SRON – SPEX

APPENDIX B
Atlas of
Dielectronic Recombination lines

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Contents

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(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 $n_e > 10^{13}\mathrm{cm}^{-3}$) 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 $s \longrightarrow k$ 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 $s \longrightarrow k$ 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 $1s2s^2 2p^{n+2} \rightarrow 1s^2 2s^2 2p^{n+1}$ 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).

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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
197	FE XXIII	*3BE n=3d	1.8593	.126	1.098
198	FE XXIII	*3BE n=3d	1.8594	.067	.580
199	FE XXIII	*3BE n=3s	1.8594	.022	.188
200	FE XXIII	*4BE n=4p	1.8594	.040	.559
201	FE XXIII	*4BE n=4d	1.8594	.021	.300
202	FE XXIII	*4BE n=4p (2)	1.8595	.150	2.113
203	FE XXIV	*4LI	1.8595	.197	2.778
204	FE XXIV	*3LI d22	1.8596	.031	.271
205	FE XXIV	*4LI	1.8596	.028	.387
206	FE XXIII	*4BE n=4p	1.8597	.066	.926
207	FE XXIV	*3LI d18	1.8597	.080	.698
208	FE XXIV	*5LI n=5- (y)	1.8598	1.500	21.066
209	FE XXIV	*3LI f1,h30	1.8601	.049	.429
210	FE XXIV	*4LI	1.8602	.221	3.108
211	FE XXIII	*3BE n=3p (2)	1.8602	.166	1.445
212	FE XXIII	*3BE n=3s	1.8604	.016	.137
213	FE XXIII	*3BE n=3p	1.8605	.032	.279
214	FE XXIV	*4LI	1.8606	.015	.217
215	FE XXIII	*3BE n=3p	1.8606	.093	.810
216	FE XXIII	*3BE n=3s	1.8607	.153	1.338
217	FE XXIV	*4LI	1.8608	.029	.409
218	FE XXIV	*4LI	1.8609	.204	2.863
219	FE XXIII	*3BE n=3p	1.8609	.018	.156
220	FE XXIII	*3BE n=3p (2)	1.8610	.348	3.037
221	FE XXIII	*3BE n=3p	1.8611	.219	1.908
222	FE XXIII	*3BE n=3d	1.8611	.021	.179
223	FE XXIV	*3LI d17	1.8612	.070	.611
224	FE XXIV	*4LI	1.8612	.033	.461
225	FE XXIII	*3BE n=3p	1.8612	.064	.554
226	FE XXIV	*2LI q	1.8613	.004	.007
227	FE XXIII	*3BE n=3d (3)	1.8613	.095	.827
228	FE XXIII	*3BE n=3p	1.8615	.246	2.144
229	FE XXIII	*3BE n=3d	1.8615	.017	.147
230	FE XXIV	*3LI h32,g5	1.8616	.090	.799
231	FE XXIII	*3BE n=3d	1.8617	.012	.108
232	FE XXIII	*4BE n=4d (3)	1.8617	.057	.795
233	FE XXIII	*4BE n=4f (2)	1.8617	.028	.397
234	FE XXIII	*5BE n=5f	1.8617	.027	.383
235	FE XXIII	*5BE n=5d	1.8617	.038	.528
236	FE XXIII	*7BE n=7p (5)	1.8618	.103	1.453
237	FE XXIII	*6BE n=6p	1.8619	.098	1.372
238	FE XXIII	*5BE n=5d	1.8619	.037	.516
239	FE XXIII	*5BE n=5d	1.8620	.210	2.955
240	FE XXIII	*6BE n=6p	1.8620	.083	1.170
241	FE XXIV	*4LI	1.8620	.067	.935
242	FE XXIV	*3LI a5	1.8620	.041	.358
243	FE XXIII	*6BE n=6p	1.8620	.083	1.170
244	FE XXIII	*5BE n=5p	1.8620	.010	.141
245	FE XXIII	*3BE n=3s	1.8621	.019	.170
246	FE XXIII	*3BE n=3p	1.8621	.016	.136
247	FE XXIII	*5BE n=5p	1.8622	.031	.432
248	FE XXIII	*4BE n=4d (2)	1.8622	.048	.674
249	FE XXIII	*4BE n=4d (4)	1.8623	.402	5.642
250	FE XXIII	*3BE n=3s	1.8624	.025	.221
251	FE XXIII	*5BE n=5p	1.8625	.116	1.625
252	FE XXIV	*2LI a	1.8625	1.451	2.934
253	FE XXIII	*4BE n=4p (3)	1.8625	.083	1.169
254	FE XXIV	*3LI h35	1.8626	.028	.244
255	FE XXIII	*4BE n=4p	1.8626	.016	.221
256	FE XXIII	*4BE n=4p (3)	1.8627	.231	3.238
257	FE XXIV	*4LI	1.8627	.048	.675
258	FE XXIII	*3BE n=3d	1.8627	.015	.132
259	FE XXIII	*4BE n=4p (2)	1.8628	.288	4.050
260	FE XXIII	*3BE n=3p	1.8628	.024	.212
261	FE XXIII	*4BE n=4s	1.8628	.011	.149
262	FE XXIII	*3BE n=3d (2)	1.8629	.056	.492
263	FE XXIII	*3BE n=3d	1.8631	.484	4.219
264	FE XXIV	*3LI d26	1.8632	.210	1.833
265	FE XXIV	*2LI d	1.8632	.017	.034
266	FE XXIII	*3BE n=3d	1.8632	.037	.320
267	FE XXIV	*4LI	1.8633	.065	.906
268	FE XXIV	*2LI k	1.8634	4.197	8.487
269	FE XXIII	*3BE n=3d	1.8635	.270	2.353
270	FE XXIII	*3BE n=3d	1.8636	.015	.128
271	FE XXIII	*3BE n=3p	1.8638	.082	.716
272	FE XXIII	*3BE n=3p (2)	1.8639	.446	3.888
273	FE XXIV	*2LI r	1.8639	.807	1.632
274	FE XXIII	*3BE n=3p (2)	1.8640	.059	.511
275	FE XXIII	*3BE n=3p	1.8641	.011	.096
276	FE XXIII	*3BE n=3p (2)	1.8645	.179	1.563
277	FE XXIII	*5BE n=5d	1.8645	.012	.168
278	FE XXIII	*5BE n=5d	1.8646	.028	.397
279	FE XXIII	*7BE n=7p (2)	1.8646	.036	.499
280	FE XXIII	*4BE n=4d	1.8646	.026	.360
281	FE XXIII	*4BE n=4d	1.8647	.049	.687
282	FE XXIII	*6BE n=6p	1.8647	.059	.825
283	FE XXIII	*3BE n=3p	1.8647	.591	5.155
284	FE XXIII	*3BE n=3s	1.8647	.038	.329
285	FE XXIII	*5BE n=5d	1.8648	.043	.604
286	FE XXIII	*4BE n=4p	1.8649	.012	.170
287	FE XXIII	*5BE n=5p	1.8649	.049	.688
288	FE XXIII	*5BE n=5p	1.8650	.044	.613
289	FE XXIII	*4BE n=4p	1.8650	.013	.185
290	FE XXIII	*3BE n=3d	1.8650	.079	.685
291	FE XXIII	*3BE n=3p	1.8650	.035	.308
292	FE XXIII	*4BE n=4s	1.8650	.015	.204
293	FE XXIII	*4BE n=4d	1.8651	.028	.388
294	FE XXIII	*4BE n=4d	1.8652	.018	.252
295	FE XXIII	*3BE n=3d	1.8652	.091	.795
296	FE XXIII	*4BE n=4d	1.8653	.024	.338
297	FE XXIII	*4BE n=4p	1.8653	.087	1.221
298	FE XXIII	*4BE n=4p	1.8655	.070	.985
299	FE XXIII	*3BE n=3p	1.8656	.079	.685
300	FE XXIII	*3BE n=3p	1.8658	.022	.192
301	FE XXIII	*4BE n=4p	1.8658	.013	.179
302	FE XXIV	*3LI i1	1.8659	.036	.314
303	FE XXIII	*3BE n=3s	1.8660	.034	.297
304	FE XXIII	*3BE n=3p	1.8661	.090	.784
305	FE XXIV	*2LI j	1.8662	6.151	12.439
306	FE XXIII	*3BE n=3d	1.8662	.054	.472
307	FE XXIII	*3BE n=3d	1.8663	.028	.248
308	FE XXIII	*2BE n=2p	1.8665	.011	.022
309	FE XXIV	*3LI c3	1.8668	.014	.118
310	FE XXIII	*3BE n=3p	1.8670	.027	.236
311	FE XXIII	*3BE n=3p	1.8671	.111	.967
312	FE XXIII	*2BE c n=2p	1.8673	.299	.604
313	FE XXIV	*3LI e2	1.8673	.110	.960
314	FE XXIII	*3BE n=3d	1.8673	.027	.235
315	FE XXIII	*3BE n=3p	1.8676	.012	.104
316	FE XXIII	*3BE n=3p	1.8677	.069	.601
317	FE XXIV	*2LI l	1.8678	.403	.815
318	FE XXIII	*3BE n=3p	1.8681	.014	.124
319	FE XXIII	*2BE d n=2p	1.8682	.059	.118
320	FE XXIII	*3BE n=3p	1.8683	.026	.227
321	FE XXIII	*2BE e n=2p	1.8685	.567	1.147
322	FE XXIII	*3BE n=3d	1.8685	.016	.135
323	FE XXIII	*2BE n=2p	1.8689	.059	.118
324	FE XXIV	*3LI e1	1.8689	.150	1.309
325	FE XXIII	*3BE n=3s	1.8694	.119	1.035
326	FE XXIII	*4BE n=4d	1.8696	.018	.258
327	FE XXIII	*4BE n=4s	1.8698	.021	.297
328	FE XXIII	*4BE n=4p	1.8701	.021	.295
329	FE XXIII	*3BE n=3p	1.8702	.094	.821
330	FE XXIII	*2BE f n=2p	1.8704	.152	.307
331	FE XXIII	*2BE n=2p	1.8707	.046	.092
332	FE XXIII	*4BE n=4p	1.8707	.029	.413
333	FE XXIII	*3BE n=3p	1.8708	.010	.083
334	FE XXIII	*3BE n=3p	1.8709	.091	.795
335	FE XXIII	*2BE bet 1 n=2s	1.8710	.078	.158
336	FE XXIII	*2BE g n=2p	1.8714	.111	.224
337	FE XXIII	*2BE n=2p	1.8716	.010	.021
338	FE XXIII	*3BE n=3p	1.8720	.176	1.537
339	FE XXIII	*2BE n=2p	1.8723	.060	.121
340	FE XXIII	*3BE n=3s	1.8724	.022	.189
341	FE XXIII	*2BE h n=2p	1.8725	.060	.121
342	FE XXIII	*3BE n=3p	1.8726	.028	.243
343	FE XXIII	*2BE sig2 in=2p	1.8729	.863	1.746
344	FE XXIII	*4BE n=4s	1.8729	.013	.176
345	FE XXIII	*7BE n=7p	1.8730	.013	.179
346	FE XXIII	*7BE n=7p (3)	1.8731	.043	.610
347	FE XXIII	*6BE n=6p	1.8731	.039	.542
348	FE XXIII	*3BE n=3p	1.8731	.049	.423
349	FE XXIII	*4BE n=4p	1.8731	.013	.189
350	FE XXIII	*3BE n=3p	1.8732	.035	.307
351	FE XXIII	*5BE n=5d	1.8732	.015	.207
352	FE XXIII	*6BE n=6p	1.8732	.030	.418
353	FE XXIII	*6BE n=6p	1.8733	.028	.386
354	FE XXIII	*5BE n=5s	1.8733	.024	.331
355	FE XXIV	*2LI e	1.8733	.963	1.947
356	FE XXIII	*5BE n=5p	1.8734	.104	1.457
357	FE XXIII	*3BE n=3s	1.8735	.023	.199
358	FE XXIII	*5BE n=5p	1.8736	.042	.593
359	FE XXIII	*3BE n=3s	1.8736	.024	.207
360	FE XXIII	*3BE n=3p	1.8736	.086	.753
361	FE XXIII	*4BE n=4s	1.8736	.049	.682
362	FE XXIII	*4BE n=4p (2)	1.8736	.048	.680
363	FE XXIII	*4BE n=4d	1.8736	.016	.224
364	FE XXIII	*4BE n=4p	1.8738	.140	1.970
365	FE XXIII	*2BE j n=2p	1.8738	.391	.792
366	FE XXIII	*4BE n=4s	1.8739	.013	.180
367	FE XXIII	*4BE n=4s	1.8740	.014	.191
368	FE XXIII	*2BE l n=2p	1.8742	.869	1.758
369	FE XXIII	*4BE n=4p	1.8742	.060	.842
370	FE XXIII	*4BE n=4p (2)	1.8743	.020	.284
371	FE XXIII	*2BE sig3 kn=2p	1.8743	1.853	3.746
372	FE XXIII	*7BE n=7p	1.8743	.012	.168
373	FE XXIII	*6BE n=6p	1.8744	.019	.271
374	FE XXIII	*2BE n=2p	1.8744	.058	.117
375	FE XXIV	*2LI u	1.8744	.038	.078
376	FE XXIII	*3BE n=3p	1.8746	.023	.204
377	FE XXIII	*5BE n=5p	1.8746	.025	.353
378	FE XXIII	*3BE n=3p	1.8747	.019	.169
379	FE XXIII	*3BE n=3s	1.8747	.102	.889
380	FE XXIII	*4BE n=4p	1.8748	.031	.439
381	FE XXIII	*3BE n=3p	1.8748	.135	1.176
382	FE XXIII	*3BE n=3d	1.8748	.018	.160
383	FE XXIII	*5BE n=5p	1.8748	.010	.142
384	FE XXIII	*3BE n=3p	1.8749	.023	.202
385	FE XXIV	*2LI f	1.8750	.058	.118
386	FE XXIII	*3BE n=3p	1.8751	.011	.094
387	FE XXIII	*3BE n=3p	1.8752	.077	.674
388	FE XXIV	*2LI v	1.8754	.005	.009
389	FE XXIII	*2BE m n=2p	1.8755	.366	.740
390	FE XXIII	*2BE n=2p	1.8756	.016	.033
391	FE XXIII	*3BE n=3s	1.8756	.019	.169
392	FE XXIII	*3BE n=3p	1.8759	.025	.215
393	FE XXIII	*2BE o n=2p	1.8761	.235	.475
394	FE XXIII	*2BE sig4 n=2p	1.8764	3.004	6.074
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
397	FE XXIII	*3BE n=3p	1.8769	.019	.163
398	FE XXIII	*2BE p n=2p	1.8775	.147	.297
399	FE XXIII	*2BE q n=2p	1.8781	.110	.222
400	FE XXII	*2B	1.8782	.019	.039
401	FE XXIII	*2BE 5 r n=2p	1.8788	.761	1.540
402	FE XXIII	*2BE b n=2s	1.8799	.227	.459
403	FE XXII	*2B 6	1.8804	.583	1.178
404	FE XXIII	*2BE n=2p	1.8807	.036	.073
405	FE XXIII	*2BE n=2p	1.8825	.031	.062
406	FE XXII	*2B	1.8831	.952	1.925
407	FE XXII	*2B	1.8837	.055	.122
408	FE XXII	*2B sig' 7	1.8838	2.278	4.607
409	FE XXII	*2B	1.8842	.015	.031
410	FE XXIII	*2BE n=2p	1.8845	.013	.025
411	FE XXIII	*2BE n=2p (2)	1.8856	.033	.067
412	FE XXII	*2B	1.8858	.045	.092
413	FE XXII	*2B gam 8	1.8862	3.165	6.401
414	FE XXIII	*2BE n=2p	1.8867	.017	.035
415	FE XXII	*2B	1.8877	.031	.062
416	FE XXIII	*2BE n=2p	1.8879	.019	.039
417	FE XXII	*2B 9	1.8881	.275	.555
418	FE XXIII	*2BE n=2p	1.8884	.157	.318
419	FE XXI	*2C NE	1.8920	.104	.210
420	FE XXII	*2B	1.8923	.199	.403
421	FE XXI	*2C	1.8929	.077	.156
422	FE XXIV	*2LI p	1.8932	.203	.410
423	FE XXII	*2B	1.8932	.019	.038
424	FE XXI	*2C NE	1.8933	.206	.417
425	FE XXI	*2C	1.8941	.559	1.131
426	FE XXI	*2C 10	1.8944	.635	1.285
427	FE XXI	*2C	1.8946	.083	.169
428	FE XXI	*2C NE	1.8950	.106	.215
429	FE XXI	*2C NE 11	1.8955	.839	1.697
430	FE XXI	*2C	1.8961	.034	.068
431	FE XXI	*2C	1.8970	.070	.141
432	FE XXI	*2C NE 12	1.8975	1.169	2.364
433	FE XXI	*2C NE 12	1.8977	.434	.878
434	FE XXIV	*2LI o	1.8978	.200	.405
435	FE XXI	*2C	1.8987	.200	.405
436	FE XXI	*2C	1.8988	.105	.212
437	FE XXI	*2C	1.8990	.020	.039
438	FE XXI	*2C	1.8997	.175	.354
439	FE XXI	*2C NE	1.9021	.170	.344
440	FE XXI	*2C	1.9026	.036	.072
441	FE XX	*2N	1.9033	.037	.074
442	FE XX	*2N	1.9036	.112	.226
443	FE XXI	*2C	1.9038	.062	.126
444	FE XXI	*2C	1.9044	.027	.054
445	FE XX	*2N NE	1.9044	.132	.267
446	FE XX	*2N NE	1.9050	.0006	.0012
447	FE XX	*2N	1.9052	.052	.106
448	FE XX	*2N NE	1.9053	.107	.217
449	FE XX	*2N NE	1.9060	.008	.016
450	FE XX	*2N NE 13	1.9061	.260	.526
451	FE XX	*2N NE 13	1.9064	.276	.558
452	FE XX	*2N	1.9077	.043	.086
453	FE XX	*2N	1.9078	.048	.097
454	FE XX	*2N	1.9079	.038	.078
455	FE XX	*2N NE 14	1.9086	.739	1.494
456	FE XX	*2N	1.9100	.038	.076
457	FE XX	*2N	1.9102	.010	.020
458	FE XX	*2N	1.9106	.023	.047
459	FE XX	*2N	1.9119	.019	.038
460	FE XX	*2N NE	1.9120	.004	.007
461	FE XX	*2N	1.9130	.070	.142
462	FE XX	*2N	1.9144	.078	.158
463	FE XIX	*2O NE (2)	1.9160	.043	.088
464	FE XIX	*2O NE	1.9170	.068	.138
465	FE XIX	*2O NE	1.9210	.026	.052
466	FE XVIII	*2F Kal1	1.9264	1.420	2.871
467	FE XVIII	*2F Kal2	1.9303	.706	1.428
468	FE XXII	*2B	1.9328	.025	.050
469	FE XXII	*2B	1.9343	.099	.201
470	FE XXII	*2B	1.9344	.016	.033
471	FE XXII	*2B	1.9347	.020	.040
472	FE XXII	*2B	1.9363	.027	.055
473	FE XXI	*2C	1.9560	.011	.023
474	CA XIX	*2HE M	3.0265	.136	.461
475	CA XIX	*2HE T	3.0365	1.182	4.009
476	CA XIX	*2HE K	3.0374	.316	1.072
477	CA XIX	*2HE Q	3.0403	.356	1.207
478	CA XIX	*2HE B	3.0419	.285	.967
479	CA XIX	*2HE R	3.0440	.238	.807
480	CA XIX	*2HE A	3.0451	.694	2.354
481	CA XIX	*2HE S	3.0455	.071	.241
482	CA XIX	*2HE J	3.0483	3.370	11.425
483	CA XIX	*2HE G	3.0561	.068	.231
484	CA XIX	*2HE P	3.0653	.033	.112
485	CA XIX	*2HE O	3.0797	.169	.573
486	CA XVIII	*3LI d2	3.1757	.039	.393
487	CA XVIII	*4LI	3.1767	.040	.611
488	CA XVIII	*4LI	3.1768	.051	.787
489	CA XVIII	*3LI d1	3.1772	.200	2.018
490	CA XVIII	*5LI n=5- (w)	3.1773	3.903	60.212
491	CA XVIII	*3LI h17	3.1775	.580	5.852
492	CA XVIII	*4LI	3.1776	.270	4.170
493	CA XVIII	*4LI	3.1777	.079	1.215
494	CA XVIII	*4LI	3.1778	.161	2.479
495	CA XVIII	*3LI h16	3.1779	.210	2.119
496	CA XVIII	*4LI	3.1782	.614	9.471
497	CA XVIII	*4LI	3.1783	.040	.624
498	CA XVIII	*4LI (2)	3.1785	.042	.652
499	CA XVIII	*3LI h15	3.1789	1.120	11.300
500	CA XVIII	*4LI (2)	3.1790	.596	9.192
501	CA XVIII	*4LI	3.1793	.597	9.212
502	CA XVIII	*3LI h7	3.1802	.044	.447
503	CA XVIII	*3LI a2	3.1806	.240	2.421
504	CA XVIII	*3LI a1	3.1810	.230	2.321
505	CA XVIII	*3LI d14	3.1813	.460	4.641
506	CA XVIII	*3LI d7	3.1814	1.260	12.713
507	CA XVIII	*3LI d13	3.1825	2.050	20.684
508	CA XVIII	*2LI n	3.1860	.053	.181
509	CA XVIII	*3LI d3	3.1873	.027	.272
510	CA XVIII	*3LI a3	3.1871	.190	1.917
511	CA XVIII	*2LI m	3.1901	.360	1.220
512	CA XVIII	*2LI s	3.1907	.310	1.051
513	CA XVIII	*2LI t	3.1916	.640	2.170
514	CA XVIII	*3LI d16	3.1907	.190	1.917
515	CA XVIII	*3LI c2	3.1909	.330	3.330
516	CA XVIII	*4LI	3.1923	.088	1.355
517	CA XVIII	*3LI d18	3.1925	.031	.314
518	CA XVIII	*5LI n=5- (y)	3.1928	.825	12.728
519	CA XVIII	*3LI d17	3.1939	.110	1.110
520	CA XVIII	*4LI	3.1941	.038	.579
521	CA XVIII	*3LI f1	3.1942	.090	.908
522	CA XVIII	*3LI d21	3.1954	.080	.807
523	CA XVIII	*4LI	3.1957	.059	.911
524	CA XVIII	*4LI	3.2000	.044	.677
525	CA XVIII	*2LI b	3.2008	.036	.122
526	CA XVIII	*2LI q	3.2015	.010	.034
527	CA XVIII	*3LI d26	3.2014	.035	.351
528	CA XVIII	*2LI r	3.2037	.380	1.288
529	CA XVIII	*2LI a	3.2049	.640	2.170
530	CA XVIII	*2LI k	3.2074	2.710	9.187
531	CA XVIII	*3LI e2	3.2099	.070	.706
532	CA XVIII	*2LI j	3.2110	3.710	12.577
533	CA XVII	*2BE c	3.2126	.179	.607
534	CA XVIII	*3LI e1	3.2114	.110	1.110
535	CA XVII	*2BE e	3.2137	.340	1.154
536	CA XVII	*2BE g	3.2190	.066	.223
537	CA XVII	*2BE beta 1	3.2228	.048	.162
538	CA XVII	*2BE f	3.2229	.089	.304
539	CA XVIII	*2LI e	3.2257	.110	.373
540	CA XVIII	*2LI u	3.2273	.005	.017
541	CA XVII	*2BE sig2 i	3.2283	.513	1.741
542	CA XVII	*2BE j	3.2290	.233	.789
543	CA XVII	*2BE l	3.2291	.519	1.761
544	CA XVIII	*2LI v	3.2285	.000	.000
545	CA XVII	*2BE sig 3 k	3.2298	1.104	3.744
546	CA XVII	*2BE o	3.2310	.140	.476
547	CA XVII	*2BE sig 4 n	3.2321	1.790	6.072
548	CA XVII	*2BE p	3.2326	.089	.304
549	CA XVII	*2BE q	3.2330	.066	.223
550	CA XVII	*2BE m	3.2343	.221	.749
551	CA XVII	*2BE 5 r	3.2380	.453	1.538
552	CA XVII	*2BE b	3.2382	.137	.465
553	CA XVIII	*2LI p	3.2668	.070	.237
554	CA XVIII	*2LI o	3.2711	.100	.339
555	AR XVII	*2HE M	3.7411	.114	.520
556	AR XVII	*2HE T	3.7551	.876	3.977
557	AR XVII	*2HE K	3.7564	.136	.618
558	AR XVII	*2HE Q	3.7610	.336	1.524
559	AR XVII	*2HE B	3.7633	.164	.745
560	AR XVII	*2HE R	3.7646	.212	.963
561	AR XVII	*2HE S	3.7661	.067	.302
562	AR XVII	*2HE A	3.7664	.438	1.988
563	AR XVII	*2HE J	3.7716	2.658	12.069
564	AR XVII	*2HE O	3.8117	.126	.570
565	AR XVI	*2LI n	3.9618	.077	.348
566	AR XVI	*2LI m	3.9658	.354	1.609
567	AR XVI	*2LI s	3.9676	.198	.898
568	AR XVI	*2LI t	3.9684	.381	1.731
569	AR XVI	*2LI q	3.9813	.063	.289
570	AR XVI	*2LI b	3.9818	.039	.177
571	AR XVI	*2LI r	3.9834	.264	1.198
572	AR XVI	*2LI a	3.9859	.547	2.483
573	AR XVI	*2LI k	3.9899	2.147	9.747
574	AR XVI	*2LI j	3.9939	2.913	13.229
575	AR XVI	*2LI p	4.0688	.040	.182
576	AR XVI	*2LI o	4.0730	.063	.285
577	S XIV	*2LI 1s-3p 3,4	4.3577	.014	.095
578	S XIV	*2LI 1s-3p 5	4.3711	.013	.087
579	S XIV	*2LI 1s-3p 7	4.3723	.038	.254
580	S XIV	*2LI 1s-3p 8	4.3740	.074	.492
581	S XIV	*2LI 1s-3p 10	4.3750	.046	.302
582	S XIV	*2LI 1s-3p 9	4.3752	.024	.159
583	S XIV	*2LI 1s-3p 12	4.3789	.061	.405
584	S XIV	*2LI 1s-3p 13	4.3823	.036	.238
585	S XIV	*2LI 1s-3p 14	4.3825	.074	.492
586	S XIV	*2LI 1s-3p 15	4.3863	.223	1.477
587	S XIV	*2LI 1s-3p 17	4.3870	.133	.881
588	S XIV	*2LI 1s-3p 16	4.3871	.773	5.121
589	S XIV	*2LI 1s-3p 18	4.3892	.044	2.938
590	S XIV	*2LI 1s-3p 19	4.3899	.020	.135
591	S XIV	*2LI 1s-3p 22	4.4102	.026	.175
592	S XIV	*2LI 1s-3p 23	4.4132	.042	.278
593	S XV	*3HE 1a	4.7162	.044	.582
594	S XV	*3HE 1c	4.7180	.048	.638
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
597	S	XV	*3HE 3a	4.7263	.456	6.064
598	S	XV	*3HE 4a	4.7276	.295	3.926
599	S	XV	*3HE 6h	4.7324	.260	3.455
600	S	XV	*3HE 6b	4.7339	.068	.910
601	S	XV	*3HE 6c	4.7344	.122	1.628
602	S	XV	*3HE 6a	4.7354	.172	2.290
603	S	XV	*3HE 8h	4.7383	.040	.535
604	S	XV	*3HE 8b,k	4.7388	.342	4.556
605	S	XV	*2HE M	4.7403	.095	.627
606	S	XV	*3HE 8d	4.7404	.086	1.149
607	S	XV	*3HE 8c	4.7413	.353	4.692
608	S	XV	*3HE 8l	4.7416	.136	1.811
609	S	XV	*3HE 8p	4.7440	.095	1.269
610	S	XV	*2HE T	4.7607	.601	3.982
611	S	XV	*2HE K	4.7625	.047	.314
612	S	XV	*2HE Q	4.7699	.303	2.004
613	S	XV	*2HE B	4.7734	.081	.534
614	S	XV	*2HE R	4.7735	.186	1.231
615	S	XV	*2HE S	4.7750	.060	.397
616	S	XV	*2HE A	4.7764	.228	1.510
617	S	XV	*2HE J	4.7843	1.894	12.542
618	S	XV	*2HE O	4.8383	.085	.565
619	P	XIII	*2LI 1s-3p 3,4	4.9900	.019	.159
620	P	XIII	*2LI 1s-3p 7	5.0080	.031	.259
621	P	XIII	*2LI 1s-3p 8	5.0096	.064	.528
622	P	XIII	*2LI 1s-3p 10	5.0107	.036	.299
623	P	XIII	*2LI 1s-3p 9	5.0108	.017	.139
624	P	XIII	*2LI 1s-3p 12	5.0152	.056	.468
625	P	XIII	*2LI 1s-3p 13	5.0197	.034	.279
626	P	XIII	*2LI 1s-3p 14	5.0199	.070	.577
627	P	XIII	*2LI 1s-3p 15	5.0249	.192	1.593
628	P	XIII	*2LI 1s-3p 16	5.0256	.627	5.206
629	P	XIII	*2LI 1s-3p 17	5.0257	.103	.856
630	P	XIII	*2LI 1s-3p 18	5.0277	.038	.319
631	P	XIII	*2LI 1s-3p 19	5.0285	.017	.139
632	S	XIV	*3LI	5.0338	.071	.951
633	S	XIV	*4LI	5.0344	.079	1.484
634	S	XIV	*4LI	5.0345	.086	1.605
635	S	XIV	*3LI	5.0353	.242	3.224
636	S	XIV	*4LI	5.0360	.028	.509
637	S	XIV	*4LI	5.0367	.086	1.605
638	S	XIV	*4LI	5.0368	.357	6.665
639	S	XIV	*3LI	5.0370	.941	12.527
640	S	XIV	*4LI	5.0371	.155	2.901
641	S	XIV	*4LI	5.0375	.745	13.902
642	S	XIV	*3LI	5.0375	.203	2.697
643	S	XIV	*4LI	5.0377	.043	.795
644	S	XIV	*3LI	5.0384	1.565	20.826
645	S	XIV	*5LI n=5- (w)	5.0389	3.955	73.795
646	S	XIV	*4LI	5.0396	.045	.837
647	S	XIV	*4LI	5.0398	.416	7.761
648	S	XIV	*4LI	5.0402	.577	10.754
649	S	XIV	*4LI	5.0405	.015	.284
650	S	XIV	*3LI	5.0410	.037	.495
651	S	XIV	*3LI	5.0427	.142	1.883
652	S	XIV	*3LI	5.0433	.174	2.315
653	S	XIV	*3LI	5.0441	.309	4.117
654	S	XIV	*3LI	5.0444	1.143	15.208
655	S	XIV	*3LI	5.0456	1.739	23.140
656	P	XIII	*2LI 1s-3p 22	5.0540	.021	.169
657	S	XIV	*3LI	5.0542	.239	3.176
658	S	XIV	*3LI	5.0546	.034	.447
659	P	XIII	*2LI 1s-3p 23	5.0569	.034	.279
660	S	XIV	*4LI	5.0576	.011	.203
661	S	XIV	*3LI	5.0579	.204	2.713
662	S	XIV	*2LI n	5.0583	.074	.492
663	S	XIV	*4LI	5.0583	.023	.426
664	S	XIV	*4LI	5.0587	.016	.297
665	S	XIV	*4LI	5.0605	.048	.893
666	S	XIV	*4LI	5.0607	.011	.210
667	S	XIV	*3LI	5.0608	.053	.709
668	S	XIV	*4LI	5.0622	.009	.168
669	S	XIV	*2LI m	5.0622	.266	1.759
670	S	XIV	*4LI	5.0623	.010	.181
671	S	XIV	*3LI	5.0626	.107	1.422
672	S	XIV	*3LI	5.0634	.070	.935
673	S	XIV	*4LI	5.0637	.019	.353
674	S	XIV	*3LI	5.0640	.036	.480
675	S	XIV	*3LI	5.0650	.196	2.605
676	S	XIV	*3LI	5.0653	.018	.243
677	S	XIV	*2LI s	5.0658	.160	1.056
678	S	XIV	*3LI	5.0665	.063	.844
679	S	XIV	*2LI t	5.0666	.210	1.389
680	S	XIV	*5LI n=5- (y)	5.0667	.622	11.608
681	S	XIV	*4LI	5.0677	.031	.580
682	S	XIV	*4LI	5.0697	.027	.503
683	S	XIV	*4LI	5.0701	.011	.207
684	S	XIV	*4LI	5.0745	.028	.526
685	S	XIV	*4LI	5.0752	.052	.972
686	S	XIV	*2LI q	5.0855	.100	.659
687	S	XIV	*2LI r	5.0875	.201	1.334
688	S	XIV	*2LI b	5.0881	.030	.198
689	S	XIV	*3LI	5.0882	.013	.177
690	S	XIV	*2LI a	5.0920	.309	2.047
691	S	XIV	*3LI	5.0952	.057	.764
692	S	XIV	*3LI	5.0968	.105	1.395
693	S	XIV	*2LI k	5.0984	1.381	9.147
694	S	XIV	*2LI j	5.1026	1.942	12.862
695	S	XIV	*2LI e	5.1293	.014	.095
696	S	XIV	*2LI p	5.2091	.024	.160
697	S	XIV	*2LI o	5.2131	.041	.270
698	P	XIV	*3HE 1a	5.3676	.038	.575
699	P	XIV	*3HE 1c	5.3693	.053	.800
700	P	XIV	*3HE 2a	5.3725	.159	2.390
701	P	XIV	*3HE 2b	5.3731	.432	6.470
702	P	XIV	*3HE 3a	5.3797	.350	5.248
703	P	XIV	*3HE 4a	5.3813	.241	3.612
704	P	XIV	*3HE 6h	5.3875	.262	3.927
705	P	XIV	*3HE 6b	5.3888	.083	1.240
706	P	XIV	*3HE 6c	5.3893	.055	.827
707	P	XIV	*3HE 6a	5.3905	.168	2.516
708	P	XIV	*3HE 8h	5.3946	.057	.854
709	P	XIV	*3HE 8b	5.3947	.088	1.321
710	P	XIV	*3HE 8d	5.3964	.082	1.222
711	P	XIV	*3HE 8c	5.3975	.314	4.709
712	P	XIV	*3HE 8k	5.3954	.245	3.675
713	P	XIV	*2HE M	5.3954	.085	.706
714	P	XIV	*3HE 8l	5.3981	.137	2.058
715	P	XIV	*3HE 8p	5.4005	.095	1.420
716	P	XIV	*2HE T	5.4206	.482	4.000
717	P	XIV	*2HE K	5.4229	.026	.216
718	P	XIV	*2HE Q	5.4322	.281	2.334
719	P	XIV	*2HE R	5.4358	.171	1.418
720	P	XIV	*2HE S	5.4367	.161	1.339
721	P	XIV	*2HE B	5.4374	.089	.743
722	P	XIV	*2HE A	5.4396	.132	1.095
723	P	XIV	*2HE J	5.4493	1.532	12.719
724	P	XIV	*2HE O	5.5134	.068	.567
725	SI	XII	*2LI 1s-3p 3,4	5.7698	.025	.270
726	P	XIII	*2LI n	5.7836	.069	.573
727	P	XIII	*2LI m	5.7874	.222	1.841
728	P	XIII	*2LI s	5.7923	.136	1.125
729	SI	XII	*2LI 1s-3p 7	5.7925	.025	.270
730	P	XIII	*2LI t	5.7931	.151	1.254
731	SI	XII	*2LI 1s-3p 8	5.7941	.053	.565
732	SI	XII	*2LI 1s-3p 9,10	5.7953	.029	.308
733	SI	XII	*2LI 1s-3p 12	5.8005	.049	.526
734	SI	XII	*2LI 1s-3p 13	5.8065	.031	.334
735	SI	XII	*2LI 1s-3p 14	5.8067	.064	.680
736	SI	XII	*2LI 1s-3p 15	5.8131	.164	1.759
737	SI	XII	*2LI 1s-3p 16	5.8139	.494	5.288
738	SI	XII	*2LI 1s-3p 17	5.8141	.073	.783
739	SI	XII	*2LI 1s-3p 18	5.8159	.032	.347
740	P	XIII	*2LI q	5.8164	.117	.968
741	SI	XII	*2LI 1s-3p 19	5.8169	.013	.141
742	P	XIII	*2LI r	5.8184	.176	1.463
743	P	XIII	*2LI b	5.8203	.024	.201
744	P	XIII	*2LI a	5.8241	.220	1.825
745	P	XIII	*2LI k	5.8324	1.059	8.789
746	P	XIII	*2LI l	5.8362	.018	.145
747	P	XIII	*2LI j	5.8366	1.523	12.641
748	SI	XII	*2LI 1s-3p 22	5.8491	.016	.167
749	SI	XII	*2LI 1s-3p 23	5.8519	.026	.282
750	P	XIII	*2LI p	5.9660	.018	.153
751	P	XIII	*2LI o	5.9700	.032	.265
752	SI	XIII	*3HE 1a	6.1613	.034	.584
753	SI	XIII	*3HE 1c	6.1663	.057	.991
754	SI	XIII	*3HE 2a	6.1698	.119	2.064
755	SI	XIII	*3HE 2b	6.1704	.405	7.048
756	SI	XIII	*3HE 3a	6.1780	.263	4.577
757	SI	XIII	*3HE 4a	6.1799	.192	3.347
758	SI	XIII	*3HE 6h	6.1880	.238	4.139
759	SI	XIII	*3HE 6b	6.1891	.077	1.345
760	SI	XIII	*3HE 6c	6.1896	.082	1.428
761	SI	XIII	*3HE 6a	6.1909	.156	2.721
762	SI	XIII	*3HE 8b	6.1963	.068	1.189
763	SI	XIII	*3HE 8h	6.1967	.071	1.241
764	SI	XIII	*3HE 8k	6.1978	.234	4.077
765	SI	XIII	*2HE M	6.1978	.075	.802
766	SI	XIII	*3HE 8d	6.1981	.076	1.314
767	SI	XIII	*3HE 8c	6.1997	.230	3.993
768	SI	XIII	*3HE 8l	6.2005	.138	2.398
769	SI	XIII	*3HE 8p	6.2029	.093	1.616
770	SI	XIII	*2HE T	6.2288	.376	4.027
771	SI	XIII	*2HE K	6.2316	.014	.145
772	SI	XIII	*2HE Q	6.2436	.254	2.721
773	SI	XIII	*2HE R	6.2471	.154	1.650
774	SI	XIII	*2HE S	6.2487	.051	.546
775	SI	XIII	*2HE B	6.2492	.037	.396
776	SI	XIII	*2HE A	6.2520	.108	1.162
777	SI	XIII	*2HE J	6.2641	1.208	12.934
778	SI	XIII	*2HE O	6.3413	.053	.570
779	SI	XII	*2LI n	6.6776	.062	.663
780	SI	XII	*2LI m	6.6813	.180	1.924
781	SI	XII	*2LI s	6.6880	.112	1.199
782	SI	XII	*2LI t	6.6888	.107	1.143
783	SI	XII	*2LI q	6.7180	.131	1.402
784	SI	XII	*2LI r	6.7199	.153	1.644
785	SI	XII	*2LI a	6.7273	.151	1.613
786	SI	XII	*2LI k	6.7379	.787	8.433
787	SI	XII	*2LI l	6.7416	.025	.270
788	SI	XII	*2LI j	6.7422	1.175	12.576
789	AL	XI	*2LI 1s-3p 3,4	6.7430	.030	.427
790	AL	XI	*2LI 1s-3p 7	6.7764	.018	.256
791	AL	XI	*2LI 1s-3p 8	6.7777	.042	.598
792	AL	XI	*2LI 1s-3p 10	6.7791	.020	.290
793	AL	XI	*2LI 1s-3p 12	6.7854	.040	.563
794	AL	XI	*2LI 1s-3p 13	6.7934	.028	.393
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
797	AL XI	*2LI 1s-3p 16	6.8026	.380	5.413
798	AL XI	*2LI 1s-3p 17	6.8032	.059	.837
799	AL XI	*2LI 1s-3p 18	6.8046	.028	.393
800	AL XI	*2LI 1s-3p 19	6.8059	.011	.154
801	AL XI	*2LI 1s-3p 22	6.8471	.012	.171
802	AL XI	*2LI 1s-3p 23	6.8499	.019	.273
803	MG XI	*2HE 1s-4p	6.8960	.007	.147
804	SI XII	*2LI p	6.9017	.014	.146
805	SI XII	*2LI o	6.9056	.024	.259
806	MG XI	*2HE 1s-4p	6.9580	.010	.201
807	AL XII	*3HE 1a	7.1494	.029	.602
808	AL XII	*3HE 1c	7.1533	.059	1.230
809	AL XII	*3HE 2a	7.1581	.083	1.744
810	AL XII	*3HE 2b	7.1587	.363	7.603
811	AL XII	*3HE 3a	7.1675	.194	4.052
812	AL XII	*3HE 4a	7.1695	.147	3.074
813	AL XII	*3HE 6h	7.1804	.170	3.551
814	AL XII	*3HE 6c	7.1817	.083	1.731
815	AL XII	*3HE 6b	7.1822	.070	1.468
816	AL XII	*3HE 6a	7.1833	.143	2.986
817	AL XII	*3HE 8b	7.1902	.082	1.719
818	AL XII	*3HE 8h	7.1913	.115	2.409
819	AL XII	*2HE M	7.1914	.065	.931
820	AL XII	*3HE 8d	7.1921	.068	1.430
821	AL XII	*3HE 8k	7.1927	.221	4.617
822	AL XII	*3HE 8c	7.1942	.152	3.187
823	AL XII	*3HE 8l	7.1954	.134	2.798
824	AL XII	*3HE 8p	7.1978	.091	1.894
825	AL XII	*2HE T	7.2304	.287	4.090
826	MG XI	*2HE 1s-3p	7.2420	.027	.524
827	MG XI	*2HE 1s-3p	7.2430	.014	.273
828	AL XII	*2HE Q	7.2494	.225	3.210
829	AL XII	*2HE R	7.2530	.136	1.938
830	AL XII	*2HE S	7.2545	.045	.642
831	AL XII	*2HE B	7.2566	.024	.344
832	AL XII	*2HE A	7.2593	.071	1.013
833	MG XI	*2HE 1s-3p	7.2610	.024	.468
834	MG XI	*2HE 1s-3p (2)	7.2690	.020	.401
835	AL XII	*2HE J	7.2744	.923	13.148
836	MG XI	*2HE 1s-3p	7.2850	.018	.353
837	MG X	*2LI 1s-4p	7.3010	.061	1.195
838	MG XI	*2HE 1s-3p	7.3110	.060	1.171
839	MG X	*2LI 1s-4p	7.6960	.046	.902
840	MG X	*2LI 1s-4p	7.7000	.061	1.200
841	MG X	*2LI 1s-4p	7.7240	.021	.422
842	MG X	*2LI 1s-4p	7.7320	.109	2.138
843	MG X	*2LI 1s-4p	7.7340	.020	.394
844	AL XI	*2LI n	7.7953	.053	.748
845	AL XI	*2LI m	7.7989	.142	2.018
846	AL XI	*2LI s	7.8081	.088	1.258
847	AL XI	*2LI t	7.8088	.074	1.050
848	AL XI	*2LI q	7.8460	.141	2.015
849	AL XI	*2LI r	7.8479	.133	1.895
850	AL XI	*2LI b	7.8538	.007	.104
851	AL XI	*2LI a	7.8574	.099	1.412
852	AL XI	*2LI k	7.8711	.568	8.087
853	AL XI	*2LI l	7.8748	.029	.413
854	AL XI	*2LI j	7.8754	.875	12.465
855	MG X	*2LI 1s-3p	7.9970	.021	.404
856	MG X	*2LI 1s-3p	8.0380	.049	.961
857	MG X	*2LI 1s-3p	8.0540	.016	.310
858	MG X	*2LI 1s-3p	8.0560	.050	.983
859	MG X	*2LI 1s-3p	8.0680	.057	1.108
860	MG X	*2LI 1s-3p	8.0700	.230	4.511
861	MG X	*2LI 1s-3p	8.0710	.025	.496
862	AL XI	*2LI p	8.0754	.010	.141
863	AL XI	*2LI o	8.0792	.018	.258
864	MG X	*2LI 1s-3p	8.1310	.019	.379
865	MG XI	*3He b9,28	8.3940	.032	.842
866	MG XI	*3HE b21	8.4010	.022	.568
867	MG XI	*3HE b24	8.4020	.238	6.251
868	MG XI	*4HE c12	8.4030	.014	.446
869	MG XI	*4HE c22 U75	8.4070	.172	5.434
870	MG XI	*4HE c37	8.4080	.061	1.933
871	MG XI	*4HE c35,36	8.4100	.027	.853
872	MG XI	*4HE c33	8.4110	.010	.321
873	MG XI	*4HE c30-2,38-9	8.4140	.059	1.857
874	MG XI	*4HE c7	8.4160	.016	.513
875	MG XI	*4HE c34	8.4160	.043	1.346
876	MG XI	*4HE c11 U101	8.4160	.163	5.163
877	MG XI	*4HE c2	8.4170	.060	1.912
878	MG XI	*3HE b6 U56	8.4180	.150	3.948
879	MG XI	*4HE c23,24	8.4190	.054	1.711
880	MG XI	*4HE c26	8.4200	.018	.568
881	MG XI	*3HE b1 U41	8.4200	.102	2.692
882	MG XI	*4HE c10	8.4210	.018	.554
883	MG XI	*4HE c19,27,27	8.4210	.080	2.532
884	MG XI	*4HE c17	8.4220	.022	.685
885	MG XI	*4HE c16,18,21	8.4230	.030	.939
886	MG XI	*4HE c28,29	8.4310	.017	.524
887	MG XI	*3HE b25,26	8.4320	.027	.710
888	MG XI	*3HE b12,13	8.4330	.062	1.625
889	MG XI	*3HE b11	8.4340	.013	.342
890	MG XI	*4HE c14	8.4350	.049	1.566
891	MG XI	*3HE b7 U58	8.4350	.086	2.263
892	MG XI	*3HE b14	8.4390	.025	.656
893	MG XI	*2HE a8 M	8.4410	.047	.913
894	MG XI	*4HE c6	8.4460	.014	.435
895	MG XI	*3HE b20	8.4480	.142	3.738
896	MG XI	*3HE b4	8.4490	.034	.882
897	MG XI	*3HE b3	8.4500	.027	.710
898	MG XI	*3HE b18,19,27	8.4500	.117	3.084
899	MG XI	*4HE c15	8.4520	.011	.346
900	MG XI	*3HE b15,16,17	8.4520	.203	5.344
901	MG XI	*3HE b10	8.4930	.016	.424
902	MG XI	*2HE a4 T	8.4940	.188	3.689
903	MG XI	*2HE a3 Q	8.5250	.169	3.310
904	MG XI	*2HE a2 R	8.5280	.101	1.988
905	MG XI	*2HE a1 S	8.5300	.034	.662
906	MG XI	*2HE a6 A	8.5330	.023	.441
907	MG XI	*2HE a7 J	8.5490	.614	12.058
908	MG XI	*2HE a9 O	8.6780	.029	.564
909	MG X	*4LI C13	9.1660	.007	.228
910	MG X	*3LI B6	9.1670	.037	.975
911	MG X	*4LI C17	9.1670	.033	1.052
912	MG X	*4LI C18	9.1670	.026	.813
913	MG X	*3LI B5	9.1680	.092	2.424
914	MG X	*4LI C5	9.1710	.048	1.519
915	MG X	*4LI C6	9.1710	.020	.630
916	MG X	*4LI C15	9.1720	.038	1.219
917	MG X	*4LI C16	9.1720	.259	8.202
918	MG X	*4LI C14	9.1730	.395	12.494
919	MG X	*3LI B19	9.1740	.049	1.281
920	MG X	*3LI B20 h17	9.1740	.390	10.287
921	MG X	*3LI B18 h15	9.1750	.590	15.529
922	MG X	*4LI C1,2	9.1760	.066	2.088
923	MG X	*4LI C8,10	9.1790	.315	9.986
924	MG X	*4LI C7,9	9.1800	.481	15.229
925	MG X	*3LI B1,2	9.1870	.380	10.004
926	MG X	*3LI B8,10 d15	9.1910	.642	16.904
927	MG X	*3LI B9 d13	9.1920	.741	19.506
928	MG X	*2LI n	9.2140	.038	.742
929	MG X	*3LI B7	9.2140	.014	.360
930	MG X	*3LI B3	9.2150	.089	2.335
931	MG X	*2LI m	9.2180	.097	1.901
932	MG X	*3LI B4	9.2190	.057	1.492
933	MG X	*4LI C3	9.2230	.010	.323
934	MG X	*4LI C4	9.2240	.010	.319
935	MG X	*4LI C12	9.2290	.015	.471
936	MG X	*3LI B21	9.2300	.006	.164
937	MG X	*2LI s	9.2340	.067	1.310
938	MG X	*2LI t	9.2340	.049	.968
939	MG X	*3LI B11	9.2350	.009	.240
940	MG X	*3LI B12	9.2350	.011	.281
941	MG X	*3LI B24	9.2360	.007	.189
942	MG X	*3LI B23	9.2370	.013	.350
943	MG X	*3LI B15	9.2380	.030	.792
944	MG X	*3LI B17	9.2380	.030	.786
945	MG X	*3LI B16	9.2400	.008	.211
946	MG X	*4LI C11	9.2580	.011	.353
947	MG X	*2LI q	9.2840	.197	3.863
948	MG X	*2LI r	9.2860	.134	2.638
949	MG X	*2LI b	9.2920	.007	.136
950	MG X	*2LI a	9.2970	.047	.914
951	MG X	*3LI B14	9.3080	.013	.353
952	MG X	*3LI B13	9.3100	.026	.672
953	MG X	*2LI k	9.3160	.393	7.711
954	MG X	*2LI l	9.3210	.028	.542
955	MG X	*2LI j	9.3220	.621	12.186
956	MG X	*2LI u	9.3990	.000	.002
957	MG X	*2LI v	9.4000	.000	.000
958	MG X	*2LI p	9.5790	.008	.164
959	MG X	*2LI o	9.5840	.015	.304
960	NA X	*2HE M	10.0540	.045	1.258
961	NA X	*2HE T	10.1200	.152	4.269
962	NA X	*2HE Q	10.1530	.157	4.412
963	NA X	*2HE R	10.1560	.094	2.645
964	NA X	*2HE S	10.1580	.031	.882
965	NA X	*2HE B	10.1650	.009	.260
966	NA X	*2HE A	10.1670	.027	.771
967	NA X	*2HE J	10.1910	.490	13.762
968	NA X	*2HE O	10.3430	.021	.593
969	NA IX	*2LI n	11.0680	.033	.919
970	NA IX	*2LI m	11.0710	.078	2.179
971	NA IX	*2LI s	11.0890	.049	1.367
972	NA IX	*2LI t	11.0900	.033	.919
973	NA IX	*2LI q	11.1540	.143	4.008
974	NA IX	*2LI r	11.1560	.097	2.735
975	NA IX	*2LI b	11.1680	.006	.168
976	NA IX	*2LI a	11.1720	.038	1.057
977	NA IX	*2LI k	11.1950	.269	7.567
978	NA IX	*2LI l	11.1990	.025	.710
979	NA IX	*2LI j	11.2000	.436	12.258
980	NA IX	*2LI p	11.5340	.005	.134
981	NA IX	*2LI o	11.5370	.009	.253
982	NE IX	*2HE M	12.1720	.035	1.469
983	NE IX	*2HE T	12.2600	.105	4.405
984	NE IX	*2HE Q	12.3050	.121	5.099
985	NE IX	*2HE R	12.3080	.073	3.054
986	NE IX	*2HE S	12.3100	.024	1.022
987	NE IX	*2HE B	12.3210	.005	.226
988	NE IX	*2HE A	12.3230	.016	.674
989	NE IX	*2HE J	12.3550	.337	14.196
990	NE IX	*2HE O	12.5530	.014	.609
991	NE VIII	*2LI n	13.5360	.023	.988
992	NE VIII	*2LI m	13.5439	.053	2.241
993	NE VIII	*2LI s	13.5640	.034	1.414
994	NE VIII	*2LI t	13.5650	.021	.878
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
997	NE	VIII	*2LI a	13.6750	.022	.908
998	NE	VIII	*2LI k	13.7070	.175	7.348
999	NE	VIII	*2LI l	13.7100	.020	.848
1000	NE	VIII	*2LI j	13.7110	.290	12.217
1001	NE	VIII	*2LI o	13.1630	.006	.252
1002	O	VII	*2HE M	19.0390	.017	1.960
1003	O	VII	*2HE T	19.2140	.043	4.859
1004	O	VII	*2HE Q	19.3040	.059	6.690
1005	O	VII	*2HE R	19.3070	.035	4.001
1006	O	VII	*2HE S	19.3090	.012	1.331
1007	O	VII	*2HE A	19.3350	.005	.521
1008	O	VII	*2HE J	19.3930	.138	15.584
1009	O	VII	*2HE O	19.7710	.018	2.034
1010	O	VI	*2LI n	21.7810	.010	1.096
1011	O	VI	*2LI m	21.7830	.021	2.325
1012	O	VI	*2LI s,t	21.8410	.021	2.331
1013	O	VI	*2LI q	22.0240	.084	9.421
1014	O	VI	*2LI r	22.0250	.044	4.933
1015	O	VI	*2LI a	22.0640	.006	.664
1016	O	VI	*2LI k	22.1250	.062	7.028
1017	O	VI	*2LI l	22.1270	.010	1.073
1018	O	VI	*2LI j	22.1290	.108	12.191
1019	N	VI	*2HE M	24.8810	.011	2.242
1020	N	VI	*2HE T	25.1460	.025	5.231
1021	N	VI	*2HE Q	25.2800	.037	7.584
1022	N	VI	*2HE R	25.2830	.022	4.546
1023	N	VI	*2HE S	25.2850	.007	1.507
1024	N	VI	*2HE J	25.4060	.080	16.688
1025	N	V	*2LI n	29.0600	.005	1.131
1026	N	V	*2LI m	29.0620	.011	2.344
1027	N	V	*2LI s,t	29.1550	.011	2.359
1028	N	V	*2LI q	29.4410	.055	11.333
1029	N	V	*2LI r	29.4430	.028	5.754
1030	N	V	*2LI k	29.5830	.034	6.999
1031	N	V	*2LI l	29.5860	.006	1.161
1032	N	V	*2LI j	29.5870	.059	12.205
1033	C	V	*2HE M	33.8840	.006	2.574
1034	C	V	*2HE T	34.3120	.013	5.792
1035	C	V	*2HE Q	33.5260	.020	8.674
1036	C	V	*2HE R	33.5290	.012	5.200
1037	C	V	*2HE S	33.5300	.004	1.732
1038	C	V	*2HE J	33.7090	.043	18.327
1039	C	IV	*2LI m	40.7130	.006	2.363
1040	C	IV	*2LI s,t	40.8750	.006	2.389
1041	C	IV	*2LI q	41.3600	.030	12.922
1042	C	IV	*2LI r	41.3610	.015	6.487
1043	C	IV	*2LI k	41.5630	.016	6.945
1044	C	IV	*2LI j	41.5670	.029	12.252

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