1}		Å	K09	Å	
124 385.706	(^{3}F)4f	4[5]	9/2	103 771.320	(^{3}H)4d ^{4}G$_{9/2}$	4849.626	−1.159		H$_\beta$ wing, not obs.
				103 986.330	(^{3}H)4d ^{4}H$_{7/2}$	4900.742	−1.404		at the continuum level
				104 807.210	(^{3}H)4d ^{2}G$_{9/2}$	5106.222	−0.305		
				104 993.860	(^{3}F)4d ^{4}D$_{7/2}$	5155.371	−0.195	5155.37	computed too strong
				105 063.550	(^{3}F)4d ^{4}G$_{11/2}$	5173.965	−0.955	5173.98	computed too weak
				105 123.000	(^{3}H)4d ^{2}G$_{7/2}$	5189.933	−0.112		blend
				105 155.090	(^{3}F)4d ^{4}G$_{9/2}$	5198.594	−0.154	5198.596	
				105 211.062	(^{5}D)5d ^{4}G$_{9/2}$	5213.769	−0.389	5213.78	
				105 220.600	(^{3}H)4d ^{4}F$_{7/2}$	5216.634	−1.420		
				105 291.010	(^{3}F)4d ^{4}G$_{7/2}$	5235.599	−0.769		blend
				105 398.852	(^{3}F)4d ^{4}H$_{11/2}$	5265.337	−0.986	5265.323	
				105 775.491	(^{3}F)4d ^{2}F$_{7/2}$	5371.899	+0.199	5371.90	
				106 018.640	(^{3}F)4d ^{2}H$_{9/2}$	5443.015	−1.240		
				106 097.520	(^{3}H)4d ^{2}H$_{9/2}$	5466.492	−0.492	5466.49	blend
				106 722.170	(^{3}F)4d ^{4}F$_{9/2}$	5659.810	−1.436		blend
				106 767.210	(^{3}F)4d ^{4}F$_{7/2}$	5674.279	−1.037	5674.30	
				106 900.370	(^{3}F)4d ^{2}G$_{7/2}$	5717.492	−1.080		blend
				106 924.430	(^{3}F)4d ^{2}G$_{9/2}$	5725.370	−0.147	5725.35	
				110 167.280	(^{3}G)4d ^{4}F$_{7/2}$	7031.188	−1.480		not observed
				110 570.300	(^{3}G)4d ^{2}F$_{7/2}$	7236.302	−1.125		not observed
124 401.939	(^{3}F)4f	4[4]	9/2	103 683.070	(^{5}D)5d ^{4}F$_{9/2}$	4825.170	−0.851		
				103 771.320	(^{3}H)4d ^{4}G$_{9/2}$	4845.810	−1.216		on the H$_\beta$ wing
				104 481.590	(^{3}H)4d ^{2}F$_{7/2}$	5018.593	−0.782		blend Fe II 5018.440
				104 765.450	(^{3}H)4d ^{2}I$_{11/2}$	5091.141	−1.199	5091.15	
				104 807.210	(^{3}H)4d ^{2}G$_{9/2}$	5101.991	−0.285		wrong,not observed
				104 868.500	(^{5}D)5d ^{6}G$_{9/2}$	5118.000	−0.871	5117.98	
				104 916.550	(^{3}H)4d ^{4}F$_{9/2}$	5130.621	+0.114	5130.60	lab
				104 993.860	(^{3}F)4d ^{4}D$_{7/2}$	5151.058	−0.280	5151.07	lab
				105 063.550	(^{3}F)4d ^{4}G$_{11/2}$	5169.622	−0.361	5169.6	
				105 155.090	(^{3}F)4d ^{4}G$_{9/2}$	5194.209	−1.245		blend Fe III
				105 211.062	(^{5}D)5d ^{4}G$_{9/2}$	5209.359	−1.260		
				105 220.600	(^{3}H)4d ^{4}F$_{7/2}$	5211.949	+0.055	5211.953	lab
				105 291.010	(^{3}F)4d ^{4}G$_{7/2}$	5231.152	−0.836		blend
				105 763.270	(^{3}F)4d ^{2}H$_{11/2}$	5363.698	−1.391		blend
				105 775.491	(^{3}F)4d ^{2}F$_{7/2}$	5367.218	−0.182	5367.22	
				106 097.520	(^{3}H)4d ^{2}H$_{9/2}$	5461.644	−0.455	5461.65	
				106 722.170	(^{3}F)4d ^{4}F$_{9/2}$	5654.613	−0.197	5654.62	
				106 900.370	(^{3}F)4d ^{2}G$_{7/2}$	5712.189	−1.361		at the level of the noise
				109 811.920	(^{3}G)4d ^{4}F$_{9/2}$	6852.110	−0.955		at the level of the noise
124 385.010	(^{3}F)4f	4[4]	7/2	103 191.917	(^{3}P)4d ^{2}F$_{7/2}$	4717.199	−1.461		
				103 597.402	(^{3}P)4d ^{2}D$_{5/2}$	4809.214	−1.233		
				104 807.210	(^{3}H)4d ^{2}G$_{9/2}$	5106.403	−1.091		
				104 993.860	(^{3}F)4d ^{4}D$_{7/2}$	5155.556	−0.412	5155.56	
				105 123.000	(^{3}H)4d ^{2}G$_{7/2}$	5190.121	−0.246	5190.123	
				105 155.090	(^{3}F)4d ^{4}G$_{9/2}$	5198.782	−0.950		blend
				105 211.062	(^{5}D)5d ^{4}G$_{9/2}$	5213.958	−1.188		blend
				105 220.600	(^{3}H)4d ^{4}F$_{7/2}$	5216.553	−1.332		blend
				105 234.237	(^{3}H)4d ^{4}F$_{5/2}$	5220.268	−1.463		
				105 291.010	(^{3}F)4d ^{4}G$_{7/2}$	5235.790	−0.829		blend
				105 775.836	(^{3}F)4d ^{2}F$_{7/2}$	5372.100	+0.165	5372.10	lab
				106 097.520	(^{3}H)4d ^{2}H$_{9/2}$	5466.700	−1.095		at the level of the noise
				106 208.560	(^{3}F)4d ^{2}F$_{5/2}$	5500.096	−0.922		blend
				106 767.210	(^{3}F)4d ^{4}F$_{7/2}$	5674.503	−1.298	5674.50	computed too weak
				106 796.660	(^{3}F)4d ^{4}P$_{5/2}$	5684.004	−0.895		
				106 866.760	(^{3}F)4d ^{4}F$_{5/2}$	5706.743	−0.920		
				106 900.370	(^{3}F)4d ^{2}G$_{7/2}$	5717.719	−1.023		not observed

Table 8. continued.

Upper level				Lower level		λ(calc)	log gf	λ(obs)	Notes
cm^{-1}			J	cm^{-1}		Å	K09	Å	
124 385.010	cont.			106 924.430	(^{3}F)4d ^{2}G$_{9/2}$	5725.598	−0.824	5725.60	
				107 407.800	(^{3}F)4d ^{2}D$_{5/2}$	5888.617	−0.044	5888.61	
				110 570.300	(^{3}G)4d ^{2}F$_{7/2}$	7236.667	−1.221		at the level of the noise
124 416.110	(^{3}F)4f	4[3]	7/2	103 683.070	(^{5}D)5d ^{4}F$_{9/2}$	4821.172	−1.273		
				104 481.590	(^{3}H)4d ^{2}F$_{7/2}$	5015.025	−0.607	5015.02	
				104 807.210	(^{3}H)4d ^{2}G$_{9/2}$	5098.304	−0.623		
				104 868.500	(^{5}D)5d ^{6}G$_{9/2}$	5114.290	−1.355		computed too strong
				104 916.550	(^{3}H)4d ^{4}F$_{9/2}$	5126.892	−0.477	5126.84	lab, blend
				104 993.860	(^{3}F)4d ^{4}D$_{7/2}$	5147.300	+0.051	5147.25	blend,lab
				105 123.000	(^{3}H)4d ^{2}G$_{7/2}$	5181.754	−1.028	5181.75	computed too weak
				105 155.090	(^{3}F)4d ^{4}G$_{9/2}$	5190.388	−1.077		blend
				105 211.062	(^{5}D)5d ^{4}G$_{9/2}$	5205.515	−1.184		blend
				105 220.600	(^{3}H)4d ^{4}F$_{7/2}$	5208.101	+0.031	5208.99	
				105 291.010	(^{3}F)4d ^{4}G$_{7/2}$	5227.276	−1.201		blend
				105 379.430	(^{3}F)4d ^{4}D$_{5/2}$	5251.555	−1.289		at the continuum level
				105 775.491	(^{3}F)4d ^{2}F$_{7/2}$	5363.137	−0.687	5363.15	
				106 097.520	(^{3}H)4d ^{2}H$_{9/2}$	5457.419	−1.335		blend
				106 722.170	(^{3}F)4d ^{4}F$_{9/2}$	5650.084	−0.819		blend
				106 767.210	(^{3}F)4d ^{4}F$_{7/2}$	5664.504	−1.029		at the level of the noise
				106 796.660	(^{3}F)4d ^{4}P$_{5/2}$	5673.972	−0.486	5673.93	blend
				107 407.800	(^{3}F)4d ^{2}D$_{5/2}$	5877.850	−1.281		at the level of the noise
				109 811.920	(^{3}G)4d ^{4}F$_{9/2}$	6845.461	−1.364		not observed
124 403.474	(^{3}F)4f	4[3]	5/2	103 597.402	(^{3}P)4d ^{2}D$_{5/2}$	4804.946	−1.146	4804.93	computed too weak
				104 993.860	(^{3}F)4d ^{4}D$_{7/2}$	5150.651	−0.855		
				105 123.000	(^{3}H)4d ^{2}G$_{7/2}$	5185.150	−0.746	5185.141	lab,blend
				105 234.237	(^{3}H)4d ^{4}F$_{5/2}$	5215.240	−1.455		blend
				105 291.010	(^{3}F)4d ^{4}G$_{7/2}$	5230.732	−1.416		blend
				105 317.440	(^{3}P)4d ^{2}P$_{3/2}$	5237.975	−1.304		blend
				105 460.230	(^{3}F)4d ^{4}D$_{3/2}$	5277.458	−0.778		wrong, not observed
				105 518.140	(^{3}H)4d ^{4}F$_{3/2}$	5293.641	−1.294	5293.627	computed too low?
				105 775.491	(^{3}F)4d ^{2}F$_{7/2}$	5366.775	−0.450	5366.78	
				106 208.560	(^{3}F)4d ^{2}F$_{5/2}$	5494.515	−0.721	5494.51	
				106 796.660	(^{3}F)4d ^{4}P$_{5/2}$	5678.044	−1.006		computed too strong
				106 866.760	(^{3}F)4d ^{4}F$_{5/2}$	5700.741	−0.790	5700.76	
				107 065.900	(^{3}F)4d ^{4}P$_{3/2}$	5766.220	−1.192		at the level of the noise
				107 407.800	(^{3}F)4d ^{2}D$_{5/2}$	5882.220	−0.040	5882.22	
				107 430.250	(^{3}F)4d ^{2}D$_{3/2}$	5890.000	−0.918		blend Na I
				108 105.900	(^{3}F)4d ^{2}P$_{3/2}$	6134.185	−0.702	6134.2	
				110 611.800	(^{3}G)4d ^{2}F$_{5/2}$	7248.754	−1.434		blend with telluric
124 434.563	(^{3}F)4f	4[2]	5/2	103 597.402	(^{3}P)4d ^{2}D$_{5/2}$	4797.777	−1.440		
				104 120.270	(^{5}D)5d ^{6}P$_{5/2}$	4921.269	−0.982		blend
				104 209.610	(^{3}H)4d ^{2}F$_{5/2}$	4943.008	−1.371	4943.0	
				104 481.590	(^{3}H)4d ^{2}F$_{7/2}$	5010.387	−0.817	5010.4	
				104 993.860	(^{3}F)4d ^{4}D$_{7/2}$	5142.414	−0.113	5142.42	lab
				105 213.000	(^{3}H)4d ^{2}G$_{7/2}$	5176.803	−1.156		blend
				105 127.770	(^{5}D)5d ^{4}D$_{5/2}$	5178.082	−1.132	5178.08	computed too weak
				105 220.600	(^{3}H)4d ^{4}F$_{7/2}$	5203.100	−0.191	5203.10	
				105 379.430	(^{3}F)4d ^{4}D$_{5/2}$	5246.469	−0.830		at the noise level, computed too strong
				105 775.491	(^{3}F)4d ^{2}F$_{7/2}$	5357.833	−1.105		
				106 208.560	(^{3}F)4d ^{2}F$_{5/2}$	5485.142	−1.413		
				106 767.210	(^{3}F)4d ^{4}F$_{7/2}$	5658.587	−1.147		blend
				106 796.660	(^{3}F)4d ^{4}P$_{5/2}$	5668.035	−0.132	5668.05	computed too strong
				106 866.760	(^{3}F)4d ^{4}F$_{5/2}$	5690.652	−1.300	5690.68	computed too weak
				107 407.800	(^{3}F)4d ^{2}D$_{5/2}$	5871.480	−1.133		

Table 8. continued.

Upper level				Lower level		λ(calc)	log gf	λ(obs)	Notes
cm^{-1}			J	cm^{-1}		Å	K09	Å	
124 460.410	(^{3}F)4f	4[2]	3/2	104 120.270	(^{5}D)5d ^{6}P$_{5/2}$	4915.015	−1.449		
				104 189.380	(^{5}D)5d ^{4}P$_{3/2}$	4931.772	−1.122		wrong,not observed
				105 234.060	(^{3}H)4d ^{4}F$_{5/2}$	5199.747	−1.496		
				105 317.440	(^{3}P)4d ^{2}P$_{3/2}$	5222.396	−0.923		blend
				105 379.430	(^{3}F)4d ^{4}D$_{5/2}$	5239.362	−1.350		blend
				105 460.230	(^{3}F)4d ^{4}D$_{3/2}$	5261.644	−0.436		wrong, not observed
				105 518.140	(^{3}H)4d ^{4}F$_{3/2}$	5277.730	−1.098		blend
				106 208.560	(^{3}F)4d ^{2}F$_{5/2}$	5477.375	−1.153		at the level of the noise
				106 846.650	(^{3}F)4d ^{4}F$_{3/2}$	5675.805	−1.332		at the level of the noise
				106 866.760	(^{3}F)4d ^{4}F$_{5/2}$	5682.292	−0.926		at the level of the noise
				107 065.930	(^{3}F)4d ^{4}P$_{3/2}$	5747.356	−0.824		at the level of the noise
				107 407.800	(^{3}F)4d ^{2}D$_{5/2}$	5862.580	−0.452	5862.58	at the level of thec noise
				107 430.250	(^{3}F)4d ^{2}D$_{3/2}$	5870.308	−0.663	5870.30	computed too weak
				108 105.900	(^{3}F)4d ^{2}P$_{3/2}$	6112.829	−0.452		EMISSION?
124 661.274	(^{3}F)4f	3[6]	13/2	103 751.660	(^{3}H)4d ^{4}H$_{11/2}$	4781.152	−1.241	4781.15	computed too weak
				105 063.550	(^{3}F)4d ^{4}G$_{11/2}$	5101.212	−1.511	5101.2	computed too weak
				105 398.852	(^{3}F)4d ^{4}H$_{11/2}$	5190.010	+0.482	5190.012	
				105 763.270	(^{3}F)4d ^{2}H$_{11/2}$	5290.092	+0.589	5290.094	
				106 045.690	(^{3}H)4d ^{2}H$_{11/2}$	5370.350	+0.111	5370.3	Fe II,5270.284 main comp.
124 656.535	(^{3}F)4f	3[6]	11/2	103 874.260	(^{3}H)4d ^{4}H$_{9/2}$	4810.449	−1.268	4810.45	weak
				104 192.480	(^{3}H)4d ^{4}I$_{9/2}$	4885.254	−1.238		blend
				105 155.090	(^{3}F)4d ^{4}G$_{9/2}$	5126.398	−0.847		very weak
				105 398.852	(^{3}F)4d ^{4}H$_{11/2}$	5191.288	−1.025		blend
				105 524.461	(^{3}F)4d ^{4}H$_{9/2}$	5225.371	+0.768	5225.364	lab + unid
				105 763.270	(^{3}F)4d ^{2}H$_{11/2}$	5291.420	−1.047		very weak
				106 018.643	(^{3}F)4d ^{2}H$_{9/2}$	5363.923	+0.201	5363.92	lab
				106 722.170	(^{3}F)4d ^{4}F$_{9/2}$	5574.341	−1.111	5574.25	
				106 924.430	(^{3}F)4d ^{2}G$_{9/2}$	5637.925	−0.160	5637.92	
				109 625.200	(^{3}G)4d ^{2}G$_{9/2}$	6650.935	−1.387		blend
124 626.900	(^{3}F)4f	3[5]	11/2	103 683.070	(^{5}D)5d ^{4}F$_{9/2}$	4773.341	−1.317		
				103 771.320	(^{3}H)4d ^{4}G$_{9/2}$	4793.540	−0.748	4793.55	
				104 807.210	(^{3}H)4d ^{2}G$_{9/2}$	5044.081	−0.396		wrong, not observed
				104 916.550	(^{3}H)4d ^{4}F$_{9/2}$	5072.063	−0.515	5072.05	
				105 063.550	(^{3}F)4d ^{4}G$_{11/2}$	5110.175	−1.355		blend
				105 155.090	(^{3}F)4d ^{4}G$_{9/2}$	5134.199	+0.353	5134.20	blend
				105 211.062	(^{5}D)5d ^{4}G$_{9/2}$	5149.000	−0.004		blend
				105 398.852	(^{3}F)4d ^{4}H$_{11/2}$	5199.288	−0.178	5199.29	
				105 524.461	(^{3}F)4d ^{4}H$_{9/2}$	5233.477	−0.662	5233.47	computed too weak
				105 763.270	(^{3}F)4d ^{2}H$_{11/2}$	5299.732	−0.158	5299.717	lab
				106 018.643	(^{3}F)4d ^{2}H$_{9/2}$	5372.464	−0.223		blend
				106 045.690	(^{3}H)4d ^{2}H$_{11/2}$	5380.285	−0.656	5380.29	
				106 097.520	(^{3}H)4d ^{2}H$_{9/2}$	5395.335	+0.054	5395.32	computed too strong
				106 722.170	(^{3}F)4d ^{4}F$_{9/2}$	5583.566	−1.347		
				106 924.430	(^{3}F)4d ^{2}G$_{9/2}$	5647.362	−0.074		blend
				109 811.920	(^{3}G)4d ^{4}F$_{9/2}$	6748.062	−1.222		at the level of the noise
124 636.116	(^{3}F)4f	3[5]	9/2	103 771.320	(^{3}H)4d ^{4}G$_{9/2}$	4791.423	−1.349		at the level of the noise
				104 107.950	(^{3}P)4d ^{4}F$_{7/2}$	4869.996	−1.378		blend
				104 481.590	(^{3}H)4d ^{2}F$_{7/2}$	4960.280	−1.109	4960.28	weak
				104 807.210	(^{3}H)4d ^{2}G$_{9/2}$	5041.737	−1.101		weak
				104 873.230	(^{5}D)5d ^{4}D$_{7/2}$	5058.579	−1.461		weak
				104 916.550	(^{3}H)4d ^{4}F$_{9/2}$	5069.692	−1.055		weak

Table 8. continued.

Upper level				Lower level		λ(calc)	log gf	λ(obs)	Notes
cm^{-1}			J	cm^{-1}		Å	K09	Å	
124 636.116	cont.			104 993.860	$(^3F)4d\ ^4D_{7/2}$	5089.646	−0.797		weak
				105 123.000	$(^3H)4d\ ^2G_{7/2}$	5123.331	−1.032		
				105 155.090	$(^3F)4d\ ^4G_{9/2}$	5131.770	−0.298		blend
				105 211.062	$(^5D)5d\ ^4G_{9/2}$	5146.557	−0.622		blend
				105 220.600	$(^3H)4d\ ^4F_{7/2}$	5149.085	+0.286	5149.1	lab
				105 291.010	$(^3F)4d\ ^4G_{7/2}$	5167.827.	−0.884	5167.82	computed too weak
				105 398.852	$(^3F)4d\ ^4H_{11/2}$	5196.797	−1.467		at the level of the noise
				105 524.461	$(^3F)4d\ ^4H_{9/2}$	5230.953	−0.507	5230.959	computed too weak
				105 589.670	$(^3F)4d\ ^4H_{7/2}$	5248.862	−0.754	5248.801	blend
				105 763.270	$(^3F)4d\ ^2H_{11/2}$	5297.144	−1.481		weak
				105 775.491	$(^3F)4d\ ^2F_{7/2}$	5300.576	−0.373		weak
				106 018.643	$(^3F)4d\ ^2H_{9/2}$	5369.805	−0.547	5369.81	
				106 097.520	$(^3H)4d\ ^2H_{9/2}$	5392.652	−0.592		not obs, wrong
				106 767.210	$(^3F)4d\ ^4F_{7/2}$	5594.760	−0.050		not obs, wrong
				106 900.370	$(^3F)4d\ ^2G_{7/2}$	5636.766	−0.061	5636.78	computed too weak
				106 924.430	$(^3F)4d\ ^2G_{9/2}$	5644.423	−0.918		blend
				109 901.500	$(^3G)4d\ ^2G_{7/2}$	6784.867	−1.141		at the level of the noise
				110 167.280	$(^3G)4d\ ^4F_{7/2}$	6909.500	−1.099		at the level of the noise
124 623.120	$(^3F)4f$	3[4]	9/2	103 921.630	$(^3H)4d\ ^4G_{7/2}$	4829.221	−1.017	4829.25	computed too weak
				103 983.510	$(^3G)5s\ ^2G_{7/2}$	4843.700	−1.308		computed too strong, not obs
				103 986.330	$(^3H)4d\ ^4H_{7/2}$	4844.361	−1.133		
				104 916.550	$(^3H)4d\ ^4F_{9/2}$	5073.036	−1.028		
				104 993.860	$(^3F)4d\ ^4D_{7/2}$	5093.016	−1.142	5093.01	weak
				105 123.000	$(^3H)4d\ ^2G_{7/2}$	5126.745	−0.382	5126.75	lab, blend
				105 155.090	$(^3F)4d\ ^4G_{9/2}$	5135.196	−0.318		blend
				105 211.062	$(^5D)5d\ ^4G_{9/2}$	5150.003	−0.755	5150.02	
				105 220.600	$(^3H)4d\ ^4F_{7/2}$	5152.534	−1.333		blend
				105 291.010	$(^3F)4d\ ^4G_{7/2}$	5171.301	+0.425	5171.305	
				105 398.852	$(^3F)4d\ ^4H_{11/2}$	5200.310	−1.359		blend
				105 449.540	$(^5D)5d\ ^4G_{7/2}$	5214.058	−0.628		blend
				105 524.461	$(^3F)4d\ ^4H_{9/2}$	5234.513	−0.157		blend
				105 763.270	$(^3F)4d\ ^2H_{11/2}$	5300.794	−1.386		blend
				105 775.491	$(^3F)4d\ ^2F_{7/2}$	5304.231	−0.076	5304.25	blend
				106 018.640	$(^3F)4d\ ^2H_{9/2}$	5373.555	−1.277		
				106 097.520	$(^3H)4d\ ^2H_{9/2}$	5396.435	−0.899	5396.45	computed too weak
				106 900.370	$(^3F)4d\ ^2G_{7/2}$	5640.900	−0.389	5640.9	computed too strong
				106 924.430	$(^3F)4d\ ^2G_{9/2}$	5648.568	−0.369	5648.57	blend
				110 570.300	$(^3G)4d\ ^2F_{7/2}$	7114.048	−1.243		
124 620.914	$(^3F)4f$	3[4]	7/2	103 921.630	$(^3H)4d\ ^4G_{7/2}$	4829.735	−1.435		
				104 023.910	$(^3H)4d\ ^4G_{5/2}$	4853.719	−0.883		
				104 569.230	$(^3P)4d\ ^4F_{5/2}$	4985.721	−0.873	4985.72	weak
				104 993.860	$(^3F)4d\ ^4D_{7/2}$	5093.588	−1.437		blend
				105 123.000	$(^3H)4d\ ^2G_{5/2}$	5127.325	−0.784		blend
				105 155.090	$(^3F)4d\ ^4G_{9/2}$	5135.778	−1.386		weak
				105 234.237	$(^3H)4d\ ^4F_{5/2}$	5156.745	−0.254		blend
				105 291.010	$(^3F)4d\ ^4G_{7/2}$	5171.891	+0.011	5171.9	
				105 379.430	$(^3F)4d\ ^4D_{5/2}$	5195.658	−0.478	5195.661	lab
				105 414.180	$(^3F)4d\ ^4G_{5/2}$	5205.058	−0.783		blend
				105 449.540	$(^5D)5d\ ^4G_{7/2}$	5214.658	−1.042		weak
				105 524.461	$(^3F)4d\ ^4H_{9/2}$	5235.117	−1.185		blend
				105 711.730	$(^5D)5d\ ^6S_{5/2}$	5286.964	−0.934		blend
				105 775.491	$(^3F)4d\ ^2F_{7/2}$	5304.852	−0.525	5304.87	blend
				106 208.560	$(^3F)4d\ ^2F_{5/2}$	5429.627	−0.531	5429.62	computed too weak
				106 866.760	$(^3F)4d\ ^4F_{5/2}$	5630.922	−1.421		weak
				106 900.370	$(^3F)4d\ ^2G_{7/2}$	5641.602	−0.724	5641.61	weak
				106 924.430	$(^3F)4d\ ^2G_{9/2}$	5649.272	−1.404		not observed
				107 407.800	$(^3F)4d\ ^2D_{5/2}$	5807.914	−0.295	5807.9	blend

Table 8. continued.

Upper level				Lower level		λ(calc)	log gf	λ(obs)	Notes
cm^{-1}			J	cm^{-1}		Å	K09	Å	
124 641.989	(^{3}F)4f	3[3]	7/2	104 107.950	(^{3}P)4d ^{4}F$_{7/2}$	4868.603	−1.393		
				104 120.270	(^{5}D)5d ^{6}P$_{5/2}$	4871.525	−1.423		
				104 481.590	(^{3}H)4d ^{2}F$_{7/2}$	4958.835	−1.370		blend
				105 123.000	(^{3}H)4d ^{2}G$_{7/2}$	5121.789	−0.828		
				105 155.090	(^{3}F)4d ^{4}G$_{9/2}$	5130.223	−0.928		blend
				105 211.062	(^{5}D)5d ^{4}G$_{9/2}$	5145.002	−1.290		at the level of the noise
				105 220.600	(^{3}H)4d ^{4}F$_{7/2}$	5147.528	−0.014	5147.52	
				105 291.010	(^{3}F)4d ^{4}G$_{7/2}$	5166.258	−1.096		weak
				105 379.430	(^{3}F)4d ^{4}D$_{5/2}$	5189.973	−0.210		blend
				105 414.180	(^{3}F)4d ^{4}G$_{5/2}$	5199.353	−1.041		blend
				105 589.670	(^{3}F)4d ^{4}H$_{7/2}$	5247.244	−0.996	5247.25	weak
				105 711.730	(^{5}D)5d ^{6}S$_{5/2}$	5281.078	−0.874		not observed
				105 775.491	(^{3}F)4d ^{2}F$_{7/2}$	5298.926	−0.405		blend
				106 097.520	(^{3}H)4d ^{2}H$_{9/2}$	5390.945	−1.384		blend
				106 208.560	(^{3}F)4d ^{2}F$_{5/2}$	5423.419	−0.138	5423.41	lab
				106 767.210	(^{3}F)4d ^{4}F$_{7/2}$	5592.922	−0.422		wrong
				106 796.660	(^{3}F)4d ^{4}P$_{5/2}$	5602.152	−0.795		blend
				106 866.760	(^{3}F)4d ^{4}F$_{5/2}$	5624.245	−1.195		blend
				106 900.370	(^{3}F)4d ^{2}G$_{7/2}$	5634.900	−0.588	5634.9	computed too weak
				106 924.430	(^{3}F)4d ^{2}G$_{9/2}$	5642.552	−1.377		at the level of the noise
				107 407.800	(^{3}F)4d ^{2}D$_{5/2}$	5800.811	−0.993		at the level of the noise
				110 167.280	(^{3}G)4d ^{4}F$_{7/2}$	6906.696	−1.294		at the level of the noise
				110 611.800	(^{3}G)4d ^{2}F$_{5/2}$	7125.523	−1.233		at the level of the noise
124 653.022	(^{3}F)4f	3[3]	5/2	104 023.910	(^{3}H)4d ^{4}G$_{5/2}$	4846.164	−1.115		weak
				104 569.230	(^{3}P)4d ^{4}F$_{5/2}$	4977.751	−0.819	4977.75	computed too weak
				104 839.998	(^{3}P)4d ^{2}D$_{3/2}$	5045.778	−0.981	5045.79	computed too weak
				105 123.000	(^{3}H)4d ^{2}G$_{7/2}$	5118.896	−1.484		
				105 234.237	(^{3}H)4d ^{4}F$_{5/2}$	5148.219	−0.286		computed too strong
				105 291.010	(^{3}F)4d ^{4}G$_{7/2}$	5163.314	−0.700	5163.29	weak
				105 317.440	(^{3}P)4d ^{2}P$_{3/2}$	5170.372	−1.129		
				105 379.430	(^{3}F)4d ^{4}D$_{5/2}$	5187.002	−0.628	5187.0	
				105 414.180	(^{3}F)4d ^{4}G$_{5/2}$	5196.371	−0.956		blend
				105 460.230	(^{3}F)4d ^{4}D$_{3/2}$	5208.839	−0.132	5208.862	lab, computed too strong
				105 711.730	(^{5}D)5d ^{6}S$_{5/2}$	5278.002	−1.442		
				105 775.491	(^{3}F)4d ^{2}F$_{7/2}$	5295.829	−1.021		blend
				106 208.560	(^{3}F)4d ^{2}F$_{5/2}$	5420.175	−0.824	5420.2	computed too weak
				106 846.650	(^{3}F)4d ^{4}F$_{3/2}$	5614.409	−0.773		computed too strong
				107 065.930	(^{3}F)4d ^{4}P$_{3/2}$	5684.411	−1.018		
				107 407.800	(^{3}F)4d ^{2}D$_{5/2}$	5797.100	−0.273	5797.1	
				107 430.250	(^{3}F)4d ^{2}D$_{3/2}$	5804.657	−0.981		at the level of the noise
				108 105.900	(^{3}F)4d ^{2}P$_{3/2}$	6041.674	−0.519		
124 731.762	(^{3}F)4f	3[0]	1/2	104 189.380	(^{5}D)5d ^{4}P$_{3/2}$	4866.625	−0.710		on the H$_\beta$ wing
				104 588.710	(^{5}D)5d ^{6}D$_{3/2}$	4963.106	−1.473		
				104 736.460	(^{3}P)4d ^{2}P$_{1/2}$	4999.780	−1.476		
				105 460.230	(^{3}F)4d ^{4}D$_{3/2}$	5187.556	−1.137		
				105 477.920	(^{3}F)4d ^{4}D$_{1/2}$	5192.323	−0.902		blend
				105 518.140	(^{3}H)4d ^{4}F$_{3/2}$	5203.192	−0.854		blend
				107 065.930	(^{3}F)4d ^{4}P$_{3/2}$	5659.074	−0.650	5659.05	computed too weak
				107 176.100	(^{5}D)5d ^{4}P$_{1/2}$	5694.588	−0.810	5694.59	good agreement
				107 430.250	(^{3}F)4d ^{2}D$_{3/2}$	5778.239	−0.939		blend
				108 105.900	(^{3}F)4d ^{2}P$_{3/2}$	6013.060	−1.184		

Table 8. continued.

Upper level				Lower level		λ(calc)	log gf	λ(obs)	Notes
cm^{-1}			J	cm^{-1}		Å	K09	Å	
124 803.873	(^{3}F)4f	2[5]	11/2	103 771.320	(^{3}H)4d ^{4}G$_{9/2}$	4753.206	−1.359		
				104 807.210	(^{3}H)4d ^{2}G$_{9/2}$	4999.441	−1.315		
				105 524.461	(^{3}F)4d ^{4}H$_{9/2}$	5185.437	+0.377	5185.422	lab
				106 018.643	(^{3}F)4d ^{2}H$_{9/2}$	5321.852	+0.731	5321.83	lab
				106 097.520	(^{3}H)4d ^{2}H$_{9/2}$	5344.292	−1.008	5344.28	
				106 924.430	(^{3}F)4d ^{2}G$_{9/2}$	5591.464	−0.173		computed too strong
				109 625.200	(^{3}G)4d ^{2}G$_{9/2}$	6586.373	−1.344		not observed
124 809.727	(^{3}F)4f	2[5]	9/2	103 921.630	(^{3}H)4d ^{4}G$_{7/2}$	4786.078	−1.434		
				103 983.510	(^{3}G)5s ^{2}G$_{7/2}$	4800.298	−1.342		
				105 291.010	(^{3}F)4d ^{4}G$_{7/2}$	5121.860	−1.107		blend
				105 449.540	(^{5}D)5d ^{4}G$_{7/2}$	5163.801	−1.335		blend
				105 524.461	(^{3}F)4d ^{4}H$_{9/2}$	5183.862	−1.227		blend
				105 589.670	(^{3}F)4d ^{4}H$_{7/2}$	5201.450	+0.802	5201.444	lab
				105 775.491	(^{3}F)4d ^{2}F$_{7/2}$	5252.229	−1.121		
				106 018.643	(^{3}F)4d ^{2}H$_{9/2}$	5320.193	−0.866		blend
				106 767.210	(^{3}F)4d ^{4}F$_{7/2}$	5540.925	−1.367		
				106 900.370	(^{3}F)4d ^{2}G$_{7/2}$	5582.123	−0.405	5582.12	
124 793.905	(^{3}F)4f	2[4]	9/2	103 921.630	(^{3}H)4d ^{4}G$_{7/2}$	4789.706	−1.174	4789.7	computed too weak
				103 986.330	(^{3}H)4d ^{4}H$_{7/2}$	4804.599	−1.426		blend
				104 481.590	(^{3}H)4d ^{2}F$_{7/2}$	4921.748	−1.081		blend
				105 123.000	(^{3}H)4d ^{2}G$_{7/2}$	5082.234	−0.341		blend
				105 220.600	(^{3}H)4d ^{4}F$_{7/2}$	5107.576	−0.574		blend
				105 291.010	(^{3}F)4d ^{4}G$_{7/2}$	5126.016	+0.065	5126.00	lab.
				105 449.540	(^{5}D)5d ^{4}G$_{7/2}$	5168.025	−1.175		good agreement
				105 524.460	(^{3}F)4d ^{4}H$_{9/2}$	5188.118	−0.544	5188.12	good agreement
				105 589.670	(^{3}F)4d ^{4}H$_{7/2}$	5205.735	−0.340		blend
				105 775.491	(^{3}F)4d ^{2}F$_{7/2}$	5256.599	−0.442	5256.599	good agreement
				106 018.640	(^{3}F)4d ^{2}H$_{9/2}$	5324.675	−0.131	5234.68	good agreementy=
				106 900.370	(^{3}F)4d ^{2}G$_{7/2}$	5587.059	+0.466		blend
				106 924.430	(^{3}F)4d ^{2}G$_{9/2}$	5594.582	−1.114		blend
				109 901.500	(^{3}G)4d ^{2}G$_{7/2}$	6712.979	−1.436		
				110 167.280	(^{3}G)4d ^{4}F$_{7/2}$	6834.961	−1.262		
				110 570.300	(^{3}G)4d ^{2}F$_{7/2}$	7028.628	−1.389		
124 783.748	(^{3}F)4f	2[4]	7/2	104 023.910	(^{3}H)4d ^{4}G$_{5/2}$	4815.647	−0.780		not observed
				104 120.270	(^{5}D)5d ^{6}P$_{5/2}$	4838.105	−1.439		
				104 209.610	(^{3}H)4d ^{2}F$_{5/2}$	4859.114	−1.499		
				104 569.230	(^{3}P)4d ^{4}F$_{5/2}$	4945.559	−1.176		weak
				105 123.000	(^{3}H)4d ^{2}G$_{7/2}$	5084.859	−1.401		
				105 291.010	(^{3}F)4d ^{4}G$_{7/2}$	5128.687	−0.876		blend
				105 414.180	(^{3}F)4d ^{4}G$_{5/2}$	5161.300	+0.512	5161.3	lab, computed too strong
				105 589.670	(^{3}F)4d ^{4}H$_{7/2}$	5208.490	−0.196	5208.501	
				105 630.750	(^{5}D)5d ^{4}G$_{5/2}$	5219.661	−0.923		blend
				106 018.640	(^{3}F)4d ^{2}H$_{9/2}$	5327.557	−1.482		
				106 208.560	(^{3}F)4d ^{2}F$_{5/2}$	5382.029	−0.281	5382.12	
				106 900.370	(^{3}F)4d ^{2}G$_{7/2}$	5590.233	−0.326	5590.22	
				107 407.800	(^{3}F)4d ^{2}D$_{5/2}$	5753.486	−0.930		at the level of the noise
				110 611.800	(^{3}G)4d ^{2}F$_{5/2}$	7054.248	−1.377		at the level of the noise

Table 9. Fe II lines in the 3800−8000 Å region with log $gf \geq -1.5$ and $3d^6(^3G)4f$ energy levels as upper levels.

Upper level				Lower level		λ(calc)	log gf	λ(obs)	Notes
cm^{-1}			J	cm^{-1}		Å	KUR	Å	
127 507.241	$(^3G)4f$	5[8]	17/2	103 878.370	$(^3H)4d\ ^4I_{15/2}$	4230.919	−1.017	4230.93	
				108 337.860	$(^3G)4d\ ^4I_{15/2}$	5215.200	+1.119	5215.21	
127 524.122	$(^3G)4f$	5[8]	15/2	104 064.670	$(^3H)4d\ ^4I_{13/2}$	4261.475	−1.477		
				104 622.300	$(^3H)4d\ ^2I_{13/2}$	4365.238	−1.210		
				108 133.440	$(^3G)4d\ ^4H_{13/2}$	5155.680	−0.971		
				108 463.910	$(^3G)4d\ ^4I_{13/2}$	5245.071	+0.889	5245.073	lab, J78
				108 648.695	$(^1I)5s\ e^2I_{13/2}$	5296.420	−0.047	5296.418	
				109 049.600	$(^3G)4d\ ^2I_{13/2}$	5411.356	+0.449		blend
127 484.653	$(^3G)4f$	5[7]	15/2	108 133.440	$(^3G)4d\ ^4H_{13/2}$	5166.196	+0.934	5166.2	lab
				108 337.860	$(^3G)4d\ ^4I_{15/2}$	5221.353	+0.453	5221.335	lab
				108 463.910	$(^3G)4d\ ^4I_{13/2}$	5255.955	−0.980		
				108 648.695	$(^1I)5s\ e^2I_{13/2}$	5307.518	−0.940		
				109 049.600	$(^3G)4d\ ^2I_{13/2}$	5422.941	−1.415		
127 515.235	$(^3G)4f$	5[7]	13/2	105 763.270	$(^3F)4d\ ^2H_{11/2}$	4595.998	−1.059		
				106 045.690	$(^3H)4d\ ^2H_{11/2}$	4656.457	−0.284		
				108 133.440	$(^3G)4d\ ^4H_{13/2}$	5158.044	−0.684		
				108 181.550	$(^3G)4d\ ^4G_{11/2}$	5170.879	−0.639		
				108 387.920	$(^3G)4d\ ^4H_{11/2}$	5226.670	+0.474	5226.686	lab
				108 463.910	$(^3G)4d\ ^4I_{13/2}$	5247.518	+0.157	5247.536	lab
				108 648.695	$(^1I)5s\ e^2I_{13/2}$	5298.915	−1.299		
				108 775.080	$(^3G)4d\ ^4I_{11/2}$	5334.651	−0.859		
				109 049.600	$(^3G)4d\ ^2I_{13/2}$	5413.960	−0.246		
				109 683.280	$(^3G)4d\ ^2H_{11/2}$	5606.354	+0.514	5606.38	
127 489.429	$(^3G)4f$	5[6]	13/2	103 600.430	$(^3H)4d\ ^4G_{11/2}$	4184.848	−1.133		
				106 045.690	$(^3H)4d\ ^2H_{11/2}$	4662.061	−1.312		
				108 133.440	$(^3G)4d\ ^4H_{13/2}$	5164.921	+0.601	5164.9	lab
				108 181.550	$(^3G)4d\ ^4G_{11/2}$	5177.791	+0.705	5177.77	lab
				108 337.860	$(^3G)4d\ ^4I_{15/2}$	5220.051	−0.463		
				108 387.920	$(^3G)4d\ ^4H_{11/2}$	5233.732	−1.225		
				108 463.910	$(^3G)4d\ ^4I_{13/2}$	5254.636	−0.596		
				108 648.695	$(^1I)5s\ e^2I_{13/2}$	5306.173	−0.818		
				109 683.280	$(^3G)4d\ ^2H_{11/2}$	5614.479	−0.728		
127 489.977	$(^3G)4f$	5[6]	11/2	103 600.430	$(^3H)4d\ ^4G_{11/2}$	4184.752	−1.422		
				103 683.070	$(^5D)5d\ ^4F_{9/2}$	4199.279	−1.301		
				106 045.690	$(^3H)4d\ ^2H_{11/2}$	4661.942	−1.108		
				106 722.170	$(^3F)4d\ ^4F_{9/2}$	4813.800	−0.314	4813.8	
				106 924.430	$(^3F)4d\ ^2G_{9/2}$	4861.143	−0.513		
				108 133.440	$(^3G)4d\ ^4H_{13/2}$	5164.775	−0.273	5164.77	
				108 181.550	$(^3G)4d\ ^4G_{11/2}$	5177.644	+0.437	5177.64	lab
				108 387.920	$(^3G)4d\ ^4H_{11/2}$	5233.581	−0.349	5233.58	
				108 391.500	$(^3G)4d\ ^4G_{9/2}$	5234.562	−0.887		
				109 049.600	$(^3G)4d\ ^2I_{13/2}$	5421.376	−1.110		
				109 625.200	$(^3G)4d\ ^2G_{9/2}$	5596.053	−0.050		computed too strong
				109 683.280	$(^3G)4d\ ^2H_{11/2}$	5614.306	−0.230		
				109 811.920	$(^3G)4d\ ^4F_{9/2}$	5655.161	−0.047	5655.15	
				110 008.300	$(^3G)4d\ ^2H_{9/2}$	5718.689	−0.545		
127 482.748	$(^3G)4f$	5[5]	11/2	105 763.270	$(^3F)4d\ ^2H_{11/2}$	4602.873	−1.478		
				106 045.690	$(^3H)4d\ ^2H_{11/2}$	4663.514	−0.736		
				106 722.170	$(^3F)4d\ ^4F_{9/2}$	4815.476	−0.239		computed too strong
				108 133.440	$(^3G)4d\ ^4H_{13/2}$	5166.704	−0.401		computed too strong
				108 181.550	$(^3G)4d\ ^4G_{11/2}$	5179.583	+0.320		blend
				108 387.920	$(^3G)4d\ ^4H_{11/2}$	5235.563	−0.190	5235.585	blend
				108 391.500	$(^3G)4d\ ^4G_{9/2}$	5236.545	+0.191		blend, computed too strong

Table 9. continued.

Upper level				Lower level		λ(calc)	log gf	λ(obs)	Notes
cm^{-1}			J	cm^{-1}		Å	KUR	Å	
127 482.748	cont.			108 463.910	(^{3}G)4d ^{4}I$_{13/2}$	5256.482	−0.830	5256.5	
				108 648.695	(^{1}I)5s e^{2}I$_{13/2}$	5308.055	−1.341		
				108 775.080	(^{3}G)4d ^{4}I$_{11/2}$	5343.915	−1.043		
				109 625.200	(^{3}G)4d ^{2}G$_{9/2}$	5598.319	−0.100	5598.32	computed too weak
				109 683.280	(^{3}G)4d ^{2}H$_{11/2}$	5616.586	−0.042	5616.6	computed too weak
				109 811.920	(^{3}G)4d ^{4}F$_{9/2}$	5657.474	−0.662	5657.50	computed too weak
				110 008.300	(^{3}G)4d ^{2}H$_{9/2}$	5721.054	−0.506		
127 485.362	(^{3}G)4f	5[4]	9/2	104 107.950	(^{3}P)4d ^{4}F$_{7/2}$	4276.430	−1.168		
				104 481.590	(^{3}H)4d ^{2}F$_{7/2}$	4345.891	−1.316		
				105 775.491	(^{3}F)4d ^{2}F$_{7/2}$	4604.910	−1.176		
				106 045.690	(^{3}H)4d ^{2}H$_{11/2}$	4662.945	−1.404		
				106 722.170	(^{3}F)4d ^{4}F$_{9/2}$	4814.870	−0.945		
				106 767.210	(^{3}F)4d ^{4}F$_{7/2}$	4825.337	−1.318		
				106 924.430	(^{3}F)4d ^{2}G$_{9/2}$	4862.235	−0.425		
				108 181.550	(^{3}G)4d ^{4}G$_{11/2}$	5178.882	−0.635		
				108 365.320	(^{3}G)4d ^{4}D$_{7/2}$	5228.658	−0.224		blend
				108 387.920	(^{3}G)4d ^{4}H$_{11/2}$	5234.846	−0.695	5234.80	
				108 391.500	(^{3}G)4d ^{4}G$_{9/2}$	5235.828	−0.195	5235.80	blend
				108 537.610	(^{3}G)4d ^{4}G$_{7/2}$	5276.203	−1.169		
				108 577.560	(^{3}G)4d ^{4}H$_{9/2}$	5287.351	−1.391		
				109 625.200	(^{3}G)4d ^{2}G$_{9/2}$	5597.499	+0.251	5597.50	computed too strong
				109 683.280	(^{3}G)4d ^{2}H$_{11/2}$	5615.762	−0.466	5615.75	
				109 811.920	(^{3}G)4d ^{4}F$_{9/2}$	5656.638	−0.349	5656.55	blend
				109 901.500	(^{3}G)4d ^{2}G$_{7/2}$	5685.455	−0.333	5685.45	
				110 008.300	(^{3}G)4d ^{2}H$_{9/2}$	5720.199	−0.468	5720.20	
				110 167.280	(^{3}G)4d ^{4}F$_{7/2}$	5772.711	−1.064		
				110 570.300	(^{3}G)4d ^{2}F$_{7/2}$	5910.253	−0.120		blend H2O
127 485.699	(^{3}G)4f	5[4]	7/2	103 683.070	(^{5}D)5d ^{4}F$_{9/2}$	4200.033	−1.226		
				106 722.170	(^{3}F)4d ^{4}F$_{9/2}$	4814.791	+0.017	4814.8	computed too strong
				106 767.210	(^{3}F)4d ^{4}F$_{7/2}$	4825.259	−0.375	4825.30	blend
				106 900.370	(^{3}F)4d ^{2}G$_{7/2}$	4856.472	−1.384		
				106 924.430	(^{3}F)4d ^{2}G$_{9/2}$	4862.155	−0.753		
				108 365.320	(^{3}G)4d ^{4}D$_{7/2}$	5228.566	+0.266		blend
				108 391.500	(^{3}G)4d ^{4}G$_{9/2}$	5235.735	−0.618		blend
				108 537.610	(^{3}G)4d ^{4}G$_{7/2}$	5276.109	−0.999		
				109 625.200	(^{3}G)4d ^{2}G$_{9/2}$	5597.394	−1.025		
				109 811.920	(^{3}G)4d ^{4}F$_{9/2}$	5656.530	+0.034	5656.55	
				110 065.750	(^{3}G)4d ^{2}D$_{5/2}$	5738.953	−1.494		
				110 167.280	(^{3}G)4d ^{4}F$_{7/2}$	5772.598	−0.676		
				110 570.300	(^{3}G)4d ^{2}F$_{7/2}$	5910.135	−1.369		
127 510.913	(^{3}G)4f	5[3]	5/2	106 767.210	(^{3}F)4d ^{4}F$_{7/2}$	4819.393	−0.294	4819.40	
				106 900.370	(^{3}F)4d ^{2}G$_{7/2}$	4850.531	−1.345		
				108 365.320	(^{3}G)4d ^{4}D$_{7/2}$	5221.680	+0.447	5221.68	lab
				108 537.610	(^{3}G)4d ^{4}G$_{7/2}$	5269.097	−0.794	5369.12	
				110 065.750	(^{3}G)4d ^{2}D$_{5/2}$	5730.658	−0.761		
				110 167.280	(^{3}G)4d ^{4}F$_{7/2}$	5764.206	−0.654		blend
				110 570.300	(^{3}G)4d ^{2}F$_{7/2}$	5901.339	−1.193		
127 487.681	(^{3}G)4f	5[2]	3/2	106 866.760	(^{3}F)4d ^{4}F$_{5/2}$	4848.090	−0.945		
				108 642.410	(^{3}G)4d ^{4}D$_{5/2}$	5304.895	−0.425	5304.89	blend
				110 065.750	(^{3}G)4d ^{2}D$_{5/2}$	5738.300	−0.104	5738.30	

Table 9. continued.

Upper level				Lower level		λ(calc)	log gf	λ(obs)	Notes
cm^{-1}			J	cm^{-1}		Å	KUR	Å	
127 892.981	(^{3}G)4f	4[7]	15/2	104 064.670	(^{3}H)4d ^{4}I$_{13/2}$	4195.506	−1.455		
				104 622.300	(^{3}H)4d ^{2}I$_{13/2}$	4296.044	−1.387		
				108 133.440	(^{3}G)4d ^{4}H$_{13/2}$	5059.436	−0.484	5059.42	lab
				108 463.910	(^{3}G)4d ^{4}I$_{13/2}$	5145.493	−0.007	5145.5	
				108 648.695	(^{1}I)5s e^{2}I$_{13/2}$	5194.901	+0.482		blend
				109 049.600	(^{3}G)4d ^{2}I$_{13/2}$	5305.427	+0.862	5305.42	lab
127 895.260	(^{3}G)4f	4[7]	13/2	104 174.270	(^{3}H)4d ^{4}I$_{11/2}$	4214.489	−1.351		
				108 387.920	(^{3}G)4d ^{4}H$_{11/2}$	5124.848	−0.679		blend
				108 630.429	(^{1}I)5s e^{2}I$_{11/2}$	5189.361	−0.144	5189.371	lab
				108 648.695	(^{1}I)5s e^{2}I$_{13/2}$	5194.286	−1.434		
				108 775.080	(^{3}G)4d ^{4}I$_{11/2}$	5228.621	+0.896	5228.635	lab
				109 389.880	(^{3}G)4d ^{2}I$_{11/2}$	5402.332	+0.099	5402.32	lab
127 875.000	(^{3}G)4f	4[6]	13/2	106 045.690	(^{3}H)4d ^{2}H$_{11/2}$	4579.713	−0.754		
				108 133.440	(^{3}G)4d ^{4}H$_{13/2}$	5064.044	−1.045		
				108 387.920	(^{3}G)4d ^{4}H$_{11/2}$	5130.176	+0.662	5130.18	lab
				108 463.910	(^{3}G)4d ^{4}I$_{13/2}$	5150.259	−0.700		
				108 648.695	(^{1}I)5s e^{2}I$_{13/2}$	5199.759	−0.190		blend
				109 049.600	(^{3}G)4d 2I$_{13/2}$	5310.495	+0.113	5310.5	lab
				109 683.280	(^{3}G)4d ^{2}H$_{11/2}$	5495.480	+0.481	5495.49	lab, J78
127 880.436	(^{3}G)4f	4[6]	11/2	106 097.520	(^{3}H)4d ^{2}H$_{9/2}$	4589.468	−0.765		
				108 387.920	(^{3}G)4d ^{4}H$_{11/2}$	5128.745	−0.375		blend
				108 391.500	(^{3}G)4d ^{4}G$_{9/2}$	5129.687	−1.085		
				108 577.560	(^{3}G)4d ^{4}H$_{9/2}$	5179.133	+0.652	5179.14	lab
				108 630.429	(^{1}I)5s e^{2}I$_{11/2}$	5193.357	−0.797		
				108 775.080	(^{3}G)4d ^{4}I$_{11/2}$	5232.678	−0.047		blend
				108 929.040	(^{3}G)4d ^{4}I$_{9/2}$	5275.188	−0.897		
				109 389.880	(^{3}G)4d ^{2}I$_{11/2}$	5406.663	−0.491		
				109 625.200	(^{3}G)4d ^{2}G$_{9/2}$	5476.359	−0.333	5476.38	
				109 683.280	(^{3}G)4d ^{2}H$_{11/2}$	5493.838	−1.052		
				109 811.920	(^{3}G)4d ^{4}F$_{9/2}$	5532.952	−0.700		
				110 008.300	(^{3}G)4d ^{2}H$_{9/2}$	5593.749	+0.039	5593.85	
127 869.158	(^{3}G)4f	4[5]	11/2	106 045.690	(^{3}H)4d ^{2}H$_{11/2}$	4580.939	−1.153		
				106 722.170	(^{3}F)4d ^{4}F$_{9/2}$	4727.483	−0.893		
				108 387.920	(^{3}G)4d ^{4}H$_{11/2}$	5131.714	+0.220	5131.7	lab
				108 391.500	(^{3}G)4d ^{4}G$_{9/2}$	5132.657	+0.408		blend
				108 577.560	(^{3}G)4d ^{4}H$_{9/2}$	5182.161	−0.938		
				108 648.695	(^{1}I)5s e^{2}I$_{13/2}$	5201.340	−1.171		
				108 775.080	(^{3}G)4d ^{4}I$_{11/2}$	5235.768	−0.234		blend
				108 929.040	(^{3}G)4d ^{4}I$_{9/2}$	5278.329	−1.413		
				109 049.600	(^{3}G)4d ^{2}I$_{13/2}$	5312.143	−0.846		
				109 625.200	(^{3}G)4d ^{2}G$_{9/2}$	5479.744	−0.089	5479.72	lab
				109 683.280	(^{3}G)4d ^{2}H$_{11/2}$	5497.245	+0.050	5497.25	
				109 811.920	(^{3}G)4d ^{4}F$_{9/2}$	5536.408	−0.555	5536.40	
				110 008.300	(^{3}G)4d ^{2}H$_{9/2}$	5597.281	−0.105	5597.30	
127 855.952	(^{3}G)4f	4[5]	9/2	106 722.170	(^{3}F)4d ^{4}F$_{9/2}$	4730.437	−0.906		
				106 767.210	(^{3}F)4d ^{4}F$_{7/2}$	4740.541	−0.409		
				106 900.370	(^{3}F)4d ^{2}G$_{7/2}$	4770.664	−1.118		
				108 365.320	(^{3}G)4d ^{4}D$_{7/2}$	5129.241	−0.301	5129.25	
				108 387.920	(^{3}G)4d ^{4}H$_{11/2}$	5135.195	−0.409		blend
				108 391.500	(^{3}G)4d ^{4}G$_{9/2}$	5136.140	+0.294		blend
				108 577.560	(^{3}G)4d ^{4}H$_{9/2}$	5185.710	−0.829		
				108 709.450	(^{3}G)4d ^{4}H$_{7/2}$	5221.432	−1.407		
				109 625.200	(^{3}G)4d ^{2}G$_{9/2}$	5483.714	+0.010	5483.70	

Table 9. continued.

Upper level				Lower level		λ(calc)	$log\,gf$	λ(obs)	Notes
cm^{-1}			J	cm^{-1}		Å	KUR	Å	
127 855.952	cont.			109 683.280	$(^3G)4d\ ^2H_{11/2}$	5501.240	−0.659		
				109 811.920	$(^3G)4d\ ^4F_{9/2}$	5540.460	−0.431	5540.47	
				109 901.500	$(^3G)4d\ ^2G_{7/2}$	5568.103	−0.216	5568.10	
				110 167.280	$(^3G)4d\ ^4F_{7/2}$	5651.767	−0.160	5651.78	computed too weak
				110 570.300	$(^3G)4d\ ^2F_{7/2}$	5783.541	−0.854		
127 869.892	$(^3G)4f$	4[4]	9/2	106 097.520	$(^3H)4d\ ^2H_{9/2}$	4591.690	−1.043		no soectrum
				106 900.370	$(^3F)4d\ ^2G_{7/2}$	4767.493	−1.141		no spectrum
				108 365.320	$(^3G)4d\ ^4D_{7/2}$	5125.575	−1.117		weak
				108 391.500	$(^3G)4d\ ^4G_{9/2}$	5132.464	−0.690		blend
				108 537.610	$(^3G)4d\ ^4G_{7/2}$	5171.255	+0.332	5171.25	lab, J78
				108 577.560	$(^3G)4d\ ^4H_{9/2}$	5181.963	+0.101	5181.97	lab
				108 709.450	$(^3G)4d\ ^4H_{7/2}$	5217.634	−1.196		weak
				108 775.080	$(^3G)4d\ ^4I_{11/2}$	5235.567	−0.810		blend
				108 929.040	$(^3G)4d\ ^4I_{9/2}$	5278.125	−0.704		blend
				109 389.880	$(^3G)4d\ ^2I_{11/2}$	5409.748	−1.407		blend
				109 901.500	$(^3G)4d\ ^2G_{7/2}$	5563.783	−0.269	5563.79	
				110 008.300	$(^3G)4d\ ^2H_{9/2}$	5597.051	+0.023	5597.05	
				110 167.280	$(^3G)4d\ ^4F_{7/2}$	5647.317	−0.723		blend
				110 570.300	$(^3G)4d\ ^2F_{7/2}$	5778.881	−0.074	5778.88	
127 874.745	$(^3G)4f$	4[3]	5/2	106 767.210	$(^3F)4d\ ^4F_{7/2}$	4736.320	−0.862		no spectrum
				106 796.660	$(^3F)4d\ ^4P_{5/2}$	4742.937	−1.442		no spectrum
				106 866.760	$(^3F)4d\ ^4F_{5/2}$	4758.764	−0.354		no spectrum
				107 407.800	$(^3F)4d\ ^2D_{5/2}$	4884.563	−1.137		blend
				108 365.320	$(^3G)4d\ ^4D_{7/2}$	5124.300	−0.351	5124.3	
				108 537.610	$(^3G)4d\ ^4G_{7/2}$	5169.957	−0.493	5169.95	
				108 613.960	$(^3G)4d\ ^4G_{5/2}$	5190.451	−1.336		blend
				108 642.410	$(^3G)4d\ ^4D_{5/2}$	5198.129	−0.577	5198.12	
				108 859.470	$(^3G)4d\ ^4D_{3/2}$	5257.467	−1.074		weak
				109 901.500	$(^3G)4d\ ^2G_{7/2}$	5562.281	−0.790		weak
				110 065.750	$(^3G)4d\ ^2D_{5/2}$	5613.582	−0.302	5613.55	blend
				110 167.280	$(^3G)4d\ ^4F_{7/2}$	5645.769	−0.897		weak
				110 428.280	$(^3G)4d\ ^4F_{5/2}$	5730.231	−0.236		blend
				110 570.300	$(^3G)4d\ ^2F_{7/2}$	5777.260	−0.288	5777.73	computed too weak
				110 611.800	$(^3G)4d\ ^2F_{5/2}$	5791.149	−1.493		blend
128 110.214	$(^3G)4f$	3[6]	13/2	104 765.450	$(^3H)4d\ ^2I_{11/2}$	4282.411	−1.266		blend
				108 387.920	$(^3G)4d\ ^4H_{11/2}$	5068.991	−0.821	5068.99	
				108 630.429	$(^1I)5s\ e^2I_{11/2}$	5132.097	−0.929		blend
				108 775.080	$(^3G)4d\ ^4I_{11/2}$	5170.492	+0.154	5170.5	lab
				109 389.880	$(^3G)4d\ ^2I_{11/2}$	5340.300	+0.922	5340.30	lab, J78
128 071.171	$(^3F)4f$	3[5]	11/2	106 097.520	$(^3H)4d\ ^2H_{9/2}$	4549.630	−0.731		no spectrum
				106 924.430	$(^3F)4d\ ^2G_{9/2}$	4727.539	−0.926		no spectrum
				108 387.920	$(^3G)4d\ ^4H_{11/2}$	5079.046	−1.376		blend
				108 391.500	$(^3G)4d\ ^4G_{9/2}$	5079.970	−1.401		at the continuum level
				108 577.560	$(^3G)4d\ ^4H_{9/2}$	5128.457	+0.377	5128.47	lab
				108 775.080	$(^3G)4d\ ^4I_{11/2}$	5180.954	−0.687		blend
				108 929.040	$(^3G)4d\ ^4I_{9/2}$	5222.625	−0.245	5222.62	computed too strong
				109 389.880	$(^3G)4d\ ^2I_{11/2}$	5351.461	+0.043	5351.47	
				106 925.200	$(^3G)4d\ ^2G_{9/2}$	5419.731	−0.013	5419.73	lab
				110 008.300	$(^3G)4d\ ^2H_{9/2}$	5534.681	+0.459	5534.68	

Table 9. continued.

Upper level				Lower level		λ(calc)	log gf	λ(obs)	Notes
cm^{-1}			J	cm^{-1}		Å	KUR	Å	
128 055.658	(^{3}F)4f	3[5]	9/2	106 097.520	(^{3}H)4d ^{2}H$_{9/2}$	4552.844	−1.204		no spectrum
				106 767.210	(^{3}F)4d ^{4}F$_{7/2}$	4696.069	−0.812		no spectrum
				106 924.430	(^{3}F)4d ^{2}G$_{9/2}$	4731.009	−1.380		no spectrum
				108 537.610	(^{3}G)4d ^{4}G$_{7/2}$	5122.036	+0.148	5122.02	lab
				108 577.560	(^{3}G)4d ^{4}H$_{9/2}$	5132.541	+0.038	5132.55	lab
				108 709.450	(^{3}G)4d ^{4}H$_{7/2}$	5167.532	−0.521		blend
				108 775.080	(^{3}G)4d ^{4}I$_{11/2}$	5185.122	−1.448	5185.141	blend
				109 389.880	(^{3}G)4d ^{2}I$_{11/2}$	5355.908	−0.925	5355.9	weak
				106 925.200	(^{3}G)4d ^{2}G$_{9/2}$	5424.293	−0.649		blend
				109 901.500	(^{3}G)4d ^{2}G$_{7/2}$	5506.850	+0.159	5506.85	
				110 008.300	(^{3}G)4d ^{2}H$_{9/2}$	5539.439	+0.045	5539.41	
				110 167.280	(^{3}G)4d ^{4}F$_{7/2}$	5588.670	−0.697	5588.65	
				110 570.300	(^{3}G)4d ^{2}F$_{7/2}$	5717.485	−0.176	5717.50	
128 062.710	(^{3}F)4f	3[4]	9/2	106 900.370	(^{3}F)4d ^{2}G$_{7/2}$	4724.054	−1.276		no spectrum
				108 709.450	(^{3}G)4d ^{4}H$_{7/2}$	5165.649	+0.734	5165.65	lab
				108 929.040	(^{3}G)4d ^{4}I$_{9/2}$	5224.934	+0.139	5224.938	
				109 901.500	(^{3}G)4d ^{2}G$_{7/2}$	5504.712	−0.840		not observed
				110 008.300	(^{3}G)4d ^{2}H$_{9/2}$	5537.275	−1.268		at the level of the noise
				110 570.300	(^{3}G)4d ^{2}F$_{7/2}$	5715.180	−1.173		at the level of the noise
128 066.823	(^{3}F)4f	3[4]	7/2	104 023.910	(^{3}H)4d ^{4}G$_{5/2}$	4158.057	−1.351		not observed, wrong
				106 208.560	(^{3}F)4d ^{2}F$_{5/2}$	4573.647	−1.130		no spectrum
				106 767.210	(^{3}F)4d ^{4}F$_{7/2}$	4693.607	−1.067		no spectrum
				106 900.370	(^{3}F)4d ^{2}G$_{7/2}$	4723.136	−1.319		no spectrum
				108 537.610	(^{3}G)4d ^{4}G$_{7/2}$	5119.108	−0.444		computed too strong
				108 577.560	(^{3}G)4d ^{4}H$_{9/2}$	5129.601	−1.316		blend
				108 613.960	(^{3}G)4d ^{4}G$_{5/2}$	5139.200	+0.196	5139.20	lab
				108 709.450	(^{3}G)4d ^{4}H$_{7/2}$	5164.552	−0.146	5164.52	computed too weak
				108 929.040	(^{3}G)4d ^{4}I$_{9/2}$	5223.811	−0.993		blend
				109 901.500	(^{3}G)4d ^{2}G$_{7/2}$	5503.465	−0.078		blend
				110 008.300	(^{3}G)4d ^{2}H$_{9/2}$	5536.014	−0.751	5536.0	
				110 570.300	(^{3}G)4d ^{2}F$_{7/2}$	5713.836	−0.308	5713.8	
				110 611.800	(^{3}G)4d ^{2}F$_{5/2}$	5727.421	−0.043	5727.45	
128 063.103	(^{3}G)4f	3[3]	5/2	106 864.650	(^{3}G)4d ^{4}F$_{3/2}$	4712.005	−0.481		no spectrum
				106 866.760	(^{3}F)4d ^{4}F$_{5/2}$	4716.475	−1.431		no spectrum
				107 430.250	(^{3}F)4d ^{2}D$_{3/2}$	4845.286	−0.946		blend,computed too strong
				108 613.960	(^{3}G)4d ^{4}G$_{5/2}$	5140.183	+0.037	5140.19	
				108 642.410	(^{3}G)4d ^{4}D$_{5/2}$	5147.713	−0.412	5147.71	computed too weak
				108 709.450	(^{3}G)4d ^{4}H$_{7/2}$	5165.544	−0.693		blend
				108 859.470	(^{3}G)4d ^{4}D$_{3/2}$	5205.898	−0.225	5205.879	
				109 901.500	(^{3}G)4d ^{2}G$_{5/2}$	5504.593	−1.414		at the continuum level
				110 428.280	(^{3}G)4d ^{4}F$_{5/2}$	5669.025	−0.651	5669.03	
				110 461.260	(^{3}G)4d ^{2}D$_{3/2}$	5679.647	−1.133		at the level of the noise
				110 609.540	(^{3}G)4d ^{4}F$_{3/2}$	5727.900	−0.186	5727.90	
				110 611.800	(^{3}G)4d ^{2}F$_{5/2}$	5728.642	−0.772		weak
128 089.313	(^{3}G)4f	3[2]	5/2	106 208.560	(^{3}F)4d ^{2}F$_{5/2}$	4568.946	−1.396		no spectrum
				106 747.210	(^{5}D)5d ^{4}F$_{7/2}$	4688.657	−1.457		no spectrum
				106 796.660	(^{3}F)4d ^{4}P$_{5/2}$	4695.142	−1.393		no spectrum
				106 866.760	(^{3}F)4d ^{4}F$_{5/2}$	4710.650	−1.102		no spectrum
				108 537.610	(^{3}G)4d ^{4}G$_{7/2}$	5113.219	−1.022		at the continuum level
				108 642.410	(^{3}G)4d ^{4}D$_{5/2}$	5140.775	−0.580		blend
				108 859.470	(^{3}G)4d ^{4}D$_{3/2}$	5198.803	−0.577		blend
				109 901.500	(^{3}G)4d ^{2}G$_{5/2}$	5496.660	−0.747		blend
				110 428.280	(^{3}G)4d ^{4}F$_{5/2}$	5660.612	−0.985		blend
				110 461.260	(^{3}G)4d ^{2}D$_{3/2}$	5671.202	−0.429	5671.20	
				110 570.300	(^{3}G)4d ^{2}F$_{7/2}$	5706.501	−0.913		at the level of the noise
				110 611.800	(^{3}G)4d ^{2}F$_{5/2}$	5720.051	+0.065	5720.05	