SRON – SPEX

APPENDIX B
Atlas of
Dielectronic Recombination lines

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Contents

1 Introduction **2**

2 Processes of dielectronic recombination and excitation **2**

2.1 Dielectronic recombination (DR) 2

2.2 Collisional Innershell Excitation (IE) 4

2.3 Parent resonance line 5

3 Formulae and definitions for the rate coefficients in Table 3 **5**

4 Contribution of recombination to He-like lines **7**

5 Literature sources and wavelengths for several satellites **7**

5.1 He-like satellites (to $1s - 2p$ H-like resonance lines) 7

5.2 Li-like satellites (to $1s - 2p$ He-like resonance or intercombination lines) 7

5.3 Be-like satellites 8

5.4 B-, C-, N-, O-, and F-like satellites 9

6 References **9**

APPENDIX B

DIELECTRONIC RECOMBINATION LINES

1 Introduction

In this Appendix we present an extended line table (Table 3) which lists more than 1000 dielectronic recombination (DR) satellite lines to the H- and He-like resonance lines of the elements Ni, Fe, Ca, Ar, S, P, Si, Al, Mg, Na, Ne, O, N, and C. The lines cover the wavelength region 1.53–41.57 Å. In Table 3 we give the coefficients α and C_{DR} for dielectronic recombination which will be defined later (cf. §3). These coefficients are applicable only in the case of the low electron density limit, i.e. for $n_e < 10^{11}$ cm^{-3}. In Table 4 a number of density-sensitive Fe XXI–XIX lines are given also at higher densities.

The rate coefficients for innershell excitation (IE) are not given here but these are read from the main data listfile LINEMF of the program LINEMX.

Unless otherwise mentioned, we deal with the satellites to the $1s-2p$ resonance lines. In the few cases where satellites to higher resonance lines are treated, it is specifically mentioned, i.e., for the satellites to the Mg XII $1s-3p\&4p$, Mg XI $1s-3p\&4p$, and Al XII,Si XIII,S XV $1s-3p$ resonance lines.

In the following chapters we deal first with the processes of dielectronic recombination in general, then specify the definitions of the parameters α and C_{DR}, and finally mention in detail for the several types of satellites grouped according to iso-electronic sequences the literature sources.

2 Processes of dielectronic recombination and excitation

In this chapter we consider the processes of dielectronic recombination (DR) and (innershell) excitation ((I)E) that lead to the formation of satellite lines and the corresponding parent resonance line. For details we refer to a review article by M88.

2.1 Dielectronic recombination (DR)

The production of a DR satellite line with upper level s corresponds to the stabilization phase of the DR process, by which the doubly excited autoionizing (or satellite) state s of the recombined ion Z^{+z} radiates a line close to the parent resonance line. The latter occurs in ion $Z^{+(z+1)}$, or in a higher ionization stage if there is more than one spectator electron, as is for example the case of DR to one of the Fe XXIII–XVIII ions. The state s is excited by dielectronic capture of a free electron colliding with the recombining ion $Z^{+(z+1)}$ in its initial state m (with population density $N_{z+1,m}$ [cm^{-3}]), which for a low-density plasma is normally the ground state ($m = 1$). The level s may radiatively decay to any lower level k' in ion Z^{+z}, or may autoionize to form the ion $Z^{+(z+1)}$ in any level m' (below s) plus a free electron. The population density $N_{z,s}$ (cm^{-3}) of state s is determined by the balance between

dielectronic capture (rate coefficient C_s^d in cm^3 s^{-1}) and autoionization plus radiative decay, i.e.,

$$N_{z+1,1}\, n_e\, C_s^d = N_{z,s}\, A_s(\mathrm{tot}), \tag{2.1}$$

where n_e is the electron density (cm^{-3}), and $A_s(\mathrm{tot})$, the total decay rate of satellite level s by autoionization (AI) and by radiative decay (RD), is given by

$$A_s(\mathrm{tot}) = \sum_{m'} A^a_{sm'} + \sum_{k'} A^r_{sk'}, \tag{2.2}$$

where A^a and A^r are AI and RD transition probabilities (s^{-1}) between the denoted levels. The summation of A^a is over all available levels m' in ion $Z^{+(z+1)}$; that of A^r is over all levels k' in Z^{+z} below s.

In the usual way the emission rate I^d_{sk} (photons cm^{-3} s^{-1}) by dielectronic excitation of the satellite line $s \rightarrow k$ is given by

$$I^d_{sk} = N_{z,s} A^r_{sk}, \tag{2.3}$$

or with Eq. (2.1)

$$I^d_{sk} = N_{z+1,1} n_e C^d_s B^r_{sk}, \tag{2.4}$$

with the branching ratio given by

$$B^r_{sk} = A^r_{sk}/A_s(\mathrm{tot}). \tag{2.5}$$

The dielectronic capture rate C^d_s is directly related to the inverse process of AI from level s towards the ground state 1 in the recombining ion $Z^{+(z+1)}$ with rate A^a_{s1} by the application of the principle of detailed balance in thermodynamical equilibrium. We have

$$N^*_{z+1,1} n_e C^d_s = N^*_{z,s} A^a_{s1}, \tag{2.6}$$

where $N^*_{z,s}$ is the satellite level density as would be given by the Saha-Boltzmann equation (and $N^*_{z+1,1}$ the corresponding $Z^{+(z+1)}$ ion density):

$$N^*_{z,s} = 3.3 \times 10^{-24} (E_{\mathrm{H}}/kT)^{3/2} (g_s/g_1) N^*_{z+1,1} n_e \exp(-E_s/kT), \tag{2.7}$$

where densities are in cm^{-3} and where T is the electron temperature (K), g_s and g_1 are the statistical weights, respectively, of the satellite state in the recombined ion Z^{+z} and of the ground state in the recombining ion $Z^{+(z+1)}$; E_s is the energy difference between these two states (=kinetic energy of the plasma electron being captured by ion $Z^{+(z+1)}$) and E_{H} (=13.6 eV) is the ionization energy of hydrogen. Using Eqs. (2.6) and (2.7) we obtain

$$C^d_s = 2.07 \times 10^{-16} T^{-3/2} (g_s/g_1) A^a_{s1} \exp(-E_s/kT), \tag{2.8}$$

which relation is valid as long as the plasma electrons have a Maxwellian energy distribution, since C^d_s and A^a_{s1} are atomic rate coefficients relating two exactly inverse processes. Inserting Eq. (2.8) into Eq. (2.4) we obtain for the DR line intensity (photons cm^{-3} s^{-1})

$$I^d_{sk} = 2.07 \times 10^{-16} N_{z+1,1} n_e T^{-3/2} (g_s/g_1) A^a_{s1} B^r_{sk} \exp(-E_s/kT). \tag{2.9}$$

We note that we can write:

$$\frac{g_s A^a_{s1} B^r_{sk}}{g_1} \equiv \frac{g_s A^a_{s1} A^r_{sk}}{g_1 [\sum_{m'} A^a_{sm'} + \sum_{k'} A^r_{sk'}]} \equiv \frac{F_2(s)}{g_1} \equiv B_s, \tag{2.9a}$$

where $F_2(s)$ is the often used line strength factor (often expressed in units of 10^{13} s^{-1}; then the forefactor in Eq. (2.8) will be 2.07×10^{-3}), and B_s is a factor introduced by MG81 in their Eq. (39) and repeated by MGO85 in Eq. (A.10) (see also Eqs. (14) and (15) of chapter 'LINEM').

Up to now we have considered the special case of a low-density plasma in which all ions $Z^{+(z+1)}$ and Z^{+z} are in their ground states $m = 1$ and $k = k_0$, respectively. At increasing density (say $n_e > 10^{13}$cm^{-3}) the excited levels m in the ground-state configuration of ion $Z^{+(z+1)}$ will become to be populated significantly so as to give sometimes also contributions to the DR satellites. The total contribution of all levels m to the emission rate $s \rightarrow k$ is then given by a summation over all m (see refs. P83 and L84). The density dependence of the satellite emission then arises through the density-dependent populations in the fine-structure levels of the ground configuration of ion $Z^{+(z+1)}$. In the case of some lines of Fe XXI-XIX we give in Table 4 values of the rate coefficients at higher densities.

2.2 Collisional Innershell Excitation (IE)

An additional satellite line formation mechanism is electron impact excitation of an innershell electron in the recombined ion Z^{+z}, with the ion initially in one of the ground configuration levels k''. Again we assume the conditions are valid for the low-density case in which excitation will proceed from the ground state $k'' = k_0$, from which the satellite upper line level s has an excitation energy E_e. This process can become efficient in atomic systems containing many electrons in the inner shell or for satellite lines arising from non-autoionizing states. It is not effective in He-like ions since it there requires simultaneous excitation of two electrons which is much less probable than single-electron excitation. In transient plasmas this process can be important.

For the photon emission rate by excitation (photons cm^{-3} s^{-1}) of the satellite line $s \rightarrow k$ we write

$$I^e_{sk} = N_{z,0} n_e B^r_{sk} S_e, \tag{2.10}$$

where $N_{z,0}$ is the number density (cm^{-3}) of ion Z^{+z} in the ground state k_0, B^r_{sk} is the branching ratio given by Eq. (2.5) and S_e is the electron impact excitation rate coefficient (cm^3 s^{-1}) from the ground:

$$S_e = 1.704 \times 10^{-3} T^{-1/2} E_e^{-1} f_e \overline{g}_e(y_e) e^{-y_e}, \tag{2.11}$$

where T in K, E_e in eV, $y_e = E_e/kT$, f_e is the absorption oscillator strength (of transition k_0–s) and $\overline{g}_e(y_e)$ is the temperature-dependent gaunt factor averaged over the Maxwellian electron energy distribution. We may approximate (e.g M88): $\overline{g}_e(y_e) \simeq 0.09(y_e + 1.5)/y_e$. The IE photon emission rate is now

$$I^e_{sk} = 1.704 \times 10^{-3} N_{z,0} n_e B^r_{sk} f_e \overline{g}_e T^{-1/2} E_e^{-1} e^{-y_e}. \tag{2.12}$$

At higher densities, also other (excited) levels k'' in the ground configuration of ion Z^{+z} can obtain a significant population, thus introducing a density dependence in the IE part of the satellite line, similarly as in the DR case (P83, L84).

2.3 Parent resonance line

For the intensity of the parent resonance line (r) in ion Z^{+z_r} we modify Eq. (2.12) to:

$$I_r = 1.704 \times 10^{-3} N_{z_r} n_e f_r \overline{g}_r T^{-1/2} E_0^{-1} e^{-y_0}, \tag{2.13}$$

where $y_0 = E_0/kT$ with E_0 the excitation energy of the resonance line, N_{z_r} the number density of ion Z^{+z_r} in the ground state ($z_r = z + 1$ in considered case), f_r is the absorption oscillator strength (including cascading from higher levels and branching ratio), and $\overline{g}_r$ is the averaged gaunt factor. E.g., for the satellites $1s2s^22p^{n+2} \rightarrow 1s^22s^22p^{n+1}$ the parent resonance line is the transition $1s2p\,^1P_1 \rightarrow 1s^2\,^1S_0$ in the He-like ion. We note that for an easy estimate the formulae used in the program LINEMX may be approximated (cf. M88) for high Z ($Z \geq 12$) by: $\overline{g}_r(y_r) \simeq 0.09(y_r + 1.5)/y_r$ and $f_r \simeq 0.75$. For the contribution from recombination to the line formation, see §4.

3 Formulae and definitions for the rate coefficients in Table 3

The coefficient α was originally defined in Eq. (26) of MSS80 as follows:

$$C_s^d = 1.726\ 10^{-2}\ \alpha\ T^{-3/2} e^{-E_s/kT} \mathrm{cm^3 s^{-1}}, \tag{3.1}$$

where C_s^d is the rate coefficient for a DR satellite line occurring in the recombined ion Z^{+z} (cf. Eq. (2.8)), T the electron temperature in K, and E_s the satellite energy relative to the ground state of the recombining ion $Z^{+(z+1)}$.

By comparing Eqs. (3.1) and (2.8) it turns out that

$$\alpha = 0.1199\ F_2(s)/g_1 = 0.1199\ B_s, \tag{3.2}$$

where $F_2(s)$ is the line strength factor (in units of 10^{13} s^{-1}), B_s the factor (in 10^{13} s^{-1}) introduced by MG81 (cf. Eq. (2.9a) and Eq. (17) of chapter 'LINEM'), and g_1 is the statistical weight of the ground state of the recombining ion. For He-, Li-, Be-, B-, C-, N-, O-, F-like satellites we have: g_1 = 2,1,2, 1,2,1,4,5, respectively. We note that inserting $F_2(s)$ or B_s into Eq. (3.1) gives a forefactor of 2.07 10^{-3} (cf. Eq. (2.8) and Eq. (A.10) of MGO85).

For the satellite energy we write (MSS80):

$$E_s[\mathrm{eV}] = 1.2398\ 10^4 \mathrm{a_{dr}}/\lambda[\text{Å}], \tag{3.3}$$

where λ is the wavelength of the satellite line and $a_{dr} = 0.7....0.96$.

We write:

$$y_{dr} = E_s/kT = a_{dr} hc/(\lambda kT) = 1.439\ 10^8 a_{dr}/(\lambda T), \tag{3.4}$$

where again λ in Å and T in K.

In our line intensity calculation program LINEMX (current version, will be changed later) the coefficient C_{DR} is used which can be derived from α by scaling it up to the corresponding Fe case for $Z = 26$. The value for C_{DR} which is given in the line Table 3 is the value scaled to the case Z =26 (Fe)

Table 1:

n	b_5	b_6	a_{dr}	$[C_{DR}/\alpha]_{Z=26}$
2	7.56	$5\ 10^{-6}$	0.70	2.0223
3	32.6	$3\ 10^{-5}$	0.86	8.7205
4	52.5	$5\ 10^{-5}$	0.92	14.0438
> 4	52.5	$5\ 10^{-5}$	0.96	14.0438

Table 2:

		$f(Z)$													
n	$Z =$ Elem.:	28 Ni	26 Fe	20 Ca	18 Ar	16 S	15 P	14 Si	13 Al	12 Mg	11 Na	10 Ne	8 O	7 N	6 C
2		1.099	1	.5965	.4454	.3054	.2436	.1889	.1420	.1031	7.20^{-2}	4.80^{-3}	1.794^{-2}	9.74^{-3}	4.71^{-3}
3		1.023	1	.8653	.7767	.6552	.5818	.5014	.4167	.3316	.2508	.1787	7.30^{-2}	4.07^{-2}	2.00^{-2}
> 3		1.012	1	.9103	.8471	.7527	.6905	.6176	.5355	.4438	.3500	.2594	.1125	6.39^{-2}	3.18^{-2}

N.B.: $7.20^{-2} = 7.20\ 10^{-2}$, etc.

so that corresponding lines from different elements can be compared. The relation between various coefficients is (cf. Eq. (17) in 'LINEM'):

$$C_{DR}(Z=26) = 0.03207\ b_5 B_s(26) = 0.03207\ b_5 \frac{F_2(s)(26)}{g_1} = 0.2675\ b_5 \frac{\alpha(Z)}{f(Z)}, \tag{3.5}$$

where $f(Z)$ is a scaling factor which we use to scale the data for Fe (Z=26) to other ions, i.e., we have:

$$C_{DR}(Z) = f(Z) C_{DR}(26), \tag{3.6}$$

with (cf. Eq. (A.11) of MGO85)

$$f(Z) = \frac{10^{-6} b_5 (Z-1)^4}{1 + b_6 (Z-1)^4}. \tag{3.7}$$

By definition: $f(26) = 1$. We note that that this scaling is only approximately valid for the stronger satellites. Weaker satellites show quite often a different behaviour. Note that for other elements than Fe:

$$C_{DR}(Z) = \left[\frac{C_{DR}}{\alpha}\right]_{Z=26} \times \frac{\alpha(Z)}{f(Z)}. \tag{3.8}$$

The parameters b_5, b_6, a_{dr} and the scaling factors $f(Z)$ are given in Tables 1 and 2.

4 Contribution of recombination to He-like lines

For all $n = 2$ He-like lines, i.e. the (He4 w) resonance, the (He5 x and y) intercombination lines, and the (He6 z) forbidden line we calculate in LINEMX the total rate coefficient (in cm^3 s^{-1}) for the contribution from radiative plus dielectronic recombination of ion $Z^{+(z+1)}$ to the formation of the considered spectral line in ion Z^{+z} by

$$\alpha_{z+1}^{rad} = 10^{-11} AREC\ (z+1)^{2\eta+1} T^{-\eta}, \tag{4.1}$$

where T is in K and the parameters $AREC$ and η ("ETA") are given in the main data line parameter file. These parameters were derived for Fe from data of BD82a, for Ca and Mg from F84, and for the other elements by interpolation.

5 Literature sources and wavelengths for several satellites

5.1 He-like satellites (to $1s - 2p$ H-like resonance lines)

Wavelengths, rate coefficients, and notations for Fe $n = 2$ and $n > 2$ satellites are from D81 (for $n = 2$ these wavelengths are slightly ($\sim$ 0.0004 Å) smaller than the Lamb-shift-corrected VS78 values). Wavelengths for the Ly α lines are from E77.

For the $n = 2$ satellites to H-like $1s$–$2p$ lines of Ni, Ca, Ar, S, P, Si, Al, Na, Ne, O, N, and C the wavelengths, rate coefficients, and notations are from VS78. For the higher elements (Ni to S) we apply a Lamb shift correction of +0.0007 Å (cf. K79), whereas in the case of Si we apply a correction of +0.0004 Å to get agreement with experimental values (B77). For P, Al and lower elements the wavelengths are left uncorrected because the VS78 values for P and Al do agree quite well with experimental values (B77). Wavelengths, rate coefficients, and notations for S,P,Si, and Al $n = 3$ satellites are from B77.

Wavelengths, rate coefficients, and notations for Mg $n = 2 - 4$ satellites are from D80 and some notations also from VS78. However, we apply a correction of +0.01 Å on the wavelengths to get agreement with experimental values (B77). From D80 we take data for the $n = 2$ satellites to the $1s - 3p$ and $1s - 4p$ resonance lines of Mg XII.

5.2 Li-like satellites (to $1s - 2p$ He-like resonance or intercombination lines)

Notations for $n = 2$ transitions are from Gabriel (G72). Wavelengths for $n = 2$ Ca satellites are from HG84, but with a shift of -0.0008 Å so that the wavelength of the Ca XIX w resonance line coincides with that from VS85 (the wavelengths for all He-like $n = 2$ w, x, y, z lines are from VS85).

Wavelengths for $n = 2$ Fe satellites are from HG84, but with a correction of -0.0004 Å to make the Fe XXV w line VS85 and HG84 wavelengths agree.

Note that blends of Fe XXIII satellites ($3\ell, 4p, 5p$ spectator electron) may contribute $\sim$ 10% to the Li-like q satellite at T=15 MK (L84). Rate coefficients are for Ca from BD82b and for Fe from BD79a,82a.

Innershell excitation rates are for Fe, Ca, and Mg from BD82a, from BD82b, and from F83, respectively.

For $n > 2$ satellites wavelengths are for Ca from BD82b and for Fe from BD79a,b, BD82a, but with corrections +0.0013 Å (close w Ca sat.), +0.0016 Å (close y Ca sat.), +0.0005 Å (close w Fe sat.), +0.0007 Å (close y Fe sat.), reflecting the difference between the BD and VS85 values for the Ca and Fe w and y line wavelengths. Rate coefficients and notations are from BD79a,b, BD82a,b.

For the S $n = 2$ satellites we use the rate coefficients and wavelengths from VS78, but we correct these wavelengths with +0.001 Å to get agreement with the VS85 He-like line wavelengths. For the S $n > 2$ satellites we use the rate coefficients and wavelengths from CD92, but we correct the wavelengths with -0.001 Å to get agreement with the VS85 He-like wavelengths. Furthermore, because the rates of the $n > 3$ satelltes appear to be somewhat too large if we compare them by using some kind of Z-scaling (cf. Eq. (3.7)) with other elements, we apply reduction factors to the CD values of 1.45 and 2.33 for the $n = 4$ and $n = 5$ satellites, respectively.

Wavelengths, rate coefficients, and notations for $n = 2 - 4$ Mg satellites are from SC80, and some notations from BD79a.

For the $n = 2$ satelites of Ni, Ar, P, Si, Al, Na, Ne, O, N, and C we derive rate coefficients and wavelengths from VS78, and apply a Lamb shift correction of +0.0007 Å to these values for the higher elements Ni and Ar, and leave the VS78 wavelengths unchanged for the elements P and lower.

From SC80 we take data for the $n = 2$ satellites to the $1s - 3p$ and $1s - 4p$ resonance lines of Mg XI, with wavelengths from VS85.

Finally, for the $n = 2$ satellites to the $1s - 3p$ resonance lines of S, Si, and Al we take rate coefficients, notations from B78, and derive the wavelengths from VS85.

5.3 Be-like satellites

Rate coefficients for $n = 2$ and $n > 2$ Fe satellites are from L84 and L83. For the $n = 2$ satellites we take the wavelengths from HG84 (which agree very well with the MCDF results) and use their letter notations and also some notations for the strongest lines from DFC81. The stronger $n = 3$ satellites are given by L84 and we take for the wavelengths the RCN/RCG values of Cowan, corrected by them with a shift of +0.0023 Å. Data for the weaker $n = 2\&3$ satellites and the $n > 3$ satelites are derived from lists communicated privately (L83).

Wavelengths for $n = 2$ Ca and Ni satellites are from HG84 and the rate coefficients are estimated by Z-scaling of the corresponding rates for Fe. Notations are from HG84 and DFC81.

5.4 B-, C-, N-, O-, and F-like satellites

Wavelengths and rate coefficients for the satellites of Fe XXII–XX are from DFC81 and those for the electron-density-sensitive lines of Fe XXI–XIX from P83. The latter lines are indicated by the symbol 'NE' in the line table. In addition to the coefficients for the low-density case ($n_e = 10^{11}$ cm^{-3}), also the coefficients calculated for higher densities (10^{13} and 10^{15} cm^{-3}) are given Table 4. Some notations are from DFC81.

The above results are based on calculations by Cowan et al. (cf. C81, M76) and have been corrected for the wavelength by a shift of +0.0030 Å to get better agreement with experimental data and theoretical data including Breit interaction and QED corrections (cf. P83).

Some weaker Fe XXII–XX lines are from lists communicated privately by BD83. In order to be consistent with the corrected Cowan wavelengths we have applied a shift of +0.0045 Å to the Fe XXII–XXI wavelengths and of +0.0025 Å for the Fe XX wavelengths.

The rate coefficients for Fe XVIII are from MSS80, based on calculations by G75 (which, however, may be too large by even an order of magnitude if we compare the G75 results with those of DFC81 for the higher ions).

6 References

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Table 3. List of DR satellite lines 1.53–41.57Å

Table 3. List of DR satellite lines 1.53--41.57 A

LNUM	ION	TRANS	LAMBDA(A)	alpha	C_DR
1	NI XXVII	*2HE V	1.5315	.119	.220
2	NI XXVII	*2HE M	1.5348	.246	.453
3	NI XXVII	*2HE K	1.5380	1.538	2.831
4	NI XXVII	*2HE T	1.5381	2.205	4.057
5	NI XXVII	*2HE Q	1.5386	2.320	4.269
6	NI XXVII	*2HE B	1.5392	1.209	2.225
7	NI XXVII	*2HE J	1.5417	3.754	6.907
8	NI XXVII	*2HE R	1.5426	.373	.687
9	NI XXVII	*2HE A	1.5430	1.672	3.076
10	NI XXVII	*2HE F	1.5433	.023	.042
11	NI XXVII	*2HE S	1.5437	.079	.145
12	NI XXVII	*2HE G	1.5467	.756	1.390
13	NI XXVII	*2HE U	1.5493	.020	.037
14	NI XXVII	*2HE P	1.5512	.333	.613
15	NI XXVII	*2HE O	1.5588	.266	.490
16	NI XXVI	*2LI n	1.5895	.020	.036
17	NI XXVI	*2LI b	1.5938	.019	.035
18	NI XXVI	*2LI m	1.5940	.716	1.318
19	NI XXVI	*2LI t	1.5942	1.535	2.824
20	NI XXVI	*2LI q	1.5975	.057	.104
21	NI XXVI	*2LI a	1.5983	.209	.385
22	NI XXVI	*2LI k	1.5990	.454	.836
23	NI XXVI	*2LI d	1.5991	.020	.037
24	NI XXVI	*2LI r	1.6002	.831	1.529
25	NI XXVI	*2LI j	1.6015	6.942	12.775
26	NI XXV	*2BE c	1.6022	.330	.607
27	NI XXV	*2BE d	1.6028	.065	.118
28	NI XXVI	*2LI l	1.6035	.685	1.261
29	NI XXV	*2BE e	1.6035	.626	1.154
30	NI XXVI	*2LI c	1.6036	.006	.011
31	NI XXV	*2BE f	1.6042	.165	.304
32	NI XXV	*2BE bet 1	1.6049	.088	.162
33	NI XXV	*2BE g	1.6061	.121	.223
34	NI XXV	*2BE h	1.6063	.066	.121
35	NI XXV	*2BE i	1.6063	.945	1.741
36	NI XXVI	*2LI i	1.6072	.014	.025
37	NI XXV	*2BE j	1.6073	.429	.789
38	NI XXVI	*2LI e	1.6077	1.727	3.177
39	NI XXV	*2BE k	1.6077	2.033	3.744
40	NI XXV	*2BE l	1.6078	.956	1.761
41	NI XXV	*2BE m	1.6082	.407	.749
42	NI XXVI	*2LI u	1.6085	.006	.011
43	NI XXVI	*2LI f	1.6092	.058	.108
44	NI XXVI	*2LI v	1.6095	.008	.014
45	NI XXV	*2BE n	1.6096	3.297	6.072
46	NI XXV	*2BE o	1.6097	.258	.476
47	NI XXV	*2BE p	1.6110	.165	.304
48	NI XXV	*2BE r	1.6115	.835	1.538
49	NI XXV	*2BE q	1.6116	.121	.223
50	NI XXV	*2BE b	1.6128	.253	.465
51	NI XXVI	*2LI p	1.6235	.251	.462
52	NI XXVI	*2LI o	1.6282	.214	.394
53	FE XXV	*3HE U24	1.7764	.200	1.745
54	FE XXV	*3HE U68	1.7765	.090	.785
55	FE XXV	*3HE U25	1.7768	.080	.698
56	FE XXV	*3HE U26	1.7769	.330	2.880
57	FE XXV	*3HE U54	1.7770	.024	.205
58	FE XXV	*3HE U40	1.7771	.110	.960
59	FE XXV	*4HE U73,99	1.7772	.102	1.433
60	FE XXV	*4HE L113	1.7773	.050	.703
61	FE XXV	*4HE U74,75,96	1.7774	.228	3.206
62	FE XXV	*4HE U95	1.7776	.016	.228
63	FE XXV	*4HE U86	1.7777	.070	.984
64	FE XXV	*4HE U100	1.7778	.280	3.927
65	FE XXV	*5HE n=5- (H1a)	1.7780	3.089	43.375
66	FE XXV	*3HE U55	1.7781	.390	3.404
67	FE XXV	*4HE U76,103	1.7782	.247	3.468
68	FE XXV	*4HE U77,101	1.7783	.430	6.044
69	FE XXV	*4HE U87	1.7784	.194	2.725
70	FE XXV	*4HE U72,98	1.7786	.123	1.727
71	FE XXV	*2HE V	1.7787	.061	.123
72	FE XXV	*4HE U104	1.7787	.020	.277
73	FE XXV	*3HE U41	1.7790	.650	5.673
74	FE XXV	*3HE U27	1.7792	.040	.349
75	FE XXV	*3HE U56,57	1.7793	1.400	12.218
76	FE XXV	*3HE U28	1.7797	.030	.262
77	FE XXV	*3HE U32-34	1.7801	.032	.276
78	FE XXV	*3HE U58	1.7804	.080	.698
79	FE XXV	*3HE U52	1.7806	.040	.349
80	FE XXV	*3HE U23	1.7809	.230	2.007
81	FE XXV	*3HE L59	1.7813	.120	1.047
82	FE XXV	*3HE U42,43	1.7815	.050	.433
83	FE XXV	*4HE L105	1.7818	.012	.174
84	FE XXV	*4HE L88	1.7819	.153	2.149
85	FE XXV	*4HE L97,106	1.7823	.060	.841
86	FE XXV	*3HE L46,60	1.7824	.164	1.430
87	FE XXV	*2HE M	1.7826	.198	.401
88	FE XXV	*4HE L78,79	1.7826	.105	1.475
89	FE XXV	*4HE L89	1.7827	.020	.285
90	FE XXV	*4HE L107	1.7828	.019	.269
91	FE XXV	*3HE L44,45	1.7829	.050	.436
92	FE XXV	*4HE L108	1.7831	.060	.843
93	FE XXV	*4HE L80,81	1.7832	.025	.358
94	FE XXV	*4HE L90,110	1.7833	.035	.488
95	FE XXV	*4HE L83	1.7834	.017	.241
96	FE XXV	*4HE L84	1.7835	.015	.208
97	FE XXV	*5HE n=5- (H1b)	1.7835	.911	12.800
98	FE XXV	*4HE L109	1.7836	.080	1.124
99	FE XXV	*3HE L61	1.7836	.014	.121
100	FE XXV	*4HE L111	1.7837	.040	.562
101	FE XXV	*3HE L29,62,67	1.7840	.242	2.113
102	FE XXV	*4HE L112	1.7842	.030	.422
103	FE XXV	*3HE U30,31,L48	1.7845	.240	2.096
104	FE XXV	*3HE L53	1.7847	.018	.160
105	FE XXV	*4HE L85	1.7849	.021	.297
106	FE XXV	*3HE L64	1.7849	.050	.436
107	FE XXV	*3HE L51,63	1.7852	.259	2.261
108	FE XXV	*4HE L115	1.7856	.052	.730
109	FE XXV	*3HE L36,37	1.7857	.100	.873
110	FE XXV	*3HE L65	1.7860	.080	.698
111	FE XXV	*2HE T	1.7861	1.809	3.659
112	FE XXV	*2HE K	1.7870	1.097	2.219
113	FE XXV	*3HE L66	1.7873	.048	.420
114	FE XXV	*3HE L70	1.7877	.110	.960
115	FE XXV	*2HE Q	1.7881	.389	.786
116	FE XXV	*2HE B	1.7882	.776	1.569
117	FE XXV	*3HE L39	1.7883	.040	.349
118	FE XXV	*3HE L71	1.7901	.110	.960
119	FE XXV	*2HE J	1.7917	3.770	7.623
120	FE XXV	*2HE R	1.7918	.311	.629
121	FE XXV	*2HE A	1.7921	1.338	2.706
122	FE XXV	*2HE F	1.7924	.015	.029
123	FE XXV	*2HE S	1.7930	.079	.159
124	FE XXV	*2HE G	1.7968	.417	.844
125	FE XXV	*2HE P	1.8022	.184	.371
126	FE XXV	*2HE O	1.8109	.264	.534
127	FE XXIV	*3LI d2	1.8491	.022	.190
128	FE XXIV	*4LI	1.8501	.044	.615
129	FE XXIV	*4LI	1.8502	.057	.807
130	FE XXIV	*3LI h17	1.8502	.500	4.364
131	FE XXIV	*4LI	1.8504	.149	2.088
132	FE XXIV	*5LI n=5- (w)	1.8505	3.640	51.119
133	FE XXIV	*4LI	1.8506	.219	3.081
134	FE XXIV	*3LI h16,d1	1.8506	.730	6.371
135	FE XXIV	*4LI (2)	1.8507	.206	2.893
136	FE XXIV	*4LI (3)	1.8509	.737	10.354
137	FE XXIV	*4LI	1.8511	.565	7.931
138	FE XXIV	*4LI	1.8512	.209	2.930
139	FE XXIV	*4LI	1.8514	.529	7.426
140	FE XXIV	*3LI h9	1.8514	.070	.611
141	FE XXIV	*3LI h15	1.8514	1.250	10.909
142	FE XXIV	*3LI a2	1.8518	.310	2.706
143	FE XXIV	*3LI h7	1.8519	.090	.785
144	FE XXIV	*3LI a1	1.8520	.080	.698
145	FE XXIV	*3LI d5	1.8521	.710	6.197
146	FE XXIV	*3LI d15	1.8523	1.460	12.742
147	FE XXIV	*2LI n	1.8524	.021	.043
148	FE XXIV	*3LI d13	1.8531	2.010	17.542
149	FE XXIV	*4LI (2)	1.8555	.032	.455
150	FE XXIV	*4LI	1.8557	.041	.578
151	FE XXIV	*3LI d3	1.8557	.035	.305
152	FE XXIV	*2LI s	1.8563	.201	.407
153	FE XXIV	*3LI d16	1.8565	.220	1.920
154	FE XXIV	*4LI	1.8566	.015	.211
155	FE XXIV	*2LI m	1.8568	.582	1.176
156	FE XXIV	*2LI t	1.8571	1.307	2.643
157	FE XXIII	*4BE n=4p	1.8573	.010	.145
158	FE XXIII	*5BE n=5d	1.8578	.010	.141
159	FE XXIII	*7BE n=7p	1.8578	.019	.270
160	FE XXIII	*7BE n=7p (2)	1.8579	.024	.333
161	FE XXIII	*3BE n=3p	1.8579	.035	.301
162	FE XXIII	*5BE n=5d	1.8580	.010	.146
163	FE XXIII	*6BE n=6p	1.8580	.071	.993
164	FE XXIV	*2LI b	1.8581	.030	.061
165	FE XXIII	*5BE n=5p	1.8581	.051	.718
166	FE XXIII	*5BE n=5p	1.8582	.010	.144
167	FE XXIII	*5BE n=5s	1.8582	.031	.429
168	FE XXIII	*3BE n=3s	1.8583	.021	.180
169	FE XXIII	*4BE n=4d	1.8583	.017	.236
170	FE XXIII	*5BE n=5p	1.8583	.039	.543
171	FE XXIII	*4BE n=4d (2)	1.8584	.011	.158
172	FE XXIII	*4BE n=4s	1.8584	.014	.192
173	FE XXIII	*3BE n=3d	1.8586	.011	.096
174	FE XXIV	*3LI d9	1.8586	.080	.698
175	FE XXIII	*4BE n=4p	1.8586	.071	.993
176	FE XXIII	*5BE n=5d	1.8586	.050	.702
177	FE XXIII	*7BE n=7p (3)	1.8586	.029	.401
178	FE XXIII	*6BE n=6p	1.8587	.062	.867
179	FE XXIII	*4BE n=4d (2)	1.8587	.042	.586
180	FE XXIII	*4BE n=4d (2)	1.8588	.049	.688
181	FE XXIII	*4BE n=4s	1.8588	.060	.838
182	FE XXIII	*4BE n=4p	1.8588	.013	.183
183	FE XXIII	*5BE n=5p	1.8588	.030	.416
184	FE XXIII	*5BE n=5p	1.8589	.070	.985
185	FE XXIII	*5BE n=5d	1.8589	.016	.222
186	FE XXIV	*3LI a4	1.8589	.660	5.760
187	FE XXIV	*3LI c1	1.8589	.033	.288
188	FE XXIV	*3LI f3	1.8590	.023	.197
189	FE XXIII	*3BE n=3p	1.8590	.085	.737
190	FE XXIII	*3BE n=3d	1.8590	.061	.528
191	FE XXIII	*4BE n=4p	1.8590	.068	.960
192	FE XXIII	*5BE n=5p	1.8590	.028	.390
193	FE XXIII	*5BE n=5p	1.8591	.022	.307
194	FE XXIII	*4BE n=4p (3)	1.8591	.055	.773
195	FE XXIII	*3BE n=3d (3)	1.8591	.152	1.326

Table 3. List of DR satellite lines 1.53–41.57Å (continued)

196	FE XXIII *4BE n=4p (3)	1.8593	.041	.573	296	FE XXIII *4BE n=4d	1.8653	.024	.338
197	FE XXIII *3BE n=3d	1.8593	.126	1.098	297	FE XXIII *4BE n=4p	1.8653	.087	1.221
198	FE XXIII *3BE n=3d	1.8594	.067	.580	298	FE XXIII *4BE n=4p	1.8655	.070	.985
199	FE XXIII *3BE n=3s	1.8594	.022	.188	299	FE XXIII *3BE n=3p	1.8656	.079	.685
200	FE XXIII *4BE n=4p	1.8594	.040	.559	300	FE XXIII *3BE n=3p	1.8658	.022	.192
201	FE XXIII *4BE n=4d	1.8594	.021	.300	301	FE XXIII *4BE n=4p	1.8658	.013	.179
202	FE XXIII *4BE n=4p (2)	1.8595	.150	2.113	302	FE XXIV *3LI i1	1.8659	.036	.314
203	FE XXIV *4LI	1.8595	.197	2.778	303	FE XXIII *3BE n=3s	1.8660	.034	.297
204	FE XXIV *3LI d22	1.8596	.031	.271	304	FE XXIII *3BE n=3p	1.8661	.090	.784
205	FE XXIV *4LI	1.8596	.028	.387	305	FE XXIV *2LI j	1.8662	6.151	12.439
206	FE XXIII *4BE n=4p	1.8597	.066	.926	306	FE XXIII *3BE n=3d	1.8662	.054	.472
207	FE XXIV *3LI d18	1.8597	.080	.698	307	FE XXIII *3BE n=3d	1.8663	.028	.248
208	FE XXIV *5LI n=5- (y)	1.8598	1.500	21.066	308	FE XXIII *2BE n=2p	1.8665	.011	.022
209	FE XXIV *3LI f1,h30	1.8601	.049	.429	309	FE XXIV *3LI c3	1.8668	.014	.118
210	FE XXIV *4LI	1.8602	.221	3.108	310	FE XXIII *3BE n=3p	1.8670	.027	.236
211	FE XXIII *3BE n=3p (2)	1.8602	.166	1.445	311	FE XXIII *3BE n=3p	1.8671	.111	.967
212	FE XXIII *3BE n=3s	1.8604	.016	.137	312	FE XXIII *2BE c n=2p	1.8673	.299	.604
213	FE XXIII *3BE n=3p	1.8605	.032	.279	313	FE XXIV *3LI e2	1.8673	.110	.960
214	FE XXIV *4LI	1.8606	.015	.217	314	FE XXIII *3BE n=3d	1.8673	.027	.235
215	FE XXIII *3BE n=3p	1.8606	.093	.810	315	FE XXIII *3BE n=3p	1.8676	.012	.104
216	FE XXIII *3BE n=3s	1.8607	.153	1.338	316	FE XXIII *3BE n=3p	1.8677	.069	.601
217	FE XXIV *4LI	1.8608	.029	.409	317	FE XXIV *2LI l	1.8678	.403	.815
218	FE XXIV *4LI	1.8609	.204	2.863	318	FE XXIII *3BE n=3p	1.8681	.014	.124
219	FE XXIII *3BE n=3p	1.8609	.018	.156	319	FE XXIII *2BE d n=2p	1.8682	.059	.118
220	FE XXIII *3BE n=3p (2)	1.8610	.348	3.037	320	FE XXIII *3BE n=3p	1.8683	.026	.227
221	FE XXIII *3BE n=3p	1.8611	.219	1.908	321	FE XXIII *2BE e n=2p	1.8685	.567	1.147
222	FE XXIII *3BE n=3d	1.8611	.021	.179	322	FE XXIII *3BE n=3d	1.8685	.016	.135
223	FE XXIV *3LI d17	1.8612	.070	.611	323	FE XXIII *2BE n=2p	1.8689	.059	.118
224	FE XXIV *4LI	1.8612	.033	.461	324	FE XXIV *3LI e1	1.8689	.150	1.309
225	FE XXIII *3BE n=3p	1.8612	.064	.554	325	FE XXIII *3BE n=3s	1.8694	.119	1.035
226	FE XXIV *2LI q	1.8613	.004	.007	326	FE XXIII *4BE n=4d	1.8696	.018	.258
227	FE XXIII *3BE n=3d (3)	1.8613	.095	.827	327	FE XXIII *4BE n=4s	1.8698	.021	.297
228	FE XXIII *3BE n=3p	1.8615	.246	2.144	328	FE XXIII *4BE n=4p	1.8701	.021	.295
229	FE XXIII *3BE n=3d	1.8615	.017	.147	329	FE XXIII *3BE n=3p	1.8702	.094	.821
230	FE XXIV *3LI h32,g5	1.8616	.090	.799	330	FE XXIII *2BE f n=2p	1.8704	.152	.307
231	FE XXIII *3BE n=3d	1.8617	.012	.108	331	FE XXIII *2BE n=2p	1.8707	.046	.092
232	FE XXIII *4BE n=4d (3)	1.8617	.057	.795	332	FE XXIII *4BE n=4p	1.8707	.029	.413
233	FE XXIII *4BE n=4f (2)	1.8617	.028	.397	333	FE XXIII *3BE n=3p	1.8708	.010	.083
234	FE XXIII *5BE n=5f	1.8617	.027	.383	334	FE XXIII *3BE n=3p	1.8709	.091	.795
235	FE XXIII *5BE n=5d	1.8617	.038	.528	335	FE XXIII *2BE bet 1 n=2s	1.8710	.078	.158
236	FE XXIII *7BE n=7p (5)	1.8618	.103	1.453	336	FE XXIII *2BE g n=2p	1.8714	.111	.224
237	FE XXIII *6BE n=6p	1.8619	.098	1.372	337	FE XXIII *2BE n=2p	1.8716	.010	.021
238	FE XXIII *5BE n=5d	1.8619	.037	.516	338	FE XXIII *3BE n=3p	1.8720	.176	1.537
239	FE XXIII *5BE n=5d	1.8620	.210	2.955	339	FE XXIII *2BE n=2p	1.8723	.060	.121
240	FE XXIII *6BE n=6p	1.8620	.083	1.170	340	FE XXIII *3BE n=3s	1.8724	.022	.189
241	FE XXIV *4LI	1.8620	.067	.935	341	FE XXIII *2BE h n=2p	1.8725	.060	.121
242	FE XXIV *3LI a5	1.8620	.041	.358	342	FE XXIII *3BE n=3p	1.8726	.028	.243
243	FE XXIII *6BE n=6p	1.8620	.083	1.170	343	FE XXIII *2BE sig2 in=2p	1.8729	.863	1.746
244	FE XXIII *5BE n=5p	1.8620	.010	.141	344	FE XXIII *4BE n=4s	1.8729	.013	.176
245	FE XXIII *3BE n=3s	1.8621	.019	.170	345	FE XXIII *7BE n=7p	1.8730	.013	.179
246	FE XXIII *3BE n=3p	1.8621	.016	.136	346	FE XXIII *7BE n=7p (3)	1.8731	.043	.610
247	FE XXIII *5BE n=5p	1.8622	.031	.432	347	FE XXIII *6BE n=6p	1.8731	.039	.542
248	FE XXIII *4BE n=4d (2)	1.8622	.048	.674	348	FE XXIII *3BE n=3p	1.8731	.049	.423
249	FE XXIII *4BE n=4d (4)	1.8623	.402	5.642	349	FE XXIII *4BE n=4p	1.8731	.013	.189
250	FE XXIII *3BE n=3s	1.8624	.025	.221	350	FE XXIII *3BE n=3p	1.8732	.035	.307
251	FE XXIII *5BE n=5p	1.8625	.116	1.625	351	FE XXIII *5BE n=5d	1.8732	.015	.207
252	FE XXIV *2LI a	1.8625	1.451	2.934	352	FE XXIII *6BE n=6p	1.8732	.030	.418
253	FE XXIII *4BE n=4p (3)	1.8625	.083	1.169	353	FE XXIII *6BE n=6p	1.8733	.028	.386
254	FE XXIV *3LI h35	1.8626	.028	.244	354	FE XXIII *5BE n=5s	1.8733	.024	.331
255	FE XXIII *4BE n=4p	1.8626	.016	.221	355	FE XXIV *2LI e	1.8733	.963	1.947
256	FE XXIII *4BE n=4p (3)	1.8627	.231	3.238	356	FE XXIII *5BE n=5p	1.8734	.104	1.457
257	FE XXIV *4LI	1.8627	.048	.675	357	FE XXIII *3BE n=3s	1.8735	.023	.199
258	FE XXIII *3BE n=3d	1.8627	.015	.132	358	FE XXIII *5BE n=5p	1.8736	.042	.593
259	FE XXIII *4BE n=4p (2)	1.8628	.288	4.050	359	FE XXIII *3BE n=3s	1.8736	.024	.207
260	FE XXIII *3BE n=3p	1.8628	.024	.212	360	FE XXIII *3BE n=3p	1.8736	.086	.753
261	FE XXIII *4BE n=4s	1.8628	.011	.149	361	FE XXIII *4BE n=4s	1.8736	.049	.682
262	FE XXIII *3BE n=3d (2)	1.8629	.056	.492	362	FE XXIII *4BE n=4p (2)	1.8736	.048	.680
263	FE XXIII *3BE n=3d	1.8631	.484	4.219	363	FE XXIII *4BE n=4d	1.8736	.016	.224
264	FE XXIV *3LI d26	1.8632	.210	1.833	364	FE XXIII *4BE n=4p	1.8738	.140	1.970
265	FE XXIV *2LI d	1.8632	.017	.034	365	FE XXIII *2BE j n=2p	1.8738	.391	.792
266	FE XXIII *3BE n=3d	1.8632	.037	.320	366	FE XXIII *4BE n=4s	1.8739	.013	.180
267	FE XXIV *4LI	1.8633	.065	.906	367	FE XXIII *4BE n=4s	1.8740	.014	.191
268	FE XXIV *2LI k	1.8634	4.197	8.487	368	FE XXIII *2BE l n=2p	1.8742	.869	1.758
269	FE XXIII *3BE n=3d	1.8635	.270	2.353	369	FE XXIII *4BE n=4p	1.8742	.060	.842
270	FE XXIII *3BE n=3d	1.8636	.015	.128	370	FE XXIII *4BE n=4p (2)	1.8743	.020	.284
271	FE XXIII *3BE n=3p	1.8638	.082	.716	371	FE XXIII *2BE sig3 kn=2p	1.8743	1.853	3.746
272	FE XXIII *3BE n=3p (2)	1.8639	.446	3.888	372	FE XXIII *7BE n=7p	1.8743	.012	.168
273	FE XXIV *2LI r	1.8639	.807	1.632	373	FE XXIII *6BE n=6p	1.8744	.019	.271
274	FE XXIII *3BE n=3p (2)	1.8640	.059	.511	374	FE XXIII *2BE n=2p	1.8744	.058	.117
275	FE XXIII *3BE n=3p	1.8641	.011	.096	375	FE XXIV *2LI u	1.8744	.038	.078
276	FE XXIII *3BE n=3p (2)	1.8645	.179	1.563	376	FE XXIII *3BE n=3p	1.8746	.023	.204
277	FE XXIII *5BE n=5d	1.8645	.012	.168	377	FE XXIII *5BE n=5p	1.8746	.025	.353
278	FE XXIII *5BE n=5d	1.8646	.028	.397	378	FE XXIII *3BE n=3p	1.8747	.019	.169
279	FE XXIII *7BE n=7p (2)	1.8646	.036	.499	379	FE XXIII *3BE n=3s	1.8747	.102	.889
280	FE XXIII *4BE n=4d	1.8646	.026	.360	380	FE XXIII *4BE n=4p	1.8748	.031	.439
281	FE XXIII *4BE n=4d	1.8647	.049	.687	381	FE XXIII *3BE n=3p	1.8748	.135	1.176
282	FE XXIII *6BE n=6p	1.8647	.059	.825	382	FE XXIII *3BE n=3d	1.8748	.018	.160
283	FE XXIII *3BE n=3p	1.8647	.591	5.155	383	FE XXIII *5BE n=5p	1.8748	.010	.142
284	FE XXIII *3BE n=3s	1.8647	.038	.329	384	FE XXIII *3BE n=3p	1.8749	.023	.202
285	FE XXIII *5BE n=5d	1.8648	.043	.604	385	FE XXIV *2LI f	1.8750	.058	.118
286	FE XXIII *4BE n=4p	1.8649	.012	.170	386	FE XXIII *3BE n=3p	1.8751	.011	.094
287	FE XXIII *5BE n=5p	1.8649	.049	.688	387	FE XXIII *3BE n=3p	1.8752	.077	.674
288	FE XXIII *5BE n=5p	1.8650	.044	.613	388	FE XXIV *2LI v	1.8754	.005	.009
289	FE XXIII *4BE n=4p	1.8650	.013	.185	389	FE XXIII *2BE m n=2p	1.8755	.366	.740
290	FE XXIII *3BE n=3d	1.8650	.079	.685	390	FE XXIII *2BE n=2p	1.8756	.016	.033
291	FE XXIII *3BE n=3p	1.8650	.035	.308	391	FE XXIII *3BE n=3s	1.8756	.019	.169
292	FE XXIII *4BE n=4s	1.8650	.015	.204	392	FE XXIII *3BE n=3p	1.8759	.025	.215
293	FE XXIII *4BE n=4d	1.8651	.028	.388	393	FE XXIII *2BE o n=2p	1.8761	.235	.475
294	FE XXIII *4BE n=4d	1.8652	.018	.252	394	FE XXIII *2BE sig4 n=2p	1.8764	3.004	6.074
295	FE XXIII *3BE n=3d	1.8652	.091	.795	395	FE XXIII *3BE n=3p	1.8765	.048	.417

Table 3. List of DR satellite lines 1.53–41.57Å (continued)

396	FE XXIII	*2BE n=2p	1.8767	.007	.013	496	CA XVIII	*4LI	3.1782	.614	9.471
397	FE XXIII	*3BE n=3p	1.8769	.019	.163	497	CA XVIII	*4LI	3.1783	.040	.624
398	FE XXIII	*2BE p n=2p	1.8775	.147	.297	498	CA XVIII	*4LI (2)	3.1785	.042	.652
399	FE XXIII	*2BE q n=2p	1.8781	.110	.222	499	CA XVIII	*3LI h15	3.1789	1.120	11.300
400	FE XXII	*2B	1.8782	.019	.039	500	CA XVIII	*4LI (2)	3.1790	.596	9.192
401	FE XXIII	*2BE 5 r n=2p	1.8788	.761	1.540	501	CA XVIII	*4LI	3.1793	.597	9.212
402	FE XXIII	*2BE b n=2s	1.8799	.227	.459	502	CA XVIII	*3LI h7	3.1802	.044	.447
403	FE XXII	*2B 6	1.8804	.583	1.178	503	CA XVIII	*3LI a2	3.1806	.240	2.421
404	FE XXIII	*2BE n=2p	1.8807	.036	.073	504	CA XVIII	*3LI a1	3.1810	.230	2.321
405	FE XXIII	*2BE n=2p	1.8825	.031	.062	505	CA XVIII	*3LI d14	3.1813	.460	4.641
406	FE XXII	*2B	1.8831	.952	1.925	506	CA XVIII	*3LI d7	3.1814	1.260	12.713
407	FE XXII	*2B	1.8837	.055	.122	507	CA XVIII	*3LI d13	3.1825	2.050	20.684
408	FE XXII	*2B sig' 7	1.8838	2.278	4.607	508	CA XVIII	*2LI n	3.1860	.053	.181
409	FE XXII	*2B	1.8842	.015	.031	509	CA XVIII	*3LI d3	3.1873	.027	.272
410	FE XXIII	*2BE n=2p	1.8845	.013	.025	510	CA XVIII	*3LI a3	3.1871	.190	1.917
411	FE XXIII	*2BE n=2p (2)	1.8856	.033	.067	511	CA XVIII	*2LI m	3.1901	.360	1.220
412	FE XXII	*2B	1.8858	.045	.092	512	CA XVIII	*2LI s	3.1907	.310	1.051
413	FE XXII	*2B gam 8	1.8862	3.165	6.401	513	CA XVIII	*2LI t	3.1916	.640	2.170
414	FE XXIII	*2BE n=2p	1.8867	.017	.035	514	CA XVIII	*3LI d16	3.1907	.190	1.917
415	FE XXII	*2B	1.8877	.031	.062	515	CA XVIII	*3LI c2	3.1909	.330	3.330
416	FE XXIII	*2BE n=2p	1.8879	.019	.039	516	CA XVIII	*4LI	3.1923	.088	1.355
417	FE XXII	*2B 9	1.8881	.275	.555	517	CA XVIII	*3LI d18	3.1925	.031	.314
418	FE XXIII	*2BE n=2p	1.8884	.157	.318	518	CA XVIII	*5LI n=5- (y)	3.1928	.825	12.728
419	FE XXI	*2C NE	1.8920	.104	.210	519	CA XVIII	*3LI d17	3.1939	.110	1.110
420	FE XXII	*2B	1.8923	.199	.403	520	CA XVIII	*4LI	3.1941	.038	.579
421	FE XXI	*2C	1.8929	.077	.156	521	CA XVIII	*3LI f1	3.1942	.090	.908
422	FE XXIV	*2LI p	1.8932	.203	.410	522	CA XVIII	*3LI d21	3.1954	.080	.807
423	FE XXII	*2B	1.8932	.019	.038	523	CA XVIII	*4LI	3.1957	.059	.911
424	FE XXI	*2C NE	1.8933	.206	.417	524	CA XVIII	*4LI	3.2000	.044	.677
425	FE XXI	*2C	1.8941	.559	1.131	525	CA XVIII	*2LI b	3.2008	.036	.122
426	FE XXI	*2C 10	1.8944	.635	1.285	526	CA XVIII	*2LI q	3.2015	.010	.034
427	FE XXI	*2C	1.8946	.083	.169	527	CA XVIII	*3LI d26	3.2014	.035	.351
428	FE XXI	*2C NE	1.8950	.106	.215	528	CA XVIII	*2LI r	3.2037	.380	1.288
429	FE XXI	*2C NE 11	1.8955	.839	1.697	529	CA XVIII	*2LI a	3.2049	.640	2.170
430	FE XXI	*2C	1.8961	.034	.068	530	CA XVIII	*2LI k	3.2074	2.710	9.187
431	FE XXI	*2C	1.8970	.070	.141	531	CA XVIII	*3LI e2	3.2099	.070	.706
432	FE XXI	*2C NE 12	1.8975	1.169	2.364	532	CA XVIII	*2LI j	3.2110	3.710	12.577
433	FE XXI	*2C NE 12	1.8977	.434	.878	533	CA XVII	*2BE c	3.2126	.179	.607
434	FE XXIV	*2LI o	1.8978	.200	.405	534	CA XVIII	*3LI e1	3.2114	.110	1.110
435	FE XXI	*2C	1.8987	.200	.405	535	CA XVII	*2BE e	3.2137	.340	1.154
436	FE XXI	*2C	1.8988	.105	.212	536	CA XVII	*2BE g	3.2190	.066	.223
437	FE XXI	*2C	1.8990	.020	.039	537	CA XVII	*2BE beta 1	3.2228	.048	.162
438	FE XXI	*2C	1.8997	.175	.354	538	CA XVII	*2BE f	3.2229	.089	.304
439	FE XXI	*2C NE	1.9021	.170	.344	539	CA XVIII	*2LI e	3.2257	.110	.373
440	FE XXI	*2C	1.9026	.036	.072	540	CA XVIII	*2LI u	3.2273	.005	.017
441	FE XX	*2N	1.9033	.037	.074	541	CA XVII	*2BE sig2 i	3.2283	.513	1.741
442	FE XX	*2N	1.9036	.112	.226	542	CA XVII	*2BE j	3.2290	.233	.789
443	FE XXI	*2C	1.9038	.062	.126	543	CA XVII	*2BE l	3.2291	.519	1.761
444	FE XXI	*2C	1.9044	.027	.054	544	CA XVIII	*2LI v	3.2285	.000	.000
445	FE XX	*2N NE	1.9044	.132	.267	545	CA XVII	*2BE sig 3 k	3.2298	1.104	3.744
446	FE XX	*2N NE	1.9050	.0006	.0012	546	CA XVII	*2BE o	3.2310	.140	.476
447	FE XX	*2N	1.9052	.052	.106	547	CA XVII	*2BE sig 4 n	3.2321	1.790	6.072
448	FE XX	*2N NE	1.9053	.107	.217	548	CA XVII	*2BE p	3.2326	.089	.304
449	FE XX	*2N NE	1.9060	.008	.016	549	CA XVII	*2BE q	3.2330	.066	.223
450	FE XX	*2N NE 13	1.9061	.260	.526	550	CA XVII	*2BE m	3.2343	.221	.749
451	FE XX	*2N NE 13	1.9064	.276	.558	551	CA XVII	*2BE 5 r	3.2380	.453	1.538
452	FE XX	*2N	1.9077	.043	.086	552	CA XVII	*2BE b	3.2382	.137	.465
453	FE XX	*2N	1.9078	.048	.097	553	CA XVIII	*2LI p	3.2668	.070	.237
454	FE XX	*2N	1.9079	.038	.078	554	CA XVIII	*2LI o	3.2711	.100	.339
455	FE XX	*2N NE 14	1.9086	.739	1.494	555	AR XVII	*2HE M	3.7411	.114	.520
456	FE XX	*2N	1.9100	.038	.076	556	AR XVII	*2HE T	3.7551	.876	3.977
457	FE XX	*2N	1.9102	.010	.020	557	AR XVII	*2HE K	3.7564	.136	.618
458	FE XX	*2N	1.9106	.023	.047	558	AR XVII	*2HE Q	3.7610	.336	1.524
459	FE XX	*2N	1.9119	.019	.038	559	AR XVII	*2HE B	3.7633	.164	.745
460	FE XX	*2N NE	1.9120	.004	.007	560	AR XVII	*2HE R	3.7646	.212	.963
461	FE XX	*2N	1.9130	.070	.142	561	AR XVII	*2HE S	3.7661	.067	.302
462	FE XX	*2N	1.9144	.078	.158	562	AR XVII	*2HE A	3.7664	.438	1.988
463	FE XIX	*2O NE (2)	1.9160	.043	.088	563	AR XVII	*2HE J	3.7716	2.658	12.069
464	FE XIX	*2O NE	1.9170	.068	.138	564	AR XVII	*2HE O	3.8117	.126	.570
465	FE XIX	*2O NE	1.9210	.026	.052	565	AR XVI	*2LI n	3.9618	.077	.348
466	FE XVIII	*2F Kal1	1.9264	1.420	2.871	566	AR XVI	*2LI m	3.9658	.354	1.609
467	FE XVIII	*2F Kal2	1.9303	.706	1.428	567	AR XVI	*2LI s	3.9676	.198	.898
468	FE XXII	*2B	1.9328	.025	.050	568	AR XVI	*2LI t	3.9684	.381	1.731
469	FE XXII	*2B	1.9343	.099	.201	569	AR XVI	*2LI q	3.9813	.063	.289
470	FE XXII	*2B	1.9344	.016	.033	570	AR XVI	*2LI b	3.9818	.039	.177
471	FE XXII	*2B	1.9347	.020	.040	571	AR XVI	*2LI r	3.9834	.264	1.198
472	FE XXII	*2B	1.9363	.027	.055	572	AR XVI	*2LI a	3.9859	.547	2.483
473	FE XXI	*2C	1.9560	.011	.023	573	AR XVI	*2LI k	3.9899	2.147	9.747
474	CA XIX	*2HE M	3.0265	.136	.461	574	AR XVI	*2LI j	3.9939	2.913	13.229
475	CA XIX	*2HE T	3.0365	1.182	4.009	575	AR XVI	*2LI p	4.0688	.040	.182
476	CA XIX	*2HE K	3.0374	.316	1.072	576	AR XVI	*2LI o	4.0730	.063	.285
477	CA XIX	*2HE Q	3.0403	.356	1.207	577	S XIV	*2LI 1s-3p 3,4	4.3577	.014	.095
478	CA XIX	*2HE B	3.0419	.285	.967	578	S XIV	*2LI 1s-3p 5	4.3711	.013	.087
479	CA XIX	*2HE R	3.0440	.238	.807	579	S XIV	*2LI 1s-3p 7	4.3723	.038	.254
480	CA XIX	*2HE A	3.0451	.694	2.354	580	S XIV	*2LI 1s-3p 8	4.3740	.074	.492
481	CA XIX	*2HE S	3.0455	.071	.241	581	S XIV	*2LI 1s-3p 10	4.3750	.046	.302
482	CA XIX	*2HE J	3.0483	3.370	11.425	582	S XIV	*2LI 1s-3p 9	4.3752	.024	.159
483	CA XIX	*2HE G	3.0561	.068	.231	583	S XIV	*2LI 1s-3p 12	4.3789	.061	.405
484	CA XIX	*2HE P	3.0653	.033	.112	584	S XIV	*2LI 1s-3p 13	4.3823	.036	.238
485	CA XIX	*2HE O	3.0797	.169	.573	585	S XIV	*2LI 1s-3p 14	4.3825	.074	.492
486	CA XVIII	*3LI d2	3.1757	.039	.393	586	S XIV	*2LI 1s-3p 15	4.3863	.223	1.477
487	CA XVIII	*4LI	3.1767	.040	.611	587	S XIV	*2LI 1s-3p 17	4.3870	.133	.881
488	CA XVIII	*4LI	3.1768	.051	.787	588	S XIV	*2LI 1s-3p 16	4.3871	.773	5.121
489	CA XVIII	*3LI d1	3.1772	.200	2.018	589	S XIV	*2LI 1s-3p 18	4.3892	.044	2.938
490	CA XVIII	*5LI n=5- (w)	3.1773	3.903	60.212	590	S XIV	*2LI 1s-3p 19	4.3899	.020	.135
491	CA XVIII	*3LI h17	3.1775	.580	5.852	591	S XIV	*2LI 1s-3p 22	4.4102	.026	.175
492	CA XVIII	*4LI	3.1776	.270	4.170	592	S XIV	*2LI 1s-3p 23	4.4132	.042	.278
493	CA XVIII	*4LI	3.1777	.079	1.215	593	S XV	*3HE 1a	4.7162	.044	.582
494	CA XVIII	*4LI	3.1778	.161	2.479	594	S XV	*3HE 1c	4.7180	.048	.638
495	CA XVIII	*3LI h16	3.1779	.210	2.119	595	S XV	*3HE 2a	4.7199	.204	2.713

Table 3. List of DR satellite lines 1.53–41.57Å (continued)

596	S	XV	*3HE 2b	4.7205	.457	6.088	696	S	XIV	*2LI p	5.2091	.024	.160
597	S	XV	*3HE 3a	4.7263	.456	6.064	697	S	XIV	*2LI o	5.2131	.041	.270
598	S	XV	*3HE 4a	4.7276	.295	3.926	698	P	XIV	*3HE 1a	5.3676	.038	.575
599	S	XV	*3HE 6h	4.7324	.260	3.455	699	P	XIV	*3HE 1c	5.3693	.053	.800
600	S	XV	*3HE 6b	4.7339	.068	.910	700	P	XIV	*3HE 2a	5.3725	.159	2.390
601	S	XV	*3HE 6c	4.7344	.122	1.628	701	P	XIV	*3HE 2b	5.3731	.432	6.470
602	S	XV	*3HE 6a	4.7354	.172	2.290	702	P	XIV	*3HE 3a	5.3797	.350	5.248
603	S	XV	*3HE 8h	4.7383	.040	.535	703	P	XIV	*3HE 4a	5.3813	.241	3.612
604	S	XV	*3HE 8b,k	4.7388	.342	4.556	704	P	XIV	*3HE 6h	5.3875	.262	3.927
605	S	XV	*2HE M	4.7403	.095	.627	705	P	XIV	*3HE 6b	5.3888	.083	1.240
606	S	XV	*3HE 8d	4.7404	.086	1.149	706	P	XIV	*3HE 6c	5.3893	.055	.827
607	S	XV	*3HE 8c	4.7413	.353	4.692	707	P	XIV	*3HE 6a	5.3905	.168	2.516
608	S	XV	*3HE 8l	4.7416	.136	1.811	708	P	XIV	*3HE 8h	5.3946	.057	.854
609	S	XV	*3HE 8p	4.7440	.095	1.269	709	P	XIV	*3HE 8b	5.3947	.088	1.321
610	S	XV	*2HE T	4.7607	.601	3.982	710	P	XIV	*3HE 8d	5.3964	.082	1.222
611	S	XV	*2HE K	4.7625	.047	.314	711	P	XIV	*3HE 8c	5.3975	.314	4.709
612	S	XV	*2HE Q	4.7699	.303	2.004	712	P	XIV	*3HE 8k	5.3954	.245	3.675
613	S	XV	*2HE B	4.7734	.081	.534	713	P	XIV	*2HE M	5.3954	.085	.706
614	S	XV	*2HE R	4.7735	.186	1.231	714	P	XIV	*3HE 8l	5.3981	.137	2.058
615	S	XV	*2HE S	4.7750	.060	.397	715	P	XIV	*3HE 8p	5.4005	.095	1.420
616	S	XV	*2HE A	4.7764	.228	1.510	716	P	XIV	*2HE T	5.4206	.482	4.000
617	S	XV	*2HE J	4.7843	1.894	12.542	717	P	XIV	*2HE K	5.4229	.026	.216
618	S	XV	*2HE O	4.8383	.085	.565	718	P	XIV	*2HE Q	5.4322	.281	2.334
619	P	XIII	*2LI 1s-3p 3,4	4.9900	.019	.159	719	P	XIV	*2HE R	5.4358	.171	1.418
620	P	XIII	*2LI 1s-3p 7	5.0080	.031	.259	720	P	XIV	*2HE S	5.4367	.161	1.339
621	P	XIII	*2LI 1s-3p 8	5.0096	.064	.528	721	P	XIV	*2HE B	5.4374	.089	.743
622	P	XIII	*2LI 1s-3p 10	5.0107	.036	.299	722	P	XIV	*2HE A	5.4396	.132	1.095
623	P	XIII	*2LI 1s-3p 9	5.0108	.017	.139	723	P	XIV	*2HE J	5.4493	1.532	12.719
624	P	XIII	*2LI 1s-3p 12	5.0152	.056	.468	724	P	XIV	*2HE O	5.5134	.068	.567
625	P	XIII	*2LI 1s-3p 13	5.0197	.034	.279	725	SI	XII	*2LI 1s-3p 3,4	5.7698	.025	.270
626	P	XIII	*2LI 1s-3p 14	5.0199	.070	.577	726	P	XIII	*2LI n	5.7836	.069	.573
627	P	XIII	*2LI 1s-3p 15	5.0249	.192	1.593	727	P	XIII	*2LI m	5.7874	.222	1.841
628	P	XIII	*2LI 1s-3p 16	5.0256	.627	5.206	728	P	XIII	*2LI s	5.7923	.136	1.125
629	P	XIII	*2LI 1s-3p 17	5.0257	.103	.856	729	SI	XII	*2LI 1s-3p 7	5.7925	.025	.270
630	P	XIII	*2LI 1s-3p 18	5.0277	.038	.319	730	P	XIII	*2LI t	5.7931	.151	1.254
631	P	XIII	*2LI 1s-3p 19	5.0285	.017	.139	731	SI	XII	*2LI 1s-3p 8	5.7941	.053	.565
632	S	XIV	*3LI	5.0338	.071	.951	732	SI	XII	*2LI 1s-3p 9,10	5.7953	.029	.308
633	S	XIV	*4LI	5.0344	.079	1.484	733	SI	XII	*2LI 1s-3p 12	5.8005	.049	.526
634	S	XIV	*4LI	5.0345	.086	1.605	734	SI	XII	*2LI 1s-3p 13	5.8065	.031	.334
635	S	XIV	*3LI	5.0353	.242	3.224	735	SI	XII	*2LI 1s-3p 14	5.8067	.064	.680
636	S	XIV	*4LI	5.0360	.028	.509	736	SI	XII	*2LI 1s-3p 15	5.8131	.164	1.759
637	S	XIV	*4LI	5.0367	.086	1.605	737	SI	XII	*2LI 1s-3p 16	5.8139	.494	5.288
638	S	XIV	*4LI	5.0368	.357	6.665	738	SI	XII	*2LI 1s-3p 17	5.8141	.073	.783
639	S	XIV	*3LI	5.0370	.941	12.527	739	SI	XII	*2LI 1s-3p 18	5.8159	.032	.347
640	S	XIV	*4LI	5.0371	.155	2.901	740	P	XIII	*2LI q	5.8164	.117	.968
641	S	XIV	*4LI	5.0375	.745	13.902	741	SI	XII	*2LI 1s-3p 19	5.8169	.013	.141
642	S	XIV	*3LI	5.0375	.203	2.697	742	P	XIII	*2LI r	5.8184	.176	1.463
643	S	XIV	*4LI	5.0377	.043	.795	743	P	XIII	*2LI b	5.8203	.024	.201
644	S	XIV	*3LI	5.0384	1.565	20.826	744	P	XIII	*2LI a	5.8241	.220	1.825
645	S	XIV	*5LI n=5- (w)	5.0389	3.955	73.795	745	P	XIII	*2LI k	5.8324	1.059	8.789
646	S	XIV	*4LI	5.0396	.045	.837	746	P	XIII	*2LI l	5.8362	.018	.145
647	S	XIV	*4LI	5.0398	.416	7.761	747	P	XIII	*2LI j	5.8366	1.523	12.641
648	S	XIV	*4LI	5.0402	.577	10.754	748	SI	XII	*2LI 1s-3p 22	5.8491	.016	.167
649	S	XIV	*4LI	5.0405	.015	.284	749	SI	XII	*2LI 1s-3p 23	5.8519	.026	.282
650	S	XIV	*3LI	5.0410	.037	.495	750	P	XIII	*2LI p	5.9660	.018	.153
651	S	XIV	*3LI	5.0427	.142	1.883	751	P	XIII	*2LI o	5.9700	.032	.265
652	S	XIV	*3LI	5.0433	.174	2.315	752	SI	XIII	*3HE 1a	6.1613	.034	.584
653	S	XIV	*3LI	5.0441	.309	4.117	753	SI	XIII	*3HE 1c	6.1663	.057	.991
654	S	XIV	*3LI	5.0444	1.143	15.208	754	SI	XIII	*3HE 2a	6.1698	.119	2.064
655	S	XIV	*3LI	5.0456	1.739	23.140	755	SI	XIII	*3HE 2b	6.1704	.405	7.048
656	P	XIII	*2LI 1s-3p 22	5.0540	.021	.169	756	SI	XIII	*3HE 3a	6.1780	.263	4.577
657	S	XIV	*3LI	5.0542	.239	3.176	757	SI	XIII	*3HE 4a	6.1799	.192	3.347
658	S	XIV	*3LI	5.0546	.034	.447	758	SI	XIII	*3HE 6h	6.1880	.238	4.139
659	P	XIII	*2LI 1s-3p 23	5.0569	.034	.279	759	SI	XIII	*3HE 6b	6.1891	.077	1.345
660	S	XIV	*4LI	5.0576	.011	.203	760	SI	XIII	*3HE 6c	6.1896	.082	1.428
661	S	XIV	*3LI	5.0579	.204	2.713	761	SI	XIII	*3HE 6a	6.1909	.156	2.721
662	S	XIV	*2LI n	5.0583	.074	.492	762	SI	XIII	*3HE 8b	6.1963	.068	1.189
663	S	XIV	*4LI	5.0583	.023	.426	763	SI	XIII	*3HE 8h	6.1967	.071	1.241
664	S	XIV	*4LI	5.0587	.016	.297	764	SI	XIII	*3HE 8k	6.1978	.234	4.077
665	S	XIV	*4LI	5.0605	.048	.893	765	SI	XIII	*2HE M	6.1978	.075	.802
666	S	XIV	*4LI	5.0607	.011	.210	766	SI	XIII	*3HE 8d	6.1981	.076	1.314
667	S	XIV	*3LI	5.0608	.053	.709	767	SI	XIII	*3HE 8c	6.1997	.230	3.993
668	S	XIV	*4LI	5.0622	.009	.168	768	SI	XIII	*3HE 8l	6.2005	.138	2.398
669	S	XIV	*2LI m	5.0622	.266	1.759	769	SI	XIII	*3HE 8p	6.2029	.093	1.616
670	S	XIV	*4LI	5.0623	.010	.181	770	SI	XIII	*2HE T	6.2288	.376	4.027
671	S	XIV	*3LI	5.0626	.107	1.422	771	SI	XIII	*2HE K	6.2316	.014	.145
672	S	XIV	*3LI	5.0634	.070	.935	772	SI	XIII	*2HE Q	6.2436	.254	2.721
673	S	XIV	*4LI	5.0637	.019	.353	773	SI	XIII	*2HE R	6.2471	.154	1.650
674	S	XIV	*3LI	5.0640	.036	.480	774	SI	XIII	*2HE S	6.2487	.051	.546
675	S	XIV	*3LI	5.0650	.196	2.605	775	SI	XIII	*2HE B	6.2492	.037	.396
676	S	XIV	*3LI	5.0653	.018	.243	776	SI	XIII	*2HE A	6.2520	.108	1.162
677	S	XIV	*2LI s	5.0658	.160	1.056	777	SI	XIII	*2HE J	6.2641	1.208	12.934
678	S	XIV	*3LI	5.0665	.063	.844	778	SI	XIII	*2HE O	6.3413	.053	.570
679	S	XIV	*2LI t	5.0666	.210	1.389	779	SI	XII	*2LI n	6.6776	.062	.663
680	S	XIV	*5LI n=5- (y)	5.0667	.622	11.608	780	SI	XII	*2LI m	6.6813	.180	1.924
681	S	XIV	*4LI	5.0677	.031	.580	781	SI	XII	*2LI s	6.6880	.112	1.199
682	S	XIV	*4LI	5.0697	.027	.503	782	SI	XII	*2LI t	6.6888	.107	1.143
683	S	XIV	*4LI	5.0701	.011	.207	783	SI	XII	*2LI q	6.7180	.131	1.402
684	S	XIV	*4LI	5.0745	.028	.526	784	SI	XII	*2LI r	6.7199	.153	1.644
685	S	XIV	*4LI	5.0752	.052	.972	785	SI	XII	*2LI a	6.7273	.151	1.613
686	S	XIV	*2LI q	5.0855	.100	.659	786	SI	XII	*2LI k	6.7379	.787	8.433
687	S	XIV	*2LI r	5.0875	.201	1.334	787	SI	XII	*2LI l	6.7416	.025	.270
688	S	XIV	*2LI b	5.0881	.030	.198	788	SI	XII	*2LI j	6.7422	1.175	12.576
689	S	XIV	*3LI	5.0882	.013	.177	789	AL	XI	*2LI 1s-3p 3,4	6.7430	.030	.427
690	S	XIV	*2LI a	5.0920	.309	2.047	790	AL	XI	*2LI 1s-3p 7	6.7764	.018	.256
691	S	XIV	*3LI	5.0952	.057	.764	791	AL	XI	*2LI 1s-3p 8	6.7777	.042	.598
692	S	XIV	*3LI	5.0968	.105	1.395	792	AL	XI	*2LI 1s-3p 10	6.7791	.020	.290
693	S	XIV	*2LI k	5.0984	1.381	9.147	793	AL	XI	*2LI 1s-3p 12	6.7854	.040	.563
694	S	XIV	*2LI j	5.1026	1.942	12.862	794	AL	XI	*2LI 1s-3p 13	6.7934	.028	.393
695	S	XIV	*2LI e	5.1293	.014	.095	795	AL	XI	*2LI 1s-3p 14	6.7936	.056	.803

Table 3. List of DR satellite lines 1.53–41.57Å (continued)

796	AL XI	*2LI 1s-3p 15	6.8019	.136	1.930	896	MG XI	*3HE b4	8.4490	.034	.882
797	AL XI	*2LI 1s-3p 16	6.8026	.380	5.413	897	MG XI	*3HE b3	8.4500	.027	.710
798	AL XI	*2LI 1s-3p 17	6.8032	.059	.837	898	MG XI	*3HE b18,19,27	8.4500	.117	3.084
799	AL XI	*2LI 1s-3p 18	6.8046	.028	.393	899	MG XI	*4HE c15	8.4520	.011	.346
800	AL XI	*2LI 1s-3p 19	6.8059	.011	.154	900	MG XI	*3HE b15,16,17	8.4520	.203	5.344
801	AL XI	*2LI 1s-3p 22	6.8471	.012	.171	901	MG XI	*3HE b10	8.4930	.016	.424
802	AL XI	*2LI 1s-3p 23	6.8499	.019	.273	902	MG XI	*2HE a4 T	8.4940	.188	3.689
803	MG XI	*2HE 1s-4p	6.8960	.007	.147	903	MG XI	*2HE a3 Q	8.5250	.169	3.310
804	SI XII	*2LI p	6.9017	.014	.146	904	MG XI	*2HE a2 R	8.5280	.101	1.988
805	SI XII	*2LI o	6.9056	.024	.259	905	MG XI	*2HE a1 S	8.5300	.034	.662
806	MG XI	*2HE 1s-4p	6.9580	.010	.201	906	MG XI	*2HE a6 A	8.5330	.023	.441
807	AL XII	*3HE 1a	7.1494	.029	.602	907	MG XI	*2HE a7 J	8.5490	.614	12.058
808	AL XII	*3HE 1c	7.1533	.059	1.230	908	MG XI	*2HE a9 O	8.6780	.029	.564
809	AL XII	*3HE 2a	7.1581	.083	1.744	909	MG X	*4LI C13	9.1660	.007	.228
810	AL XII	*3HE 2b	7.1587	.363	7.603	910	MG X	*3LI B6	9.1670	.037	.975
811	AL XII	*3HE 3a	7.1675	.194	4.052	911	MG X	*4LI C17	9.1670	.033	1.052
812	AL XII	*3HE 4a	7.1695	.147	3.074	912	MG X	*4LI C18	9.1670	.026	.813
813	AL XII	*3HE 6h	7.1804	.170	3.551	913	MG X	*3LI B5	9.1680	.092	2.424
814	AL XII	*3HE 6c	7.1817	.083	1.731	914	MG X	*4LI C5	9.1710	.048	1.519
815	AL XII	*3HE 6b	7.1822	.070	1.468	915	MG X	*4LI C6	9.1710	.020	.630
816	AL XII	*3HE 6a	7.1833	.143	2.986	916	MG X	*4LI C15	9.1720	.038	1.219
817	AL XII	*3HE 8b	7.1902	.082	1.719	917	MG X	*4LI C16	9.1720	.259	8.202
818	AL XII	*3HE 8h	7.1913	.115	2.409	918	MG X	*4LI C14	9.1730	.395	12.494
819	AL XII	*2HE M	7.1914	.065	.931	919	MG X	*3LI B19	9.1740	.049	1.281
820	AL XII	*3HE 8d	7.1921	.068	1.430	920	MG X	*3LI B20 h17	9.1740	.390	10.287
821	AL XII	*3HE 8k	7.1927	.221	4.617	921	MG X	*3LI B18 h15	9.1750	.590	15.529
822	AL XII	*3HE 8c	7.1942	.152	3.187	922	MG X	*4LI C1,2	9.1760	.066	2.088
823	AL XII	*3HE 8l	7.1954	.134	2.798	923	MG X	*4LI C8,10	9.1790	.315	9.986
824	AL XII	*3HE 8p	7.1978	.091	1.894	924	MG X	*4LI C7,9	9.1800	.481	15.229
825	AL XII	*2HE T	7.2304	.287	4.090	925	MG X	*3LI B1,2	9.1870	.380	10.004
826	MG XI	*2HE 1s-3p	7.2420	.027	.524	926	MG X	*3LI B8,10 d15	9.1910	.642	16.904
827	MG XI	*2HE 1s-3p	7.2430	.014	.273	927	MG X	*3LI B9 d13	9.1920	.741	19.506
828	AL XII	*2HE Q	7.2494	.225	3.210	928	MG X	*2LI n	9.2140	.038	.742
829	AL XII	*2HE R	7.2530	.136	1.938	929	MG X	*3LI B7	9.2140	.014	.360
830	AL XII	*2HE S	7.2545	.045	.642	930	MG X	*3LI B3	9.2150	.089	2.335
831	AL XII	*2HE B	7.2566	.024	.344	931	MG X	*2LI m	9.2180	.097	1.901
832	AL XII	*2HE A	7.2593	.071	1.013	932	MG X	*3LI B4	9.2190	.057	1.492
833	MG XI	*2HE 1s-3p	7.2610	.024	.468	933	MG X	*4LI C3	9.2230	.010	.323
834	MG XI	*2HE 1s-3p (2)	7.2690	.020	.401	934	MG X	*4LI C4	9.2240	.010	.319
835	AL XII	*2HE J	7.2744	.923	13.148	935	MG X	*4LI C12	9.2290	.015	.471
836	MG XI	*2HE 1s-3p	7.2850	.018	.353	936	MG X	*3LI B21	9.2300	.006	.164
837	MG X	*2LI 1s-4p	7.3010	.061	1.195	937	MG X	*2LI s	9.2340	.067	1.310
838	MG XI	*2HE 1s-3p	7.3110	.060	1.171	938	MG X	*2LI t	9.2340	.049	.968
839	MG X	*2LI 1s-4p	7.6960	.046	.902	939	MG X	*3LI B11	9.2350	.009	.240
840	MG X	*2LI 1s-4p	7.7000	.061	1.200	940	MG X	*3LI B12	9.2350	.011	.281
841	MG X	*2LI 1s-4p	7.7240	.021	.422	941	MG X	*3LI B24	9.2360	.007	.189
842	MG X	*2LI 1s-4p	7.7320	.109	2.138	942	MG X	*3LI B23	9.2370	.013	.350
843	MG X	*2LI 1s-4p	7.7340	.020	.394	943	MG X	*3LI B15	9.2380	.030	.792
844	AL XI	*2LI n	7.7953	.053	.748	944	MG X	*3LI B17	9.2380	.030	.786
845	AL XI	*2LI m	7.7989	.142	2.018	945	MG X	*3LI B16	9.2400	.008	.211
846	AL XI	*2LI s	7.8081	.088	1.258	946	MG X	*4LI C11	9.2580	.011	.353
847	AL XI	*2LI t	7.8088	.074	1.050	947	MG X	*2LI q	9.2840	.197	3.863
848	AL XI	*2LI q	7.8460	.141	2.015	948	MG X	*2LI r	9.2860	.134	2.638
849	AL XI	*2LI r	7.8479	.133	1.895	949	MG X	*2LI b	9.2920	.007	.136
850	AL XI	*2LI b	7.8538	.007	.104	950	MG X	*2LI a	9.2970	.047	.914
851	AL XI	*2LI a	7.8574	.099	1.412	951	MG X	*3LI B14	9.3080	.013	.353
852	AL XI	*2LI k	7.8711	.568	8.087	952	MG X	*3LI B13	9.3100	.026	.672
853	AL XI	*2LI l	7.8748	.029	.413	953	MG X	*2LI k	9.3160	.393	7.711
854	AL XI	*2LI j	7.8754	.875	12.465	954	MG X	*2LI l	9.3210	.028	.542
855	MG X	*2LI 1s-3p	7.9970	.021	.404	955	MG X	*2LI j	9.3220	.621	12.186
856	MG X	*2LI 1s-3p	8.0380	.049	.961	956	MG X	*2LI u	9.3990	.000	.002
857	MG X	*2LI 1s-3p	8.0540	.016	.310	957	MG X	*2LI v	9.4000	.000	.000
858	MG X	*2LI 1s-3p	8.0560	.050	.983	958	MG X	*2LI p	9.5790	.008	.164
859	MG X	*2LI 1s-3p	8.0680	.057	1.108	959	MG X	*2LI o	9.5840	.015	.304
860	MG X	*2LI 1s-3p	8.0700	.230	4.511	960	NA X	*2HE M	10.0540	.045	1.258
861	MG X	*2LI 1s-3p	8.0710	.025	.496	961	NA X	*2HE T	10.1200	.152	4.269
862	AL XI	*2LI p	8.0754	.010	.141	962	NA X	*2HE Q	10.1530	.157	4.412
863	AL XI	*2LI o	8.0792	.018	.258	963	NA X	*2HE R	10.1560	.094	2.645
864	MG X	*2LI 1s-3p	8.1310	.019	.379	964	NA X	*2HE S	10.1580	.031	.882
865	MG XI	*3He b9,28	8.3940	.032	.842	965	NA X	*2HE B	10.1650	.009	.260
866	MG XI	*3HE b21	8.4010	.022	.568	966	NA X	*2HE A	10.1670	.027	.771
867	MG XI	*3HE b24	8.4020	.238	6.251	967	NA X	*2HE J	10.1910	.490	13.762
868	MG XI	*4HE c12	8.4030	.014	.446	968	NA X	*2HE O	10.3430	.021	.593
869	MG XI	*4HE c22 U75	8.4070	.172	5.434	969	NA IX	*2LI n	11.0680	.033	.919
870	MG XI	*4HE c37	8.4080	.061	1.933	970	NA IX	*2LI m	11.0710	.078	2.179
871	MG XI	*4HE c35,36	8.4100	.027	.853	971	NA IX	*2LI s	11.0890	.049	1.367
872	MG XI	*4HE c33	8.4110	.010	.321	972	NA IX	*2LI t	11.0900	.033	.919
873	MG XI	*4HE c30-2,38-9	8.4140	.059	1.857	973	NA IX	*2LI q	11.1540	.143	4.008
874	MG XI	*4HE c7	8.4160	.016	.513	974	NA IX	*2LI r	11.1560	.097	2.735
875	MG XI	*4HE c34	8.4160	.043	1.346	975	NA IX	*2LI b	11.1680	.006	.168
876	MG XI	*4HE c11 U101	8.4160	.163	5.163	976	NA IX	*2LI a	11.1720	.038	1.057
877	MG XI	*4HE c2	8.4170	.060	1.912	977	NA IX	*2LI k	11.1950	.269	7.567
878	MG XI	*3HE b6 U56	8.4180	.150	3.948	978	NA IX	*2LI l	11.1990	.025	.710
879	MG XI	*4HE c23,24	8.4190	.054	1.711	979	NA IX	*2LI j	11.2000	.436	12.258
880	MG XI	*4HE c26	8.4200	.018	.568	980	NA IX	*2LI p	11.5340	.005	.134
881	MG XI	*3HE b1 U41	8.4200	.102	2.692	981	NA IX	*2LI o	11.5370	.009	.253
882	MG XI	*4HE c10	8.4210	.018	.554	982	NE IX	*2HE M	12.1720	.035	1.469
883	MG XI	*4HE c19,27,27	8.4210	.080	2.532	983	NE IX	*2HE T	12.2600	.105	4.405
884	MG XI	*4HE c17	8.4220	.022	.685	984	NE IX	*2HE Q	12.3050	.121	5.099
885	MG XI	*4HE c16,18,21	8.4230	.030	.939	985	NE IX	*2HE R	12.3080	.073	3.054
886	MG XI	*4HE c28,29	8.4310	.017	.524	986	NE IX	*2HE S	12.3100	.024	1.022
887	MG XI	*3HE b25,26	8.4320	.027	.710	987	NE IX	*2HE B	12.3210	.005	.226
888	MG XI	*3HE b12,13	8.4330	.062	1.625	988	NE IX	*2HE A	12.3230	.016	.674
889	MG XI	*3HE b11	8.4340	.013	.342	989	NE IX	*2HE J	12.3550	.337	14.196
890	MG XI	*4HE c14	8.4350	.049	1.566	990	NE IX	*2HE O	12.5530	.014	.609
891	MG XI	*3HE b7 U58	8.4350	.086	2.263	991	NE VIII	*2LI n	13.5360	.023	.988
892	MG XI	*3HE b14	8.4390	.025	.656	992	NE VIII	*2LI m	13.5439	.053	2.241
893	MG XI	*2HE a8 M	8.4410	.047	.913	993	NE VIII	*2LI s	13.5640	.034	1.414
894	MG XI	*4HE c6	8.4460	.014	.435	994	NE VIII	*2LI t	13.5650	.021	.878
895	MG XI	*3HE b20	8.4480	.142	3.738	995	NE VIII	*2LI q	13.6520	.132	5.553

Table 3. List of DR satellite lines 1.53–41.57Å (continued)

996	NE	VIII	*2LI r	13.6540	.079	3.347	1021	N	VI	*2HE Q	25.2800	.037	7.584
997	NE	VIII	*2LI a	13.6750	.022	.908	1022	N	VI	*2HE R	25.2830	.022	4.546
998	NE	VIII	*2LI k	13.7070	.175	7.348	1023	N	VI	*2HE S	25.2850	.007	1.507
999	NE	VIII	*2LI l	13.7100	.020	.848	1024	N	VI	*2HE J	25.4060	.080	16.688
1000	NE	VIII	*2LI j	13.7110	.290	12.217	1025	N	V	*2LI n	29.0600	.005	1.131
1001	NE	VIII	*2LI o	13.1630	.006	.252	1026	N	V	*2LI m	29.0620	.011	2.344
1002	O	VII	*2HE M	19.0390	.017	1.960	1027	N	V	*2LI s,t	29.1550	.011	2.359
1003	O	VII	*2HE T	19.2140	.043	4.859	1028	N	V	*2LI q	29.4410	.055	11.333
1004	O	VII	*2HE Q	19.3040	.059	6.690	1029	N	V	*2LI r	29.4430	.028	5.754
1005	O	VII	*2HE R	19.3070	.035	4.001	1030	N	V	*2LI k	29.5830	.034	6.999
1006	O	VII	*2HE S	19.3090	.012	1.331	1031	N	V	*2LI l	29.5860	.006	1.161
1007	O	VII	*2HE A	19.3350	.005	.521	1032	N	V	*2LI j	29.5870	.059	12.205
1008	O	VII	*2HE J	19.3930	.138	15.584	1033	C	V	*2HE M	33.8840	.006	2.574
1009	O	VII	*2HE O	19.7710	.018	2.034	1034	C	V	*2HE T	34.3120	.013	5.792
1010	O	VI	*2LI n	21.7810	.010	1.096	1035	C	V	*2HE Q	33.5260	.020	8.674
1011	O	VI	*2LI m	21.7830	.021	2.325	1036	C	V	*2HE R	33.5290	.012	5.200
1012	O	VI	*2LI s,t	21.8410	.021	2.331	1037	C	V	*2HE S	33.5300	.004	1.732
1013	O	VI	*2LI q	22.0240	.084	9.421	1038	C	V	*2HE J	33.7090	.043	18.327
1014	O	VI	*2LI r	22.0250	.044	4.933	1039	C	IV	*2LI m	40.7130	.006	2.363
1015	O	VI	*2LI a	22.0640	.006	.664	1040	C	IV	*2LI s,t	40.8750	.006	2.389
1016	O	VI	*2LI k	22.1250	.062	7.028	1041	C	IV	*2LI q	41.3600	.030	12.922
1017	O	VI	*2LI l	22.1270	.010	1.073	1042	C	IV	*2LI r	41.3610	.015	6.487
1018	O	VI	*2LI j	22.1290	.108	12.191	1043	C	IV	*2LI k	41.5630	.016	6.945
1019	N	VI	*2HE M	24.8810	.011	2.242	1044	C	IV	*2LI j	41.5670	.029	12.252
1020	N	VI	*2HE T	25.1460	.025	5.231							

Table 4. List of electron density-sensitive lines of Fe XXI-XIX

				ne (cm-3)					
				1e11		1e13		1e15	
LNUM	ION	TRANS	LAMBDA(A)	alpha	C_DR	alpha	C_DR	alpha	C_DR
419	FE XXI	*2C NE	1.8920	.104	.210	.120	.242	.267	.542
424	FE XXI	*2C NE	1.8933	.206	.417	.228	.461	.299	.604
428	FE XXI	*2C NE	1.8950	.106	.215	.255	.516	.748	1.513
429	FE XXI	*2C NE 11	1.8955	.839	1.697	.735	1.486	.392	.793
432	FE XXI	*2C NE 12	1.8975	1.169	2.364	1.042	2.107	.622	1.258
433	FE XXI	*2C NE 12	1.8977	.434	.878	.480	.970	.632	1.278
439	FE XXI	*2C NE	1.9021	.170	.344	.188	.381	.248	.502
445	FE XX	*2N NE	1.9044	.132	.267	.156	.315	.248	.502
446	FE XX	*2N NE	1.9050	.0006	.0012	.022	.044	.138	.279
448	FE XX	*2N NE	1.9053	.107	.217	.139	.281	.115	.233
449	FE XX	*2N NE	1.9060	.008	.016	.114	.230	.337	.681
450	FE XX	*2N NE 13	1.9061	.260	.526	.296	.599	.252	.509
451	FE XX	*2N NE 13	1.9064	.276	.558	.329	.664	.347	.701
455	FE XX	*2N NE 14	1.9086	.739	1.494	.530	1.072	.342	.691
460	FE XX	*2N NE	1.9120	.004	.007	.053	.107	.157	.318
463	FE XIX	*2O NE (2)	1.9160	.043	.088	.120	.242	.351	.710
464	FE XIX	*2O NE	1.9170	.068	.138	.134	.272	.278	.563
465	FE XIX	*2O NE	1.9210	.026	.052	.050	.102	.104	.210