SRON – SPEX

APPENDIX C
Atlas of Innershell Ionization lines

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Contents

APPENDIX C

INNERSHELL IONIZATION LINES

1 Introduction

In this Appendix we present an extended line table (Table 1) which lists more than 400 Kα and Kβ fluorescence lines of elements with $Z = 6$–28 compiled from a recent publication (KM93). In the following chapters we give first the formula as derived by MG81 for the innershell ionization contribution to a line in an optically thin plasma (§2), then consider the various literature sources and the way we derive wavelengths, and finally give the line table.

2 Formula for innershell ionization

Mewe and Gronenschild (MG81) and Mewe *et al.* (MSS80) have considered electron impact ionization from the inner $1s^2$ shell of ion $Z^{(z-1)}$ which contributes to the production in an optically thin plasma to the formation of a certain line in the next higher ion Z^{+z} (e.g. the satellites to He-like resonance lines from lower Li-, Be-, etc. like ions). On the basis of the formula of Lotz (L68) with $\zeta = 2$ (total number of electrons in the $1s^2$ shell) and assuming the upper line level to be populated in proportion to its statistical weight g_j MG81 obtain for the rate coefficient:

$$S_{II} = 6.49 \times 10^{-4} C_{II} T^{-1/2} \chi^{-1} E_1(\chi/kT) \ (\mathrm{cm^3 s^{-1}}), \tag{1}$$

where the fluorescence yield is given by

$$C_{II} = \frac{g_j}{\sum g_j} \frac{A_r}{A_a + \sum A_r}. \tag{1a}$$

Here $\sum g_j$ is the total statistical weight of the configuration to which level j belongs and A_a, A_r are transition probabilities for decay by auto-ionization and radiation, where the summation is over all possible spontaneous radiative transitions from level j. The electron temperature T is here expressed in K and the ionization energy χ of the $1s^2$ shell in ion $Z^{+(z-1)}$ is expressed in eV (cf. Eq. (21a) of chapter 'LINEM').

In recent work Kaastra and Mewe (KM93) have calculated the yield C_{II} for the Kα and Kβ lines from many ionization stages of the cosmically abundant elements. These are given in Table 1 and will replace the previously calculated yields given by MSS80 and MG81.

3 Literature sources and wavelengths

3.1 Kα transitions

For the Kα transitions the energy and wavelength in the second and third column of Table 1 are derived by KM93 based on data of L68, whereas the (slightly more accurate) energy and wavelength in the last two columns are the data from H69 corrected by a comparison with the data from BB67 for Kα transitions in singly ionized atoms. In the latter case, we apply, for example for iron and calcium for all ionization stages a shift of -0.017 Å, i.e. we use the 'adjusted' values given by H69.

For $Z > 13$ we take for the most abundant elements (Si, Ca, Fe) a doublet splitting equal to that derived from the BB67 data for singly ionized atoms (e.g., 0.0024, 0033, and 0.0039 Å for SiII, CaII, and FeII, respectively). We apply this splitting only up to the stage where the $2p$ electron jumps from a full $2p$ shell (e.g. up to Fe XVIII where L68 still gives different energies for the Kα_1 (Kal1) and $K\alpha_2$ (Kal2) components), thereafter we give the average-of-configuration data from H69. For $Z \leq 13$ we give the averaged data for all more than singly ionized atoms. We note that the H69 data are in good agreement with those from MW86 calculated for $Z = 9$ to 18.

3.2 Kβ transitions

For the Kβ lines we take the data from BB67 for singly ionized atoms and in the case of titanium from M83 for the higher ions. Corresponding values for other ions we approximately derived by scaling λ_H (lam_H) for Kα_2 (Kal2) with the ratio of the wavelengths of Kβ_3 (Kbe3) and Kα_2 (Kal2) from KM93 which are based on the data from L68. For the two components Kβ_3 (Kbe3) and Kβ_1 (Kbe1) we take the same wavelength except for iron where we apply a splitting Kbe3-Kbe1 of 0.0004 Å based on the L68 data up to the stage Fe X where the $3p$ electron still jumps from a full $3p$ shell and L68 gives different energy values for the two components.

4 Remarks and explanation of Table 1

To convert energies into wavelengths and vice versa we use a conversion factor of 12.39842 Å/ keV.

The energy and wavelength should be taken from the last two columns of Table 1 (i.e. the values for E_H and lam_H based on BB67 and H69), and not those from the second and third column (values for E and λ from KM93 based on L68).

Explanation of Table 1:

Z = atomic number, s = ionization stage, l = line transition (notation from KM93), E = energy, λ (lambda) = wavelength (from KM93), yield (= C_{II}) = fluorescence yield (photons per ionization) (from KM93), transition = ion and line transition, E_H (E_H) = energy, λ_H (lam_H) = wavelength (from H69 and BB67) .

5 References

Bearden, J.A., Burr, A.F.: 1967, *Rev. Mod. Phys.* **39**, 125 (**BB67**)
House, L.L.: 1969, *Astrophys. J. Suppl.* **18**, 21 (**H69**)
Kaastra, J.S., Mewe, R.: 1992, *Astron. Astrophys. Suppl.* , **443** (**KM93**)
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Mewe, R., Gronenschild, E.H.B.M.: 1981, *Astron. Astrophys. Suppl. Ser.* **45**, 11 (**MG81**)
Mewe, R., Schrijver, J., Sylwester, J.:1980, *Astron. Astrophys. Suppl. Ser.* **40**, 323 (**MSS80**)
Morita, S. *et al.*: 1983, *Phys. Letters* **94A**, 147 (**M83**)

Table 1. List of Kα and Kβ innershell ionization lines

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 Table 1. List of Kalpha and Kbeta innershell ionization lines   15 1 1      2.0133      6.1584      0.0192  P II   Kal2  2.0127
                                                                 15 1 2      2.0142      6.1555      0.0385  P II   Kal1  2.0137
 =============================================================== 15 1 3      2.1375      5.8005      0.0015  P II   Kbe3  2.1390
 Z s l        E        lambda       yield   transition    E_H    15 1 4      2.1375      5.8005      0.0008  P II   Kbe1  2.1390
             (keV)       (A)                              (keV)  15 2 1      2.0272      6.1160      0.0196  P III  Kal2  2.0137
 =============================================================== 15 2 2      2.0281      6.1132      0.0392  P III  Kal1  2.0137
 5 1 1      0.1837     67.4942      0.0006  B II   Kal2  0.1833  15 2 3      2.1582      5.7447      0.0016  P III  Kbe3  2.1439
 6 1 1      0.2768     44.7988      0.0026  C II   Kal2  0.277   15 3 1      2.0413      6.0739      0.0200  P IV   Kal2  2.0144
 6 2 1      0.2816     44.0318      0.0019  C III  Kal2  0.2916  15 3 2      2.0422      6.0711      0.0400  P IV   Kal1  2.0144
 7 1 1      0.3885     31.9129      0.0040  N II   Kal2  0.3924  15 3 3      2.1777      5.6933      0.0008  P IV   Kbe3  2.1490
 7 1 2      0.3885     31.9129      0.0020  N II   Kal1  0.3924  15 4 1      2.0540      6.0362      0.0204  P V    Kal2  2.0157
 7 2 1      0.3964     31.2800      0.0071  N III  Kal2  0.4044  15 4 2      2.0549      6.0335      0.0408  P V    Kal1  2.0157
 7 3 1      0.4006     30.9504      0.0052  N IV   Kal2  0.4108  15 5 1      2.0682      5.9947      0.0208  P VI   Kal2  2.0167
 8 1 1      0.5243     23.6465      0.0047  O II   Kal2  0.5249  15 5 2      2.0692      5.9919      0.0416  P VI   Kal1  2.0167
 8 1 2      0.5243     23.6465      0.0047  O II   Kal1  0.5249  15 6 1      2.0787      5.9644      0.0211  P VII  Kal2  2.0183
 8 2 1      0.5299     23.3973      0.0073  O III  Kal2  0.5357  15 6 2      2.0797      5.9616      0.0423  P VII  Kal1  2.0183
 8 2 2      0.5299     23.3973      0.0036  O III  Kal1  0.5357  15 7 1      2.0907      5.9302      0.0288  P VIII Kal2  2.0322
 8 3 1      0.5372     23.0816      0.0129  O IV   Kal2  0.5423  15 7 2      2.0907      5.9302      0.0431  P VIII Kal1  2.0322
 8 4 1      0.5406     22.9333      0.0096  O V    Kal2  0.5505  15 8 1      2.0989      5.9070      0.0416  P IX   Kal2  2.0476
 9 1 1      0.6766     18.3259      0.0053  F II   Kal2  0.6768  15 8 2      2.0989      5.9070      0.0416  P IX   Kal1  2.0476
 9 1 2      0.6766     18.3259      0.0080  F II   Kal1  0.6768  15 9 1      2.0903      5.9315      0.0665  P X    Kal2  2.0647
 9 2 1      0.6890     17.9956      0.0076  F III  Kal2  0.6855  15 9 2      2.0903      5.9315      0.0333  P X    Kal1  2.0647
 9 2 2      0.6890     17.9956      0.0076  F III  Kal1  0.6855  1510 1      2.0927      5.9247      0.1279  P XI   Kal2  2.0834
 9 3 1      0.6914     17.9336      0.0118  F IV   Kal2  0.6923  1511 1      2.0917      5.9274      0.1102  P XII  Kal2  2.1032
 9 3 2      0.6914     17.9336      0.0059  F IV   Kal1  0.6923  16 1 1      2.3067      5.3749      0.0258  S II   Kal2  2.3066
 9 4 1      0.6979     17.7651      0.0208  F V    Kal2  0.7006  16 1 2      2.3078      5.3724      0.0516  S II   Kal1  2.3078
 9 5 1      0.7008     17.6916      0.0154  F VI   Kal2  0.7105  16 1 3      2.4655      5.0288      0.0023  S II   Kbe3  2.4640
10 1 1      0.8484     14.6139      0.0061  NeII   Kal2  0.8486  16 1 4      2.4655      5.0288      0.0023  S II   Kbe1  2.4640
10 1 2      0.8486     14.6105      0.0121  NeII   Kal1  0.8486  16 2 1      2.3217      5.3403      0.0264  S III  Kal2  2.308
10 2 1      0.8620     14.3836      0.0082  NeIII  Kal2  0.8540  16 2 2      2.3227      5.3379      0.0527  S III  Kal1  2.308
10 2 2      0.8620     14.3836      0.0123  NeIII  Kal1  0.8540  16 2 3      2.4848      4.9896      0.0024  S III  Kbe3  2.470
10 3 1      0.8736     14.1927      0.0116  NeIV   Kal2  0.8608  16 2 4      2.4848      4.9896      0.0012  S III  Kbe1  2.470
10 3 2      0.8736     14.1927      0.0116  NeIV   Kal1  0.8608  16 3 1      2.3356      5.3084      0.0269  S IV   Kal2  2.309
10 4 1      0.8740     14.1862      0.0179  NeV    Kal2  0.8695  16 3 2      2.3372      5.3048      0.0539  S IV   Kal1  2.309
10 4 2      0.8740     14.1862      0.0089  NeV    Kal1  0.8695  16 3 3      2.5050      4.9496      0.0024  S IV   Kbe3  2.476
10 5 1      0.8788     14.1080      0.0312  NeVI   Kal2  0.8794  16 4 1      2.3486      5.2792      0.0275  S V    Kal2  2.310
10 6 1      0.8810     14.0723      0.0229  NeVII  Kal2  0.8909  16 4 2      2.3502      5.2755      0.0550  S V    Kal1  2.310
11 1 1      1.0409     11.9115      0.0087  NaII   Kal2  1.0410  16 4 3      2.5235      4.9132      0.0012  S V    Kbe3  2.482
11 1 2      1.0411     11.9088      0.0173  NaII   Kal1  1.0410  16 5 1      2.3616      5.2501      0.0281  S VI   Kal2  2.311
11 2 1      1.0534     11.7697      0.0088  NaIII  Kal2  1.0410  16 5 2      2.3632      5.2465      0.0562  S VI   Kal1  2.311
11 2 2      1.0537     11.7670      0.0175  NaIII  Kal1  1.0410  16 6 1      2.3768      5.2163      0.0286  S VII  Kal2  2.313
11 3 1      1.0673     11.6163      0.0118  NaIV   Kal2  1.0480  16 6 2      2.3779      5.2139      0.0573  S VII  Kal1  2.313
11 3 2      1.0673     11.6163      0.0178  NaIV   Kal1  1.0480  16 7 1      2.3856      5.1972      0.0292  S VIII Kal2  2.315
11 4 1      1.0782     11.4992      0.0169  NaV    Kal2  1.0566  16 7 2      2.3873      5.1936      0.0583  S VIII Kal1  2.315
11 4 2      1.0782     11.4992      0.0169  NaV    Kal1  1.0566  16 8 1      2.3977      5.1709      0.0393  S IX   Kal2  2.331
11 5 1      1.0767     11.5151      0.0262  NaVI   Kal2  1.0668  16 8 2      2.3977      5.1709      0.0590  S IX   Kal1  2.331
11 5 2      1.0767     11.5151      0.0131  NaVI   Kal1  1.0668  16 9 1      2.4060      5.1531      0.0564  S X    Kal2  2.348
11 6 1      1.0809     11.4701      0.0466  NaVII  Kal2  1.0785  16 9 2      2.4060      5.1531      0.0564  S X    Kal1  2.348
11 7 1      1.0824     11.4542      0.0352  NaVIII Kal2  1.0918  1610 1      2.3961      5.1745      0.0887  S XI   Kal2  2.367
12 1 1      1.2537      9.8893      0.0112  MgII   Kal2  1.2536  1610 2      2.3961      5.1745      0.0443  S XI   Kal1  2.367
12 1 2      1.2540      9.8870      0.0224  MgII   Kal1  1.2536  1611 1      2.3972      5.1721      0.1661  S XII  Kal2  2.387
12 2 1      1.2677      9.7806      0.0114  MgIII  Kal2  1.2536  1612 1      2.3955      5.1757      0.1446  S XIII Kal2  2.408
12 2 2      1.2679      9.7784      0.0227  MgIII  Kal1  1.2536  17 1 1      2.6212      4.7301      0.0295  ClII   Kal2  2.6208
12 3 1      1.2797      9.6887      0.0115  MgIV   Kal2  1.2545  17 1 2      2.6230      4.7268      0.0591  ClII   Kal1  2.6224
12 3 2      1.2800      9.6865      0.0231  MgIV   Kal1  1.2545  17 1 3      2.8158      4.4032      0.0028  ClII   Kbe3  2.8156
12 4 1      1.2927      9.5911      0.0155  MgV    Kal2  1.2633  17 1 4      2.8158      4.4032      0.0041  ClII   Kbe1  2.8156
12 4 2      1.2927      9.5911      0.0232  MgV    Kal1  1.2633  17 2 1      2.6363      4.7029      0.0302
12 5 1      1.3026      9.5185      0.0218  MgVI   Kal2  1.2737  17 2 2      2.6382      4.6997      0.0603
12 5 2      1.3026      9.5185      0.0218  MgVI   Kal1  1.2737  17 2 3      2.8379      4.3688      0.0028
12 6 1      1.2996      9.5404      0.0332  MgVII  Kal2  1.2856  17 2 4      2.8379      4.3688      0.0028
12 6 2      1.2996      9.5404      0.0166  MgVII  Kal1  1.2856  17 3 1      2.6516      4.6759      0.0308
12 7 1      1.3029      9.5163      0.0569  MgVIII Kal2  1.2991  17 3 2      2.6528      4.6738      0.0616
12 8 1      1.3041      9.5075      0.0424  MgIX   Kal2  1.3139  17 3 3      2.8563      4.3408      0.0029
13 1 1      1.4866      8.3400      0.0125  AlII   Kal2  1.4863  17 3 4      2.8563      4.3408      0.0014
13 1 2      1.4870      8.3381      0.0250  AlII   Kal1  1.4867  17 4 1      2.6644      4.6534      0.0315
13 1 3      1.5581      7.9573      0.0004  AlII   Kbe3  1.5574  17 4 2      2.6662      4.6501      0.0629
13 2 1      1.4997      8.2674      0.0127  AlIII  Kal2  1.4873  17 4 3      2.8754      4.3119      0.0029
13 2 2      1.5000      8.2654      0.0255  AlIII  Kal1  1.4873  17 5 1      2.6773      4.6309      0.0321
13 3 1      1.5146      8.1859      0.0130  ALIV   Kal2  1.4880  17 5 2      2.6792      4.6277      0.0643
13 3 2      1.5150      8.1840      0.0260  AlIV   Kal1  1.4880  17 5 3      2.8947      4.2832      0.0015
13 4 1      1.5255      8.1277      0.0132  AlV    Kal2  1.4888  17 6 1      2.6915      4.6065      0.0328
13 4 2      1.5262      8.1239      0.0264  AlV    Kal1  1.4888  17 6 2      2.6928      4.6043      0.0657
13 5 1      1.5382      8.0606      0.0177  AlVI   Kal2  1.4994  17 7 1      2.7052      4.5832      0.0334
13 5 2      1.5382      8.0606      0.0265  AlVI   Kal1  1.4994  17 7 2      2.7071      4.5800      0.0668
13 6 1      1.5474      8.0125      0.0249  AlVII  Kal2  1.5114  17 8 1      2.7139      4.5684      0.0340
13 6 2      1.5474      8.0125      0.0249  AlVII  Kal1  1.5114  17 8 2      2.7152      4.5663      0.0679
13 7 1      1.5428      8.0365      0.0379  AlVIII Kal2  1.5252  17 9 1      2.7258      4.5485      0.0459
13 7 2      1.5428      8.0365      0.0189  AlVIII Kal1  1.5252  17 9 2      2.7258      4.5485      0.0688
13 8 1      1.5453      8.0235      0.0650  AlIX   Kal2  1.5402  1710 1      2.7334      4.5359      0.0657
13 9 1      1.5460      8.0199      0.0484  AlX    Kal2  1.5568  1710 2      2.7334      4.5359      0.0657
14 1 1      1.7394      7.1280      0.0140  SiII   Kal2  1.7394  1711 1      2.7227      4.5537      0.1034
14 1 2      1.7398      7.1263      0.0280  SiII   Kal1  1.7400  1711 2      2.7227      4.5537      0.0517
14 1 3      1.8357      6.7541      0.0010  SiII   Kbe3  1.8359  1712 1      2.7233      4.5527      0.1926
14 2 1      1.7535      7.0708      0.0142  SiIII  Kal2  1.7404  1713 1      2.7208      4.5569      0.1656
14 2 2      1.7539      7.0691      0.0285  SiIII  Kal1  1.7404  18 1 1      2.9560      4.1944      0.0373  ArII   Kal2  2.9556
14 2 3      1.8557      6.6814      0.0005  SiIII  Kbe3  1.842   18 1 2      2.9580      4.1915      0.0745  ArII   Kal1  2.9577
14 3 1      1.7673      7.0156      0.0145  SiIV   Kal2  1.7407  18 1 3      3.1901      3.8866      0.0034  ArII   Kbe3  3.1905
14 3 2      1.7681      7.0124      0.0290  SiIV   Kal1  1.7413  18 1 4      3.1908      3.8857      0.0068  ArII   Kbe1  3.1905
14 4 1      1.7816      6.9593      0.0147  SiV    Kal2  1.7417  18 2 1      2.9717      4.1722      0.0380  ArIII  Kal2  2.958
14 4 2      1.7820      6.9577      0.0295  SiV    Kal1  1.7423  18 2 2      2.9737      4.1693      0.0760  ArIII  Kal1  2.958
14 5 1      1.7914      6.9210      0.0150  SiVI   Kal2  1.7429  18 2 3      3.2137      3.8580      0.0035  ArIII  Kbe3  3.196
14 5 2      1.7923      6.9178      0.0299  SiVI   Kal1  1.7435  18 2 4      3.2137      3.8580      0.0052  ArIII  Kbe1  3.196
14 6 1      1.8038      6.8733      0.0203  SiVII  Kal2  1.7554  18 3 1      2.9868      4.1511      0.0388  ArIV   Kal2  2.959
14 6 2      1.8038      6.8733      0.0304  SiVII  Kal1  1.7554  18 3 2      2.9888      4.1483      0.0776  ArIV   Kal1  2.959
14 7 1      1.8126      6.8402      0.0293  SiVIII Kal2  1.7694  18 3 3      3.2352      3.8324      0.0035  ArIV   Kbe3  3.203
14 7 2      1.8126      6.8402      0.0293  SiVIII Kal1  1.7694  18 3 4      3.2352      3.8324      0.0035  ArIV   Kbe1  3.203
14 8 1      1.8059      6.8654      0.0466  SiIX   Kal2  1.7847  18 4 1      3.0005      4.1321      0.0396  ArV    Kal2  2.960
14 8 2      1.8059      6.8654      0.0233  SiIX   Kal1  1.7847  18 4 2      3.0033      4.1283      0.0791  ArV    Kal1  2.960
14 9 1      1.8088      6.8544      0.0890  SiX    Kal2  1.8016  18 4 3      3.2516      3.8130      0.0036  ArV    Kbe3  3.205
1410 1      1.8084      6.8559      0.0768  SiXI   Kal2  1.8198  18 4 4      3.2516      3.8130      0.0018  ArV    Kbe1  3.205
```

Table 1. List of Kα and Kβ innershell ionization lines (continued)

18 5 1	3.0137	4.1140	0.0404	ArVI	Kal2	2.962
18 5 2	3.0158	4.1112	0.0808	ArVI	Kal1	2.962
18 5 3	3.2711	3.7902	0.0037	ArVI	Kbe3	3.213
18 6 1	3.0276	4.0951	0.0412	ArVII	Kal2	2.963
18 6 2	3.0297	4.0923	0.0824	ArVII	Kal1	2.963
18 6 3	3.2900	3.7685	0.0019	ArVII	Kbe3	3.218
18 7 1	3.0416	4.0763	0.0421	ArVIII	Kal2	2.966
18 7 2	3.0437	4.0735	0.0842	ArVIII	Kal1	2.966
18 8 1	3.0549	4.0585	0.0428	ArIX	Kal2	2.968
18 8 2	3.0570	4.0557	0.0856	ArIX	Kal1	2.968
18 9 1	3.0627	4.0482	0.0435	ArX	Kal2	2.970
18 9 2	3.0655	4.0445	0.0870	ArX	Kal1	2.970
1810 1	3.0747	4.0324	0.0579	ArXI	Kal2	2.990
1810 2	3.0747	4.0324	0.0868	ArXI	Kal1	2.990
1811 1	3.0818	4.0232	0.0812	ArXII	Kal2	3.010
1811 2	3.0818	4.0232	0.0812	ArXII	Kal1	3.010
1812 1	3.0697	4.0389	0.1229	ArXIII	Kal2	3.032
1812 2	3.0697	4.0389	0.0614	ArXIII	Kal1	3.032
1813 1	3.0690	4.0399	0.2116	ArXIV	Kal2	3.056
1814 1	3.0655	4.0445	0.1671	ArXV	Kal2	3.080
19 1 1	3.3113	3.7443	0.0347	K II	Kal2	3.3111
19 1 2	3.3144	3.7408	0.0693	K II	Kal1	3.3138
19 1 3	3.5909	3.4528	0.0037	K II	Kbe3	3.5896
19 1 4	3.5917	3.4520	0.0073	K II	Kbe1	3.5896
19 2 1	3.3274	3.7262	0.0347			
19 2 2	3.3297	3.7236	0.0694			
19 2 3	3.6124	3.4322	0.0037			
19 2 4	3.6124	3.4322	0.0073			
19 3 1	3.3435	3.7082	0.0355			
19 3 2	3.3458	3.7057	0.0711			
19 3 3	3.6350	3.4109	0.0038			
19 3 4	3.6350	3.4109	0.0056			
19 4 1	3.3581	3.6920	0.0364			
19 4 2	3.3612	3.6886	0.0728			
19 4 3	3.6568	3.3905	0.0039			
19 4 4	3.6568	3.3905	0.0039			
19 5 1	3.3713	3.6776	0.0373			
19 5 2	3.3736	3.6751	0.0745			
19 5 3	3.6711	3.3773	0.0039			
19 5 4	3.6711	3.3773	0.0020			
19 6 1	3.3853	3.6624	0.0382			
19 6 2	3.3877	3.6599	0.0764			
19 6 3	3.6906	3.3594	0.0040			
19 7 1	3.3994	3.6473	0.0391			
19 7 2	3.4017	3.6447	0.0782			
19 7 3	3.7102	3.3417	0.0021			
19 8 1	3.4135	3.6322	0.0401			
19 8 2	3.4159	3.6297	0.0802			
19 9 1	3.4253	3.6196	0.0409			
19 9 2	3.4277	3.6171	0.0819			
1910 1	3.4332	3.6113	0.0418			
1910 2	3.4364	3.6080	0.0835			
1911 1	3.4451	3.5989	0.0557			
1911 2	3.4451	3.5989	0.0836			
1912 1	3.4514	3.5922	0.0784			
1912 2	3.4514	3.5922	0.0784			
1913 1	3.4372	3.6072	0.1191			
1913 2	3.4372	3.6072	0.0596			
1914 1	3.4364	3.6080	0.2064			
1915 1	3.4316	3.6130	0.1626			
20 1 1	3.6881	3.3618	0.0413	CaII	Kal2	3.6881
20 1 2	3.6923	3.3579	0.0827	CaII	Kal1	3.6917
20 1 3	4.0124	3.0901	0.0047	CaII	Kbe3	4.0127
20 1 4	4.0133	3.0893	0.0093	CaII	Kbe1	4.0127
20 2 1	3.7051	3.3463	0.0414	CaIII	Kal2	3.6887
20 2 2	3.7094	3.3425	0.0828	CaIII	Kal1	3.6923
20 2 3	4.0365	3.0716	0.0047	CaIII	Kbe3	4.018
20 2 4	4.0374	3.0709	0.0093	CaIII	Kbe1	4.018
20 3 1	3.7205	3.3325	0.0415	CaIV	Kal2	3.6887
20 3 2	3.7239	3.3294	0.0830	CaIV	Kal1	3.6923
20 3 3	4.0588	3.0547	0.0047	CaIV	Kbe3	4.024
20 3 4	4.0588	3.0547	0.0094	CaIV	Kbe1	4.024
20 4 1	3.7359	3.3187	0.0425	CaV	Kal2	3.6909
20 4 2	3.7402	3.3149	0.0850	CaV	Kal1	3.6945
20 4 3	4.0813	3.0379	0.0048	CaV	Kbe3	4.031
20 4 4	4.0813	3.0379	0.0072	CaV	Kbe1	4.031
20 5 1	3.7506	3.3057	0.0436	CaVI	Kal2	3.6920
20 5 2	3.7540	3.3027	0.0871	CaVI	Kal1	3.6956
20 5 3	4.1020	3.0225	0.0049	CaVI	Kbe3	4.038
20 5 4	4.1020	3.0225	0.0049	CaVI	Kbe1	4.038
20 6 1	3.7636	3.2943	0.0447	CaVII	Kal2	3.6942
20 6 2	3.7670	3.2913	0.0893	CaVII	Kal1	3.6978
20 6 3	4.1162	3.0121	0.0050	CaVII	Kbe3	4.041
20 6 4	4.1162	3.0121	0.0025	CaVII	Kbe1	4.041
20 7 1	3.7775	3.2822	0.0458	CaVIII	Kal2	3.6964
20 7 2	3.7809	3.2792	0.0916	CaVIII	Kal1	3.7000
20 7 3	4.1362	2.9976	0.0052	CaVIII	Kbe3	4.048
20 8 1	3.7914	3.2701	0.0470	CaIX	Kal2	3.6997
20 8 2	3.7949	3.2671	0.0939	CaIX	Kal1	3.7033
20 8 3	4.1553	2.9838	0.0026	CaIX	Kbe3	4.055
20 9 1	3.8045	3.2589	0.0482	CaX	Kal2	3.7030
20 9 2	3.8080	3.2559	0.0963	CaX	Kal1	3.7067
2010 1	3.8159	3.2491	0.0492	CaXI	Kal2	3.7052
2010 2	3.8203	3.2454	0.0983	CaXI	Kal1	3.7089
2011 1	3.8247	3.2417	0.0502	CaXII	Kal2	3.7085
2011 2	3.8282	3.2387	0.1003	CaXII	Kal1	3.7122
2012 1	3.8371	3.2312	0.0669	CaXIII	Kal2	3.733
2012 2	3.8371	3.2312	0.1003	CaXIII	Kal1	3.733
2013 1	3.8424	3.2268	0.0939	CaXIV	Kal2	3.757
2013 2	3.8424	3.2268	0.0939	CaXIV	Kal1	3.757
2014 1	3.8265	3.2402	0.1427	CaXV	Kal2	3.782
2014 2	3.8265	3.2402	0.0713	CaXV	Kal1	3.782
2015 1	3.8247	3.2417	0.2478	CaXVI	Kal2	3.810
2016 1	3.8186	3.2469	0.1984	CaXVII	Kal2	3.837
21 1 1	4.0860	3.0344	0.0566	ScII	Kal2	4.0861
21 1 2	4.0907	3.0309	0.1131	ScII	Kal1	4.0906
21 1 3	4.4607	2.7795	0.0068	ScII	Kbe3	4.4605
21 1 4	4.4607	2.7795	0.0135	ScII	Kbe1	4.4605
21 2 1	4.1020	3.0225	0.0567			
21 2 2	4.1068	3.0190	0.1133			
21 2 3	4.4833	2.7655	0.0068			
21 2 4	4.4844	2.7648	0.0136			
21 3 1	4.1191	3.0100	0.0568			
21 3 2	4.1238	3.0065	0.1135			
21 3 3	4.5071	2.7508	0.0068			
21 3 4	4.5082	2.7502	0.0136			
21 4 1	4.1343	2.9989	0.0568			
21 4 2	4.1390	2.9955	0.1136			
21 4 3	4.5300	2.7369	0.0068			
21 4 4	4.5300	2.7369	0.0136			
21 5 1	4.1495	2.9879	0.0583			
21 5 2	4.1543	2.9845	0.1166			
21 5 3	4.5520	2.7237	0.0070			
21 5 4	4.5520	2.7237	0.0105			
21 6 1	4.1629	2.9783	0.0598			
21 6 2	4.1677	2.9749	0.1197			
21 6 3	4.5730	2.7112	0.0072			
21 6 4	4.5730	2.7112	0.0072			
21 7 1	4.1764	2.9687	0.0614			
21 7 2	4.1812	2.9653	0.1229			
21 7 3	4.5856	2.7037	0.0073			
21 7 4	4.5856	2.7037	0.0037			
21 8 1	4.1889	2.9598	0.0631			
21 8 2	4.1937	2.9564	0.1262			
21 8 3	4.6047	2.6926	0.0075			
21 9 1	4.2034	2.9496	0.0648			
21 9 2	4.2082	2.9462	0.1297			
21 9 3	4.6249	2.6808	0.0039			
2110 1	4.2160	2.9408	0.0666			
2110 2	4.2209	2.9374	0.1333			
2111 1	4.2286	2.9320	0.0679			
2111 2	4.2325	2.9293	0.1358			
2112 1	4.2364	2.9266	0.0691			
2112 2	4.2413	2.9233	0.1382			
2113 1	4.2491	2.9179	0.0922			
2113 2	4.2491	2.9179	0.1382			
2114 1	4.2540	2.9145	0.1298			
2114 2	4.2540	2.9145	0.1298			
2115 1	4.2364	2.9266	0.1986			
2115 2	4.2364	2.9266	0.0993			
2116 1	4.2345	2.9280	0.3521			
2117 1	4.2267	2.9334	0.2963			
22 1 1	4.5051	2.7521	0.0657	TiII	Kal2	4.5049
22 1 2	4.5113	2.7483	0.1314	TiII	Kal1	4.5108
22 1 3	4.9317	2.5140	0.0080	TiII	Kbe3	4.9318
22 1 4	4.9317	2.5140	0.0159	TiII	Kbe1	4.9318
22 2 1	4.5196	2.7433	0.0658	TiIII	Kal2	4.509
22 2 2	4.5258	2.7395	0.1316	TiIII	Kal1	4.509
22 2 3	4.9545	2.5025	0.0080	TiIII	Kbe3	4.9318
22 2 4	4.9545	2.5025	0.0160	TiIII	Kbe1	4.9318
22 3 1	4.5373	2.7325	0.0659	TiIV	Kal2	4.509
22 3 2	4.5426	2.7294	0.1318	TiIV	Kal1	4.509
22 3 3	4.9785	2.4904	0.0080	TiIV	Kbe3	4.9318
22 3 4	4.9785	2.4904	0.0160	TiIV	Kbe1	4.9318
22 4 1	4.5530	2.7231	0.0659	TiV	Kal2	4.509
22 4 2	4.5593	2.7194	0.1319	TiV	Kal1	4.509
22 4 3	5.0026	2.4784	0.0080	TiV	Kbe3	4.9318
22 4 4	5.0026	2.4784	0.0160	TiV	Kbe1	4.9318
22 5 1	4.5677	2.7144	0.0660	TiVI	Kal2	4.507
22 5 2	4.5740	2.7106	0.1320	TiVI	Kal1	4.507
22 5 3	5.0246	2.4676	0.0080	TiVI	Kbe3	4.9370
22 5 4	5.0246	2.4676	0.0160	TiVI	Kbe1	4.9370
22 6 1	4.5835	2.7050	0.0677	TiVII	Kal2	4.509
22 6 2	4.5888	2.7019	0.1355	TiVII	Kal1	4.509
22 6 3	5.0478	2.4562	0.0082	TiVII	Kbe3	4.9454
22 6 4	5.0478	2.4562	0.0123	TiVII	Kbe1	4.9454
22 7 1	4.5973	2.6969	0.0696	TiVIII	Kal2	4.512
22 7 2	4.6026	2.6938	0.1391	TiVIII	Kal1	4.512
22 7 3	5.0687	2.4461	0.0084	TiVIII	Kbe3	4.9544
22 7 4	5.0687	2.4461	0.0084	TiVIII	Kbe1	4.9544
22 8 1	4.6100	2.6895	0.0715	TiIX	Kal2	4.515
22 8 2	4.6164	2.6858	0.1429	TiIX	Kal1	4.515
22 8 3	5.0804	2.4404	0.0087	TiIX	Kbe3	4.9629
22 8 4	5.0804	2.4404	0.0043	TiIX	Kbe1	4.9629
22 9 1	4.6217	2.6827	0.0734	TiX	Kal2	4.517
22 9 2	4.6281	2.6790	0.1469	TiX	Kal1	4.517
22 9 3	5.0992	2.4315	0.0089	TiX	Kbe3	4.9744
2210 1	4.6366	2.6740	0.0755	TiXI	Kal2	4.522
2210 2	4.6419	2.6710	0.1509	TiXI	Kal1	4.522
2210 3	5.1180	2.4225	0.0046	TiXI	Kbe3	4.9853
2211 1	4.6494	2.6667	0.0776	TiXII	Kal2	4.525
2211 2	4.6548	2.6636	0.1552	TiXII	Kal1	4.525
2212 1	4.6612	2.6599	0.0790	TiXIII	Kal2	4.528
2212 2	4.6666	2.6568	0.1580	TiXIII	Kal1	4.528
2213 1	4.6698	2.6550	0.0804	TiXIV	Kal2	4.532
2213 2	4.6752	2.6520	0.1607	TiXIV	Kal1	4.532
2214 1	4.6827	2.6477	0.1068	TiXV	Kal2	4.558
2214 2	4.6827	2.6477	0.1602	TiXV	Kal1	4.558
2215 1	4.6871	2.6452	0.1497	TiXVI	Kal2	4.585
2215 2	4.6871	2.6452	0.1497	TiXVI	Kal1	4.585

Table 1. List of Kα and Kβ innershell ionization lines (continued)

2216 1	4.6677	2.6562	0.2279	TiXVII	Kal2	4.614	2411 1	5.5501	2.2339	0.0938			
2216 2	4.6677	2.6562	0.1139	TiXVII	Kal1	4.614	2411 2	5.5590	2.2303	0.1875			
2217 1	4.6644	2.6581	0.4016	TiXVIII	Kal2	4.645	2411 3	6.1617	2.0122	0.0116			
2218 1	4.6559	2.6630	0.3438	TiXIX	Kal2	4.677	2412 1	5.5642	2.2283	0.0963			
23 1 1	4.9442	2.5076	0.0751	V II	Kal2	4.9446	2412 2	5.5731	2.2247	0.1926			
23 1 2	4.9522	2.5036	0.1502	V II	Kal1	4.9522	2412 3	6.1816	2.0057	0.0060			
23 1 3	5.4263	2.2849	0.0092	V II	Kbe3	5.4273	2413 1	5.5770	2.2231	0.0990			
23 1 4	5.4275	2.2844	0.0184	V II	Kbe1	5.4273	2413 2	5.5860	2.2196	0.1980			
23 2 1	4.9602	2.4996	0.0753				2414 1	5.5898	2.2180	0.1006			
23 2 2	4.9682	2.4956	0.1506				2414 2	5.5976	2.2150	0.2013			
23 2 3	5.4500	2.2749	0.0092				2415 1	5.5989	2.2145	0.1023			
23 2 4	5.4513	2.2744	0.0185				2415 2	5.6079	2.2109	0.2045			
23 3 1	4.9751	2.4921	0.0753				2416 1	5.6144	2.2083	0.1346			
23 3 2	4.9831	2.4881	0.1507				2416 2	5.6144	2.2083	0.2019			
23 3 3	5.4727	2.2655	0.0092				2417 1	5.6169	2.2073	0.1865			
23 3 4	5.4739	2.2650	0.0185				2417 2	5.6169	2.2073	0.1865			
23 4 1	4.9911	2.4841	0.0754				2418 1	5.5937	2.2165	0.2797			
23 4 2	4.9992	2.4801	0.1508				2418 2	5.5937	2.2165	0.1398			
23 4 3	5.4967	2.2556	0.0092				2419 1	5.5886	2.2185	0.4826			
23 4 4	5.4979	2.2551	0.0185				2420 1	5.5783	2.2226	0.4214			
23 5 1	5.0073	2.4761	0.0755				25 1 1	5.8884	2.1056	0.0928	MnII	Kal2	5.8877
23 5 2	5.0153	2.4721	0.1509				25 1 2	5.8993	2.1017	0.1855	MnII	Kal1	5.8988
23 5 3	5.5208	2.2458	0.0093				25 1 3	6.4893	1.9106	0.0116	MnII	Kbe3	6.5352
23 5 4	5.5220	2.2453	0.0185				25 1 4	6.4908	1.9101	0.0231	MnII	Kbe1	6.5352
23 6 1	5.0223	2.4687	0.0755				25 2 1	5.9034	2.1002	0.0929			
23 6 2	5.0304	2.4647	0.1510				25 2 2	5.9156	2.0959	0.1858			
23 6 3	5.5437	2.2365	0.0093				25 2 3	6.5133	1.9036	0.0116			
23 6 4	5.5450	2.2360	0.0185				25 2 4	6.5148	1.9031	0.0232			
23 7 1	5.0362	2.4619	0.0775				25 3 1	5.9197	2.0944	0.0930			
23 7 2	5.0443	2.4579	0.1550				25 3 2	5.9306	2.0906	0.1860			
23 7 3	5.5667	2.2272	0.0095				25 3 3	6.5373	1.8966	0.0116			
23 7 4	5.5667	2.2272	0.0143				25 3 4	6.5388	1.8961	0.0232			
23 8 1	5.0513	2.4545	0.0796				25 4 1	5.9334	2.0896	0.0931			
23 8 2	5.0582	2.4511	0.1591				25 4 2	5.9443	2.0858	0.1861			
23 8 3	5.5873	2.2190	0.0098				25 4 3	6.5599	1.8900	0.0116			
23 8 4	5.5873	2.2190	0.0098				25 4 4	6.5615	1.8896	0.0232			
23 9 1	5.0641	2.4483	0.0817				25 5 1	5.9470	2.0848	0.0931			
23 9 2	5.0711	2.4449	0.1634				25 5 2	5.9580	2.0810	0.1863			
23 9 3	5.5989	2.2145	0.0100				25 5 3	6.5842	1.8831	0.0116			
23 9 4	5.5989	2.2145	0.0050				25 5 4	6.5857	1.8826	0.0232			
2310 1	5.0757	2.4427	0.0839				25 6 1	5.9635	2.0791	0.0932			
2310 2	5.0828	2.4393	0.1679				25 6 2	5.9745	2.0752	0.1864			
2310 3	5.6169	2.2073	0.0103				25 6 3	6.6100	1.8757	0.0116			
2311 1	5.0898	2.4359	0.0862				25 6 4	6.6115	1.8753	0.0232			
2311 2	5.0968	2.4326	0.1725				25 7 1	5.9786	2.0738	0.0933			
2311 3	5.6377	2.1992	0.0053				25 7 2	5.9896	2.0700	0.1866			
2312 1	5.1027	2.4298	0.0886				25 7 3	6.6328	1.8692	0.0116			
2312 2	5.1098	2.4264	0.1773				25 7 4	6.6344	1.8688	0.0233			
2313 1	5.1145	2.4242	0.0902				25 8 1	5.9924	2.0690	0.0933			
2313 2	5.1215	2.4208	0.1803				25 8 2	6.0034	2.0652	0.1867			
2314 1	5.1239	2.4197	0.0917				25 8 3	6.6558	1.8628	0.0116			
2314 2	5.1310	2.4164	0.1834				25 8 4	6.6573	1.8624	0.0233			
2315 1	5.1381	2.4131	0.1212				25 9 1	6.0062	2.0643	0.0958			
2315 2	5.1381	2.4131	0.1818				25 9 2	6.0173	2.0605	0.1915			
2316 1	5.1404	2.4119	0.1689				25 9 3	6.6788	1.8564	0.0119			
2316 2	5.1404	2.4119	0.1689				25 9 4	6.6788	1.8564	0.0179			
2317 1	5.1204	2.4214	0.2550				2510 1	6.0200	2.0595	0.0983			
2317 2	5.1204	2.4214	0.1275				2510 2	6.0311	2.0557	0.1966			
2318 1	5.1145	2.4242	0.4442				2510 3	6.7004	1.8504	0.0123			
2319 1	5.1062	2.4281	0.3838				2510 4	6.7004	1.8504	0.0123			
24 1 1	5.4063	2.2933	0.0840	CrII	Kal2	5.4055	2511 1	6.0339	2.0548	0.1009			
24 1 2	5.4150	2.2896	0.1679	CrII	Kal1	5.4147	2511 2	6.0437	2.0515	0.2018			
24 1 3	5.9457	2.0853	0.0104	CrII	Kbe3	5.9467	2511 3	6.7112	1.8474	0.0126			
24 1 4	5.9470	2.0848	0.0208	CrII	Kbe1	5.9467	2511 4	6.7112	1.8474	0.0063			
24 2 1	5.4213	2.2870	0.0841				2512 1	6.0464	2.0505	0.1037			
24 2 2	5.4313	2.2828	0.1681				2512 2	6.0576	2.0468	0.2073			
24 2 3	5.9704	2.0767	0.0104				2512 3	6.7313	1.8419	0.0129			
24 2 4	5.9704	2.0767	0.0208				2513 1	6.0604	2.0458	0.1065			
24 3 1	5.4363	2.2807	0.0841				2513 2	6.0716	2.0421	0.2129			
24 3 2	5.4463	2.2765	0.1683				2513 3	6.7499	1.8368	0.0066			
24 3 3	5.9924	2.0690	0.0104				2514 1	6.0730	2.0416	0.1094			
24 3 4	5.9938	2.0686	0.0208				2514 2	6.0842	2.0378	0.2188			
24 4 1	5.4513	2.2744	0.0842				2515 1	6.0856	2.0374	0.1112			
24 4 2	5.4601	2.2707	0.1684				2515 2	6.0954	2.0341	0.2223			
24 4 3	6.0173	2.0605	0.0104				2516 1	6.0954	2.0341	0.1129			
24 4 4	6.0187	2.0600	0.0208				2516 2	6.1066	2.0303	0.2257			
24 5 1	5.4664	2.2681	0.0843				2517 1	6.1122	2.0285	0.1479			
24 5 2	5.4765	2.2639	0.1685				2517 2	6.1122	2.0285	0.2219			
24 5 3	6.0409	2.0524	0.0104				2518 1	6.1136	2.0280	0.2038			
24 5 4	6.0423	2.0519	0.0208				2518 2	6.1136	2.0280	0.2038			
24 6 1	5.4828	2.2613	0.0843				2519 1	6.0884	2.0364	0.3035			
24 6 2	5.4916	2.2577	0.1686				2519 2	6.0884	2.0364	0.1517			
24 6 3	6.0646	2.0444	0.0104				2520 1	6.0813	2.0388	0.5184			
24 6 4	6.0660	2.0439	0.0208				2521 1	6.0716	2.0421	0.4562			
24 7 1	5.4967	2.2556	0.0844				26 1 1	6.3915	1.9398	0.1013	FeII	Kal2	6.3910
24 7 2	5.5055	2.2520	0.1688				26 1 2	6.4047	1.9358	0.2026	FeII	Kal1	6.4040
24 7 3	6.0884	2.0364	0.0104				26 1 3	7.0567	1.7570	0.0127	FeII	Kbe3	7.0568
24 7 4	6.0884	2.0364	0.0209				26 1 4	7.0583	1.7566	0.0254	FeII	Kbe1	7.0582
24 8 1	5.5106	2.2499	0.0866				26 2 1	6.4077	1.9349	0.1014	FeIII	Kal2	6.3934
24 8 2	5.5195	2.2463	0.1732				26 2 2	6.4195	1.9314	0.2028	FeIII	Kal1	6.4064
24 8 3	6.1108	2.0289	0.0107				26 2 3	7.0811	1.7509	0.0127	FeIII	Kbe3	7.0682
24 8 4	6.1108	2.0289	0.0161				26 2 4	7.0827	1.7505	0.0255	FeIII	Kbe1	7.0698
24 9 1	5.5246	2.2442	0.0889				26 3 1	6.4224	1.9305	0.1015	FeIV	Kal2	6.3927
24 9 2	5.5335	2.2406	0.1778				26 3 2	6.4343	1.9269	0.2030	FeIV	Kal1	6.4057
24 9 3	6.1320	2.0219	0.0110				26 3 3	7.1056	1.7449	0.0127	FeIV	Kbe3	7.0758
24 9 4	6.1320	2.0219	0.0110				26 3 4	7.1072	1.7445	0.0255	FeIV	Kbe1	7.0774
2410 1	5.5386	2.2385	0.0913				26 4 1	6.4358	1.9265	0.1016	FeV	Kal2	6.3920
2410 2	5.5475	2.2349	0.1825				26 4 2	6.4491	1.9225	0.2032	FeV	Kal1	6.4050
2410 3	6.1433	2.0182	0.0113				26 4 3	7.1285	1.7393	0.0128	FeV	Kbe3	7.0809
2410 4	6.1433	2.0182	0.0056				26 4 4	7.1318	1.7385	0.0255	FeV	Kbe1	7.0825

Table 1. List of Kα and Kβ innershell ionization lines (continued)

26 5 1	6.4491	1.9225	0.1017	FeVI	Kal2	6.3913	2713 1	7.0876	1.7493	0.1179			
26 5 2	6.4625	1.9185	0.2034	FeVI	Kal1	6.4043	2713 2	7.1023	1.7457	0.2358			
26 5 3	7.1515	1.7337	0.0128	FeVI	Kbe3	7.0868	2713 3	7.9232	1.5648	0.0148			
26 5 4	7.1532	1.7333	0.0255	FeVI	Kbe1	7.0884	2713 4	7.9232	1.5648	0.0074			
26 6 1	6.4640	1.9181	0.1018	FeVII	Kal2	6.3906	2714 1	7.1007	1.7461	0.1211			
26 6 2	6.4774	1.9141	0.2035	FeVII	Kal1	6.4036	2714 2	7.1154	1.7425	0.2421			
26 6 3	7.1763	1.7277	0.0128	FeVII	Kbe3	7.0951	2714 3	7.9433	1.5609	0.0152			
26 6 4	7.1796	1.7269	0.0255	FeVII	Kbe1	7.0967	2715 1	7.1154	1.7425	0.1243			
26 7 1	6.4789	1.9137	0.1018	FeVIII	Kal2	6.3899	2715 2	7.1302	1.7389	0.2486			
26 7 2	6.4923	1.9097	0.2037	FeVIII	Kal1	6.4029	2715 3	7.9634	1.5569	0.0078			
26 7 3	7.2028	1.7213	0.0128	FeVIII	Kbe3	7.1039	2716 1	7.1285	1.7393	0.1277			
26 7 4	7.2044	1.7209	0.0256	FeVIII	Kbe1	7.1055	2716 2	7.1433	1.7357	0.2554			
26 8 1	6.4938	1.9093	0.1019	FeIX	Kal2	6.3892	2717 1	7.1400	1.7365	0.1296			
26 8 2	6.5073	1.9053	0.2038	FeIX	Kal1	6.4022	2717 2	7.1548	1.7329	0.2591			
26 8 3	7.2244	1.7162	0.0128	FeIX	Kbe3	7.1083	2718 1	7.1515	1.7337	0.1314			
26 8 4	7.2277	1.7154	0.0256	FeIX	Kbe1	7.1099	2718 2	7.1664	1.7301	0.2628			
26 9 1	6.5088	1.9049	0.1020	FeX	Kal2	6.3886	2719 1	7.1713	1.7289	0.1710			
26 9 2	6.5208	1.9014	0.2040	FeX	Kal1	6.4016	2719 2	7.1713	1.7289	0.2565			
26 9 3	7.2494	1.7103	0.0128	FeX	Kbe3	7.1165	2720 1	7.1713	1.7289	0.2339			
26 9 4	7.2510	1.7099	0.0256	FeX	Kbe1	7.1181	2720 2	7.1713	1.7289	0.2339			
2610 1	6.5223	1.9009	0.1046	FeXI	Kal2	6.3905	2721 1	7.1417	1.7361	0.3451			
2610 2	6.5343	1.8974	0.2092	FeXI	Kal1	6.4035	2721 2	7.1417	1.7361	0.1726			
2610 3	7.2728	1.7048	0.0131	FeXI	Kbe3	7.1271	2722 1	7.1335	1.7381	0.5839			
2610 4	7.2728	1.7048	0.0197	FeXI	Kbe1	7.1271	2723 1	7.1203	1.7413	0.5267			
2611 1	6.5358	1.8970	0.1074	FeXII	Kal2	6.3964	28 1 1	7.4611	1.6618	0.1226	NiII	Kal2	7.4609
2611 2	6.5494	1.8931	0.2147	FeXII	Kal1	6.4096	28 1 2	7.4783	1.6579	0.2451	NiII	Kal1	7.4782
2611 3	7.2946	1.6997	0.0135	FeXII	Kbe3	7.1388	28 1 3	8.2623	1.5006	0.0154	NiII	Kbe3	8.2647
2611 4	7.2946	1.6997	0.0135	FeXII	Kbe1	7.1388	28 1 4	8.2642	1.5003	0.0309	NiII	Kbe1	8.2647
2612 1	6.5509	1.8926	0.1102	FeXIII	Kal2	6.3407	28 2 1	7.4748	1.6587	0.1227	NiIII	Kal2	7.473
2612 2	6.5630	1.8892	0.2204	FeXIII	Kal1	6.4137	28 2 2	7.4920	1.6549	0.2454	NiIII	Kal1	7.473
2612 3	7.3047	1.6973	0.0138	FeXIII	Kbe3	7.1391	28 2 3	8.2871	1.4961	0.0155	NiIII	Kbe3	8.286
2612 4	7.3047	1.6973	0.0069	FeXIII	Kbe1	7.1391	28 2 4	8.2909	1.4954	0.0309	NiIII	Kbe1	8.286
2613 1	6.5630	1.8892	0.1132	FeXIV	Kal2	6.4055	28 3 1	7.4886	1.6556	0.1228	NiIV	Kal2	7.473
2613 2	6.5766	1.8852	0.2264	FeXIV	Kal1	6.4186	28 3 2	7.5059	1.6518	0.2456	NiIV	Kal1	7.473
2613 3	7.3249	1.6926	0.0142	FeXIV	Kbe3	7.1492	28 3 3	8.3119	1.4916	0.0155	NiIV	Kbe3	8.295
2614 1	6.5781	1.8848	0.1162	FeXV	Kal2	6.4107	28 3 4	8.3138	1.4913	0.0309	NiIV	Kbe1	8.295
2614 2	6.5902	1.8813	0.2325	FeXV	Kal1	6.4238	28 4 1	7.5041	1.6522	0.1229	NiV	Kal2	7.473
2614 3	7.3451	1.6880	0.0073	FeXV	Kbe3	7.1592	28 4 2	7.5214	1.6484	0.2458	NiV	Kal1	7.473
2615 1	6.5902	1.8813	0.1194	FeXVI	Kal2	6.4164	28 4 3	8.3368	1.4872	0.0155	NiV	Kbe3	8.303
2615 2	6.6024	1.8779	0.2389	FeXVI	Kal1	6.4295	28 4 4	8.3407	1.4865	0.0310	NiV	Kbe1	8.303
2616 1	6.6024	1.8779	0.1213	FeXVII	Kal2	6.4209	28 5 1	7.5180	1.6492	0.1230	NiVI	Kal2	7.473
2616 2	6.6145	1.8744	0.2425	FeXVII	Kal1	6.4340	28 5 2	7.5353	1.6454	0.2459	NiVI	Kal1	7.473
2617 1	6.6130	1.8748	0.1231	FeXVIII	Kal2	6.4259	28 5 3	8.3618	1.4827	0.0155	NiVI	Kbe3	8.313
2617 2	6.6267	1.8710	0.2461	FeXVIII	Kal1	6.4390	28 5 4	8.3637	1.4824	0.0310	NiVI	Kbe1	8.313
2618 1	6.6313	1.8697	0.1606	FeXIX	Kal2	6.468	28 6 1	7.5318	1.6461	0.1231	NiVII	Kal2	7.473
2618 2	6.6313	1.8697	0.2409	FeXIX	Kal1	6.468	28 6 2	7.5492	1.6424	0.2461	NiVII	Kal1	7.473
2619 1	6.6313	1.8697	0.2202	FeXX	Kal2	6.5028	28 6 3	8.3869	1.4783	0.0155	NiVII	Kbe3	8.322
2619 2	6.6313	1.8697	0.2202	FeXX	Kal1	6.502	28 6 4	8.3888	1.4780	0.0310	NiVII	Kbe1	8.322
2620 1	6.6054	1.8770	0.3258	FeXXI	Kal2	6.536	28 7 1	7.5457	1.6431	0.1232	NiVIII	Kal2	7.473
2620 2	6.6054	1.8770	0.1629	FeXXI	Kal1	6.536	28 7 2	7.5631	1.6393	0.2463	NiVIII	Kal1	7.473
2621 1	6.5963	1.8796	0.5521	FeXXII	Kal2	6.574	28 7 3	8.4120	1.4739	0.0155	NiVIII	Kbe3	8.331
2622 1	6.5857	1.8826	0.4903	FeXXIII	Kal2	6.574	28 7 4	8.4140	1.4736	0.0310	NiVIII	Kbe1	8.331
27 1 1	6.9151	1.7929	0.1084	CoII	Kal2	6.9153	28 8 1	7.5596	1.6401	0.1232	NiIX	Kal2	7.473
27 1 2	6.9295	1.7892	0.2168	CoII	Kal1	6.9303	28 8 2	7.5770	1.6363	0.2465	NiIX	Kal1	7.473
27 1 3	7.6472	1.6213	0.0136	CoII	Kbe3	7.6494	28 8 3	8.4353	1.4698	0.0155	NiIX	Kbe3	8.339
27 1 4	7.6489	1.6209	0.0272	CoII	Kbe1	7.6494	28 8 4	8.4392	1.4692	0.0311	NiIX	Kbe1	8.339
27 2 1	6.9295	1.7892	0.1085				28 9 1	7.5753	1.6367	0.1233	NiX	Kal2	7.469
27 2 2	6.9454	1.7851	0.2171				28 9 2	7.5928	1.6329	0.2467	NiX	Kal1	7.469
27 2 3	7.6718	1.6161	0.0136				28 9 3	8.4606	1.4654	0.0155	NiX	Kbe3	8.342
27 2 4	7.6736	1.6157	0.0273				28 9 4	8.4645	1.4648	0.0311	NiX	Kbe1	8.342
27 3 1	6.9454	1.7851	0.1086				2810 1	7.5893	1.6337	0.1234	NiXI	Kal2	7.469
27 3 2	6.9599	1.7814	0.2172				2810 2	7.6068	1.6299	0.2468	NiXI	Kal1	7.469
27 3 3	7.6966	1.6109	0.0136				2810 3	8.4859	1.4611	0.0156	NiXI	Kbe3	8.351
27 3 4	7.6984	1.6105	0.0273				2810 4	8.4899	1.4604	0.0311	NiXI	Kbe1	8.351
27 4 1	6.9599	1.7814	0.1087				2811 1	7.6033	1.6307	0.1235	NiXII	Kal2	7.469
27 4 2	6.9743	1.7777	0.2174				2811 2	7.6208	1.6269	0.2470	NiXII	Kal1	7.469
27 4 3	7.7215	1.6057	0.0137				2811 3	8.5114	1.4567	0.0156	NiXII	Kbe3	8.361
27 4 4	7.7232	1.6053	0.0273				2811 4	8.5133	1.4564	0.0311	NiXII	Kbe1	8.361
27 5 1	6.9727	1.7781	0.1088				2812 1	7.6190	1.6273	0.1266	NiXIII	Kal2	7.473
27 5 2	6.9888	1.7741	0.2176				2812 2	7.6366	1.6236	0.2533	NiXIII	Kal1	7.473
27 5 3	7.7446	1.6009	0.0137				2812 3	8.5369	1.4523	0.0160	NiXIII	Kbe3	8.374
27 5 4	7.7464	1.6005	0.0273				2812 4	8.5369	1.4523	0.0239	NiXIII	Kbe1	8.374
27 6 1	6.9871	1.7745	0.1089				2813 1	7.6331	1.6243	0.1299	NiXIV	Kal2	7.478
27 6 2	7.0016	1.7708	0.2177				2813 2	7.6507	1.6206	0.2597	NiXIV	Kal1	7.478
27 6 3	7.7696	1.5958	0.0137				2813 3	8.5585	1.4487	0.0164	NiXIV	Kbe3	8.384
27 6 4	7.7714	1.5954	0.0274				2813 4	8.5585	1.4487	0.0164	NiXIV	Kbe1	8.384
27 7 1	7.0016	1.7708	0.1089				2814 1	7.6472	1.6213	0.1332	NiXV	Kal2	7.487
27 7 2	7.0162	1.7671	0.2179				2814 2	7.6648	1.6176	0.2665	NIXV	Kal1	7.487
27 7 3	7.7929	1.5910	0.0137				2814 3	8.5684	1.4470	0.0168	NiXV	Kbe3	8.839
27 7 4	7.7965	1.5903	0.0274				2814 4	8.5684	1.4470	0.0084	NiXV	Kbe1	8.389
27 8 1	7.0162	1.7671	0.1090				2815 1	7.6613	1.6183	0.1367	NiXVI	Kal2	7.491
27 8 2	7.0307	1.7635	0.2181				2815 2	7.6771	1.6150	0.2735	NiXVI	Kal1	7.491
27 8 3	7.8181	1.5859	0.0137				2815 3	8.5882	1.4437	0.0172	NiXVI	Kbe3	8.398
27 8 4	7.8217	1.5851	0.0274				2816 1	7.6754	1.6153	0.1403	NiXVII	Kal2	7.496
27 9 1	7.0307	1.7635	0.1091				2816 2	7.6913	1.6120	0.2807	NiXVII	Kal1	7.496
27 9 2	7.0453	1.7598	0.2182				2816 3	8.6099	1.4400	0.0088	NiXVII	Kbe3	8.409
27 9 3	7.8433	1.5808	0.0137				2817 1	7.6878	1.6127	0.1441	NiXVIII	Kal2	7.505
27 9 4	7.8451	1.5804	0.0274				2817 2	7.7055	1.6090	0.2883	NiXVIII	Kal1	7.505
2710 1	7.0453	1.7598	0.1092				2818 1	7.7002	1.6102	0.1461	NiXIX	Kal2	7.510
2710 2	7.0599	1.7562	0.2184				2818 2	7.7161	1.6068	0.2921	NiXIX	Kal1	7.510
2710 3	7.8668	1.5760	0.0137				2819 1	7.7108	1.6079	0.1479	NiXX	Kal2	7.514
2710 4	7.8705	1.5753	0.0274				2819 2	7.7286	1.6042	0.2959	NiXX	Kal1	7.514
2711 1	7.0599	1.7562	0.1120				2820 1	7.7321	1.6035	0.1913	NiXXI	Kal2	7.551
2711 2	7.0746	1.7525	0.2240				2820 2	7.7321	1.6035	0.2870	NiXXI	Kal1	7.551
2711 3	7.8922	1.5710	0.0141				2821 1	7.7321	1.6035	0.2596	NiXXII	Kal2	7.588
2711 4	7.8922	1.5710	0.0211				2821 2	7.7321	1.6035	0.2596	NiXXII	Kal1	7.588
2712 1	7.0746	1.7525	0.1149				2822 1	7.7002	1.6102	0.3797	NiXXIII	Kal2	7.625
2712 2	7.0892	1.7489	0.2298				2822 2	7.7002	1.6102	0.1898	NiXXIII	Kal1	7.625
2712 3	7.9141	1.5666	0.0144				2823 1	7.6913	1.6120	0.6355	NiXXIV	Kal2	7.668
2712 4	7.9141	1.5666	0.0144				2824 1	7.6771	1.6150	0.5836	NiXXV	Kal2	7.710

Table 1. List of Kα and Kβ innershell ionization lines (continued)

29 1 1	8.0279	1.5444	0.1311	CuII	Kal2	8.0278
29 1 2	8.0482	1.5405	0.2621	CuII	Kal1	8.0478
29 1 3	8.9023	1.3927	0.0166	CuII	Kbe3	8.9029
29 1 4	8.9064	1.3921	0.0332	CuII	Kbe1	8.9053
29 2 1	8.0408	1.5419	0.1312			
29 2 2	8.0593	1.5384	0.2623			
29 2 3	8.9248	1.3892	0.0166			
29 2 4	8.9289	1.3886	0.0333			
29 3 1	8.0538	1.5395	0.1313			
29 3 2	8.0742	1.5356	0.2625			
29 3 3	8.9516	1.3851	0.0166			
29 3 4	8.9536	1.3847	0.0333			
29 4 1	8.0686	1.5366	0.1314			
29 4 2	8.0872	1.5331	0.2627			
29 4 3	8.9764	1.3812	0.0166			
29 4 4	8.9784	1.3809	0.0333			
29 5 1	8.0816	1.5341	0.1315			
29 5 2	8.1021	1.5303	0.2629			
29 5 3	9.0012	1.3774	0.0167			
29 5 4	9.0033	1.3771	0.0333			
29 6 1	8.0965	1.5313	0.1315			
29 6 2	8.1171	1.5274	0.2631			
29 6 3	9.0261	1.3736	0.0167			
29 6 4	9.0303	1.3730	0.0333			
29 7 1	8.1133	1.5282	0.1316			
29 7 2	8.1339	1.5243	0.2633			
29 7 3	9.0552	1.3692	0.0167			
29 7 4	9.0573	1.3689	0.0334			
29 8 1	8.1246	1.5260	0.1317			
29 8 2	8.1452	1.5222	0.2635			
29 8 3	9.0782	1.3657	0.0167			
29 8 4	9.0803	1.3654	0.0334			
29 9 1	8.1395	1.5232	0.1318			
29 9 2	8.1583	1.5197	0.2637			
29 9 3	9.1033	1.3620	0.0167			
29 9 4	9.1075	1.3613	0.0334			
2910 1	8.1545	1.5204	0.1319			
2910 2	8.1733	1.5169	0.2639			
2910 3	9.1285	1.3582	0.0167			
2910 4	9.1327	1.3576	0.0334			
2911 1	8.1696	1.5176	0.1320			
2911 2	8.1884	1.5141	0.2641			
2911 3	9.1538	1.3545	0.0167			
2911 4	9.1580	1.3538	0.0335			
2912 1	8.1828	1.5152	0.1321			
2912 2	8.2035	1.5114	0.2643			
2912 3	9.1791	1.3507	0.0167			
2912 4	9.1833	1.3501	0.0335			
2913 1	8.1979	1.5124	0.1354			
2913 2	8.2186	1.5086	0.2708			
2913 3	9.2087	1.3464	0.0172			
2913 4	9.2087	1.3464	0.0257			
2914 1	8.2130	1.5096	0.1388			
2914 2	8.2338	1.5058	0.2777			
2914 3	9.2300	1.3433	0.0176			
2914 4	9.2300	1.3433	0.0176			
2915 1	8.2262	1.5072	0.1424			
2915 2	8.2471	1.5034	0.2848			
2915 3	9.2385	1.3420	0.0181			
2915 4	9.2385	1.3420	0.0090			
2916 1	8.2414	1.5044	0.1461			
2916 2	8.2604	1.5010	0.2923			
2916 3	9.2598	1.3390	0.0185			
2917 1	8.2547	1.5020	0.1500			
2917 2	8.2756	1.4982	0.2999			
2917 3	9.2790	1.3362	0.0095			
2918 1	8.2680	1.4996	0.1540			
2918 2	8.2871	1.4961	0.3079			
2919 1	8.2794	1.4975	0.1559			
2919 2	8.3004	1.4937	0.3118			
2920 1	8.2909	1.4954	0.1578			
2920 2	8.3119	1.4916	0.3156			
2921 1	8.3157	1.4910	0.2034			
2921 2	8.3157	1.4910	0.3051			
2922 1	8.3138	1.4913	0.2750			
2922 2	8.3138	1.4913	0.2750			
2923 1	8.2813	1.4972	0.4005			
2923 2	8.2813	1.4972	0.2002			
2924 1	8.2699	1.4992	0.6678			
2925 1	8.2547	1.5020	0.6215			
30 1 1	8.6159	1.4390	0.1316	ZnII	Kal2	8.6158
30 1 2	8.6397	1.4350	0.2631	ZnII	Kal1	8.6389
30 1 3	9.5675	1.2959	0.0168	ZnII	Kbe3	9.5720
30 1 4	9.5719	1.2953	0.0335	ZnII	Kbe1	9.5720
30 2 1	8.6258	1.4374	0.1317			
30 2 2	8.6497	1.4334	0.2633			
30 2 3	9.5896	1.2929	0.0168			
30 2 4	9.5940	1.2923	0.0336			
30 3 1	8.6397	1.4350	0.1318			
30 3 2	8.6636	1.4311	0.2635			
30 3 3	9.6139	1.2896	0.0168			
30 3 4	9.6183	1.2890	0.0336			
30 4 1	8.6537	1.4327	0.1319			
30 4 2	8.6776	1.4288	0.2637			
30 4 3	9.6383	1.2864	0.0168			
30 4 4	9.6427	1.2858	0.0336			
30 5 1	8.6676	1.4304	0.1320			
30 5 2	8.6916	1.4265	0.2639			
30 5 3	9.6650	1.2828	0.0168			
30 5 4	9.6694	1.2822	0.0337			
30 6 1	8.6816	1.4281	0.1321			
30 6 2	8.7056	1.4242	0.2641			
30 6 3	9.6895	1.2796	0.0168			
30 6 4	9.6939	1.2790	0.0337			
30 7 1	8.6976	1.4255	0.1322			
30 7 2	8.7197	1.4219	0.2643			
30 7 3	9.7163	1.2760	0.0169			
30 7 4	9.7208	1.2755	0.0337			
30 8 1	8.7116	1.4232	0.1323			
30 8 2	8.7357	1.4193	0.2645			
30 8 3	9.7432	1.2725	0.0169			
30 8 4	9.7477	1.2719	0.0337			
30 9 1	8.7257	1.4209	0.1324			
30 9 2	8.7498	1.4170	0.2647			
30 9 3	9.7701	1.2690	0.0169			
30 9 4	9.7746	1.2684	0.0338			
3010 1	8.7398	1.4186	0.1325			
3010 2	8.7640	1.4147	0.2649			
3010 3	9.7949	1.2658	0.0169			
3010 4	9.7994	1.2652	0.0338			
3011 1	8.7539	1.4163	0.1326			
3011 2	8.7781	1.4124	0.2651			
3011 3	9.8220	1.2623	0.0169			
3011 4	9.8265	1.2617	0.0338			
3012 1	8.7700	1.4137	0.1327			
3012 2	8.7922	1.4102	0.2653			
3012 3	9.8492	1.2588	0.0169			
3012 4	9.8537	1.2582	0.0338			
3013 1	8.7842	1.4115	0.1328			
3013 2	8.8064	1.4079	0.2655			
3013 3	9.8742	1.2556	0.0169			
3013 4	9.8787	1.2551	0.0339			
3014 1	8.8004	1.4089	0.1361			
3014 2	8.8227	1.4053	0.2722			
3014 3	9.9038	1.2519	0.0174			
3014 4	9.9038	1.2519	0.0260			
3015 1	8.8125	1.4069	0.1395			
3015 2	8.8369	1.4030	0.2791			
3015 3	9.9243	1.2493	0.0178			
3015 4	9.9243	1.2493	0.0178			
3016 1	8.8267	1.4046	0.1431			
3016 2	8.8512	1.4008	0.2863			
3016 3	9.9312	1.2484	0.0183			
3016 4	9.9312	1.2484	0.0091			
3017 1	8.8410	1.4024	0.1469			
3017 2	8.8654	1.3985	0.2938			
3017 3	9.9541	1.2456	0.0187			
3018 1	8.8552	1.4001	0.1507			
3018 2	8.8797	1.3963	0.3015			
3018 3	9.9724	1.2433	0.0096			
3019 1	8.8675	1.3982	0.1548			
3019 2	8.8920	1.3943	0.3096			
3020 1	8.8797	1.3963	0.1567			
3020 2	8.9043	1.3924	0.3134			
3021 1	8.8941	1.3940	0.1586			
3021 2	8.9187	1.3902	0.3172			
3022 1	8.9207	1.3898	0.2045			
3022 2	8.9207	1.3898	0.3067			
3023 1	8.9166	1.3905	0.2766			
3023 2	8.9166	1.3905	0.2766			
3024 1	8.8818	1.3959	0.4033			
3024 2	8.8818	1.3959	0.2016			
3025 1	8.8695	1.3979	0.6742			
3026 1	8.8512	1.4008	0.6322			

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N.B.
Explanation of the table:
Z = atomic number, s = ionization stage, l = line transition (notation from KM92), E = energy, lambda = wavelength (from KM92 yield = fluorescence yield (photons per ionization) (from KM92), transition = ion and line transition, E_H = energy, lam_H = wavelength (from H69 and BB67).