MODULE 8
Observing, modelling and analysing solar spectra

Demonstration script

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1 Demo (a) Exploiting line ratios

```
------------------------------
DEMO a: Exploiting line ratios
------------------------------
PURPOSE: The contour of line ratio as a function of Te and Ne show
when the ratio depend on Te or Ne (e.g. for a certain value of Ne the ratio
has Ne constant in a wide range o Te or vice-versa). It helps to find
line ratios which give Te or Ne diagnostic.

EXAMPLE: In the solar case a line ratio used as electron diagnostic is:
Fe+11 193.51 Ang./(186.86 Ang.+186.88 Ang.). This ratio is observed by
Hinode/EIS.
The transitions are the following:
193.51 Ang. 3s2 3p3 4S3/2 - 3p2 3d 4P3/2
186.86 Ang. 3s2 3p3 2D3/2 - 3p2 3d 2F5/2
186.88 Ang. 3s2 3p3 2D5/2 - 3p2 3d 2F7/2

Therefore, IC resolution is required.
The adf04 for Fe+11 in IC resolution within ADAS are the following:
1. /home/adas/adas/adf04/copmm#26/ic#fe11.dat
2. /home/adas/adas/adf04/cophps/dw/ic#fe11.dat
3. /home/adas/adas/adf04/plike/plike_al97#fe11.dat
4. /home/adas/adas/adf04/copch#26/chv6_ic#fe11.dat

The preferred adf04 for the demo is 4., because it contains the most recent
calculation  for Fe+11 (R-matrix from Storey et al. 2005).

COMMENTS: If the preferred adf04 is 2. (new DW from AUTOSTRUCTURE), then before
using the adf04, in most cases and especially using the IC resolution, it is
necessary to cut the file to remove the transitions arising from the levels above
the ionisation potential. This is done using trim_cophps_adf04.pro  (in
/home/adas/idl/adaslib/proc_adf/).



DEMO a-1: Using ADAS205 and ADAS207 from interactive ADAS windows.

1. Use ADAS205 to create a contour.pass file
  (input files : adf04/copch#26/chv6_ic#fe11.dat
   output files: pass/demo_a_1_graph205.ps
               : pass/demo_a_1_paper205.txt
               : pass/contour.pass).
2. Use the contour.pass as input for ADA207
  (input files : contour.pass
   output files: pass/demo_a_1_graph207.ps
               : pass/demo_a_1_paper207.txt).


DEMO a-2: Displaying line ratios using the command line.
```

```
1. Use read_adf15.pro to read an adf15 dataset of the PEC for the line considered.
OR
1. If the PEC is not available, use run_adas208.pro to produce the PEC
   and then use read_adf15.pro to read it.
2. Plot the PEC ratio as a function of Te and Ne in a contour plot.
3. Compare the plots obtained in DEMO a-1 and DEMO a-2.
   (idl procedure: demo_a/demo_a_2.pro
    input files  : adf04/copch#26/chv6_ic#fe11.dat
    output files : pass/demo_a_2.txt
                 : pass/demo_a_2_pecfile.dat
                 : pass/demo_a_2.ps
```

1.1 Demo (a) Figures

1.1.1 Demo (a-1) demo_a/demo_a_1_graph205.pdf

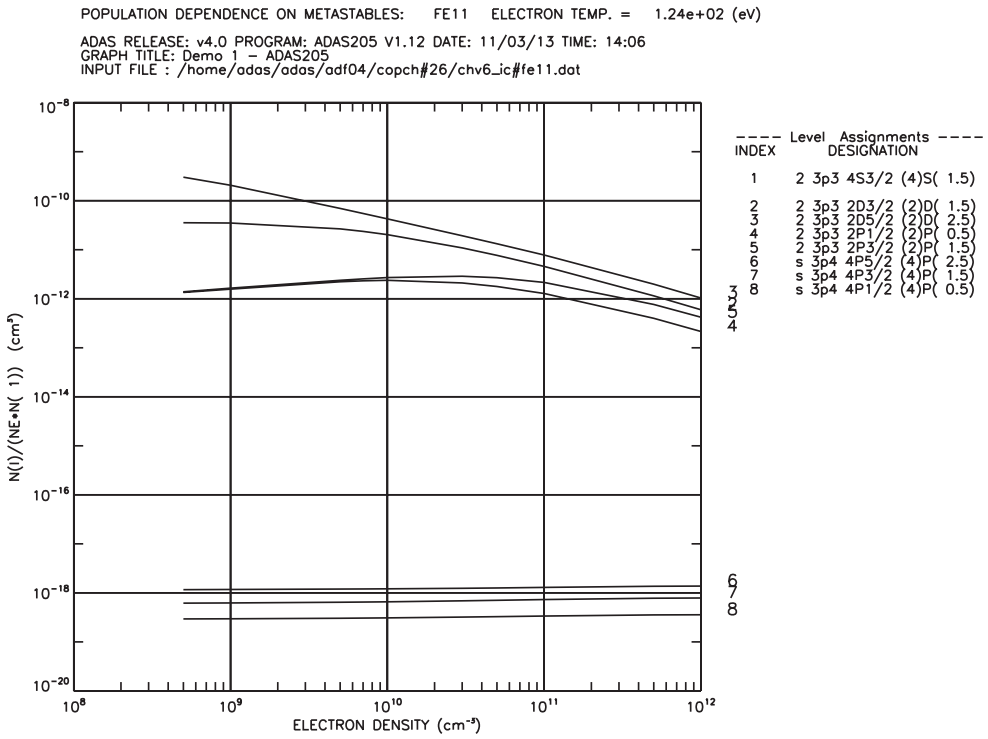

Figure 1: Population ratios $N_i/(N_e N_1$ vs N_e at fixed T_e. Note the traces for $i = 2, 3, 4, 5$ at low density have not become flat. They have not reached the coronal limit at these densities and are large ($N_i \sim N_1$) - properly they should be treated as metastables

1.1.2 Demo (a-1) demo_a/demo_a_1_graph207.pdf

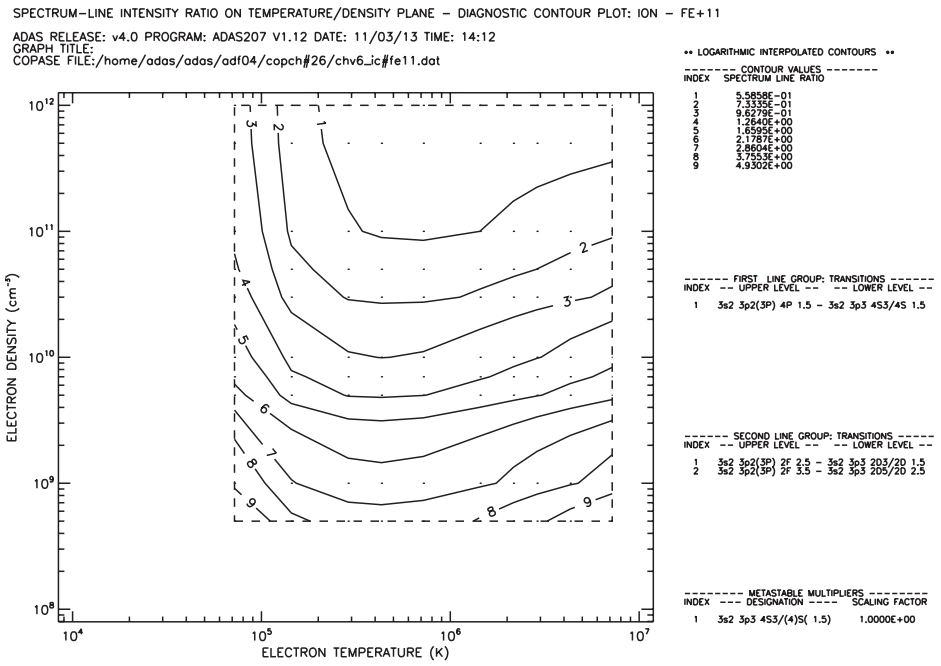

Figure 2: Contour plot of emissivity ratio in the T_e/N_e plane. ADAS207 graphical output.

1.1.3 Demo (a-2) demo_a/demo_a_2.pdf

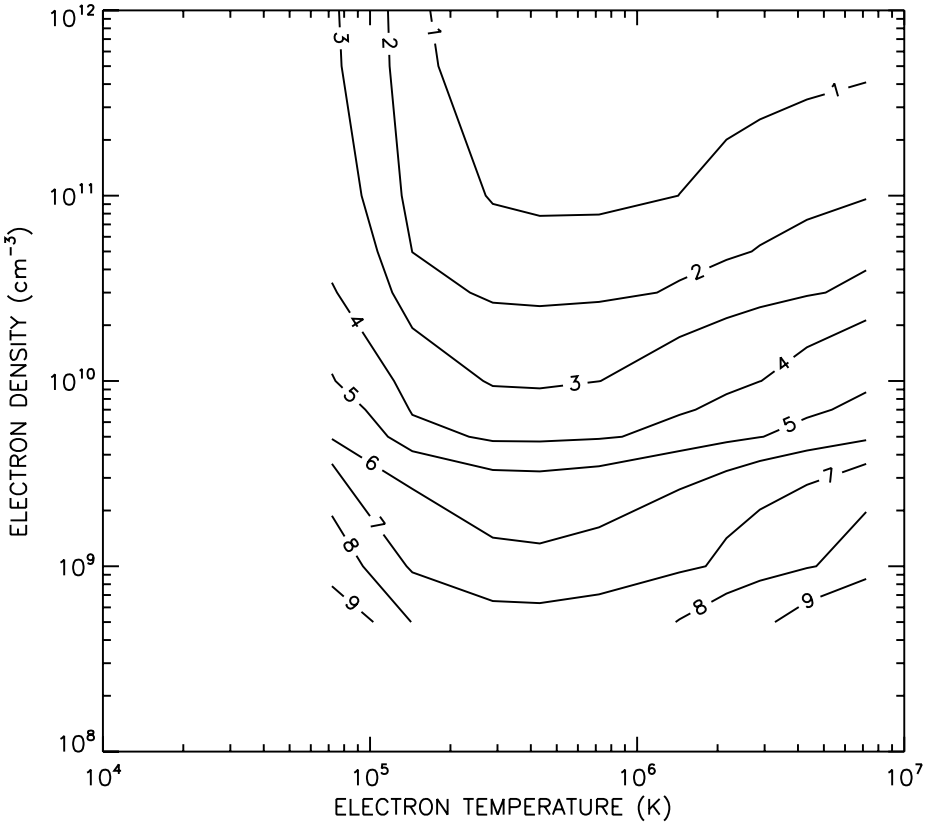

Figure 3: Contour plot of emissivity ratio in the T_e/N_e plane. Caclulated in IDL at the commmand lines with script *demo_a_2.pro* and main procedures *run_adas208* and *read_adf15.pro*

1.2 Demo (a) IDL procedures

1.2.1 Demo (a-2) demo_a_2.pro

Demonstration IDL procedure using *run_adas208.pro* and *read_adf15*.

```
pro demo_a_2
;Use run_adas208 to produce a PEC
;for Fe+11 193.51 A/(186.86 A+186.88 A): density diagnostic in
;the solar case

;define electron temperature (eV) and electron density array (cm-3)
te=[6.204E+00,1.241E+01,2.482E+01,3.722E+01,6.204E+01,1.241E+02,1.861E+02,$
    2.482E+02,3.722E+02,6.204E+02]
dens=[5.000E+08,1.000E+09,5.000E+09,7.000E+09,1.000E+10,3.000E+10,5.000E+10,$
      1.000E+11,5.000E+11,1.000E+12]

nte=n_elements(te)
ndens=n_elements(dens)

;define input values for run_adas208
unit_te   = 'eV'
unit_dens = 'cm-3'

wmin      = 100.
wmax      = 300.
amin      = 1.0e-3

adf04='/home/hps/adas_central/adas/adf04/copch#26/chv6_ic#fe11.dat'


meta_list=[1]

;Use run_adas208.pro to produce a PEC file of the type adf15
run_adas208, adf04=adf04,                                              $
             te=te,dens=dens, unit_te=unit_te,unit_dens=unit_dens,     $
             meta=meta_list,                                           $
             wmin=100.0, wmax=300.0, amin=1e6,                          $
             log='demo_a_2.txt',  /pec, pass_dir='.',pop=pop


cmd = 'mv pec.pass demo_a_2_pecfile.dat'
spawn, cmd, /sh


;Use read_adf15.pro to read the PEC file produced by run_adas208.pro
file='demo_a_2_pecfile.dat'
block=[2,3,5]
nblock=n_elements(block)

data=fltarr(nblock,nte,ndens)
```

```
for i=0,nblock-1 do begin
  read_adf15,file=file,block=block[i],te=te,dens=dens,   $
             data=idata,wlngth=wlngth,/all
  data[i,*,*]=idata
endfor

;plot the line ratio
set_plot,'ps'
device, /isolatin1, font_index=8
device, bits=8, filename='demo_a_2.ps',  $
        font_size = 14, xsize=18.0, ysize=16.0, $
        yoffset=7.0, /color
device, /helvetica

;contour plot
contour,data[0,*,*]/(data[1,*,*]+data[2,*,*]),te*11604.,dens, $
        xtit='ELECTRON TEMPERATURE (K)',                      $
        ytit='ELECTRON DENSITY (cm!u-3!n)',                   $
        c_annotation=['1','2','3','4','5','6','7','8','9'],  $
        /xlog,/ylog,                                          $
        lev=[5.6931e-1,7.4804e-1,9.8289e-1,1.2915e0,1.6969e0, $
             2.2296e0,2.9296e0,3.8494e0,5.0579e0]

;intesity ratio versus electron density at a fixed electron temperature
plot_oo,dens,data[0,5,*]/(data[1,5,*]+data[2,5,*]),    $
        xtit='ELECTRON DENSITY (cm!u-3!n)',            $
        ytit='SPECTRUM LINE RATIO (PH)'


;intesity ratio versus electron temperature at a fixed electron density
plot_oo,te*11604.,data[0,*,4]/(data[1,*,4]+data[2,*,4]),   $
        xtit='ELECTRON TEMPERATURE (K)',                   $
        ytit='SPECTRUM LINE RATIO (PH)'

device, /close
set_plot,'X'
!p.font=-1

end
```

1.3 Demo (a) Tables and datasets

1.3.1 Demo (a-1) adf04/copch#26/chv6_ic#fe11.dat

Input adf04 dataset for interactive execution of ADAS205.

```
FE+11        26        12       2668150.5
    1 3s2 3p3 4S3/2         (4)0( 1.5)             0.0
    2 3s2 3p3 2D3/2         (2)2( 1.5)         44401.0
    3 3s2 3p3 2D5/2         (2)2( 2.5)         48820.0
    4 3s2 3p3 2P1/2         (2)1( 0.5)         76629.0
        .         .         .
  141 3s2 3p 3d2 4D3/2      (4)2( 1.5)       1014502.0
  142 3s 3p3 3d 2S1/2       (2)0( 0.5)       1014750.0
  143 3s2 3p 3d2 4D1/2      (4)2( 0.5)       1015458.0
   -1
 12.0    3       4.00+03 8.00+03 1.20+04 2.00+04 4.00+04 8.00+04 1.20+05 2.00+05 4.00+05 8.00+05 1.20+06 2.00+06 4.00+06
    2   1 5.64+01 7.63-01 7.64-01 7.64-01 7.65-01 7.66-01 7.65-01 7.61-01 7.35-01 6.07-01 4.24-01 3.26-01 2.26-01 1.32-01
    3   1 2.34+00 1.02+00 1.02+00 1.02+00 1.02+00 1.02+00 1.01+00 1.00+00 9.58-01 7.87-01 5.53-01 4.27-01 3.00-01 1.80-01
    4   1 1.93+02 2.70-01 2.70-01 2.70-01 2.69-01 2.68-01 2.65-01 2.61-01 2.47-01 1.96-01 1.33-01 9.93-02 6.65-02 3.69-02
    5   1 3.47+02 4.73-01 4.75-01 4.77-01 4.80-01 4.89-01 5.02-01 5.09-01 4.98-01 4.03-01 2.73-01 2.04-01 1.36-01 7.53-02
        .         .         .
  141  25 1.00-30 2.47-04 2.47-04 2.46-04 2.45-04 2.41-04 2.34-04 2.28-04 2.17-04 1.98-04 1.74-04 1.57-04 1.34-04 1.03-04
  142  25 1.00-30 4.07-04 4.06-04 4.06-04 4.04-04 3.99-04 3.91-04 3.82-04 3.66-04 3.32-04 2.81-04 2.46-04 1.98-04 1.38-04
  143  25 1.00-30 1.14-04 1.14-04 1.14-04 1.13-04 1.12-04 1.09-04 1.07-04 1.02-04 9.17-05 7.78-05 6.85-05 5.53-05 3.87-05
   -1
   -1  -1
C-----------------------------------------------------------------------------
C
C  Data generated from CHIANTI version 6.0
C
C       http://www.chianti.rl.ac.uk/
C
C  CHIANTI references
C  ------------------
        .       .       .
C
C-----------------------------------------------------------------------------
C
C Filtered adf04 file to
C  - sort energy levels
C  - remove non physical A values from
C    energy level reversals
C  - remove energies above ionisation potential
C  - remove duplicate transitions
C
C Code     : ADAS utility program, filter04
C Date     : 04-08-2009
C Producer : Martin O'Mullane
C
C-----------------------------------------------------------------------------
```

1.3.2 Demo (a-1) demo_a/demo_a_1_paper205.txt

Output summary text data set from interactive execution of ADAS205.

```
ADAS RELEASE: v4.0 PROGRAM: ADAS205 V1.12 DATE: 21/03/13 TIME: 09:11
************************** TABULAR OUTPUT FROM METASTABLE POPULATION  PROGRAM: ADAS205 - DATE: 21/03/13 ***************************

INPUT COPASE FILE NAME: /home/hps/adas_central/adas/adf04/copch#26/chv6_ic#fe11.dat

 ION      NUCLEAR        RECOMBINING      ------- IONIZATION POTENTIAL -------
         CHARGE (Z0)    ION CHARGE (Z1)    (wave number <cm-1>)     (rydbergs)
 ---------------------------------------------------------------------------
 FE+11        26              12                2668150.          24.3140284


------------------------------------------------------ ENERGY LEVELS ------------------------------------------------------
  INDEX    CONFIGURATION   (2S+1)L(J)       ----- ENERGY RELATIVE TO LEVEL 1 ------    ENERGY RELATIVE TO IONISATION POTENTIAL
                                             (wave number <cm-1>)     (rydbergs)        (wave number <cm-1>)     (rydbergs)
 ---------------------------------------------------------------------------------------------------------------------------
    1  3s2 3p3 4S3/2       (4)0(   1.5)                 0.          0.0000000              2668150.          24.3140284
    2  3s2 3p3 2D3/2       (2)2(   1.5)             44401.          0.4046125              2623750.          23.9094158
    3  3s2 3p3 2D5/2       (2)2(   2.5)             48820.          0.4448815              2619330.          23.8691469
    4  3s2 3p3 2P1/2       (2)1(   0.5)             76629.          0.6982963              2591522.          23.6157321
    5  3s2 3p3 2P3/2       (2)1(   1.5)             82567.          0.7524075              2585584.          23.5616209
    6  3s 3p4 4P5/2        (4)1(   2.5)            273532.          2.4926123              2394618.          21.8214161
        .       .       .
  139  3s2 3p 3d2 4D7/2    (4)2(   3.5)           1012175.          9.2236370              1655976.          15.0903914
  140  3s2 3p 3d2 4D5/2    (4)2(   2.5)           1013361.          9.2344447              1654790.          15.0795837
  141  3s2 3p 3d2 4D3/2    (4)2(   1.5)           1014502.          9.2448422              1653648.          15.0691861
  142  3s 3p3 3d 2S1/2     (2)0(   0.5)           1014750.          9.2471022              1653400.          15.0669262
  143  3s2 3p 3d2 4D1/2    (4)2(   0.5)           1015458.          9.2535540              1652692.          15.0604744

-- INPUT COPASE FILE TEMPERATURES: (TE=TP=TH) --
 INDEX    (kelvin)        (eV)        (reduced)
 ---------------------------------------------
   1      4.00E+03      3.45E-01      2.78E+01
   2      8.00E+03      6.89E-01      5.56E+01
   3      1.20E+04      1.03E+00      8.33E+01
   4      2.00E+04      1.72E+00      1.39E+02
   5      4.00E+04      3.45E+00      2.78E+02
```

```
   6      8.00E+04      6.89E+00      5.56E+02
   7      1.20E+05      1.03E+01      8.33E+02
   8      2.00E+05      1.72E+01      1.39E+03
   9      4.00E+05      3.45E+01      2.78E+03
  10      8.00E+05      6.89E+01      5.56E+03
  11      1.20E+06      1.03E+02      8.33E+03
  12      2.00E+06      1.72E+02      1.39E+04
  13      4.00E+06      3.45E+02      2.78E+04

INPUT COPASE FILE INFORMATION:
------------------------------
NUMBER OF ELECTRON IMPACT TRANSITIONS    =   1638
NUMBER OF PROTON   IMPACT TRANSITIONS    =      0
NUMBER OF CHARGE EXCHANGE RECOMBINATIONS =      0
NUMBER OF FREE   ELECTRON RECOMBINATIONS =      0

METASTABLE INFORMATION:
-----------------------
NUMBER OF ORDINARY LEVELS        = 142
NUMBER OF METASTABLES            =   1

---------------- METASTABLE DETAILS ----------------
METASTABLE    ENERGY LEVEL    ---- DESIGNATION -----
   INDEX          INDEX
 ------------------------------------------------------
    1             1          2 3p3 4S3/2 (4)S( 1.5)

OUTPUT PLASMA PARAMETERS:
-------------------------

NUMBER OF TEMPERATURES     = 10
NUMBER OF DENSITIES/RATIOS = 10

INDEX   --------- TEMPERATURES (UNITS: eV) ---------
           ELECTRON        PROTON    NEUTRAL HYDROGEN
             <TE>           <TP>           <TH>
-----------------------------------------------------
   1       6.204E+00      1.000E+00 #    1.000E+00 #
   2       1.241E+01      1.000E+00 #    1.000E+00 #
   3       2.482E+01      1.000E+00 #    1.000E+00 #
   4       3.722E+01      1.000E+00 #    1.000E+00 #
   5       6.204E+01      1.000E+00 #    1.000E+00 #
   6       1.241E+02      1.000E+00 #    1.000E+00 #
   7       1.861E+02      1.000E+00 #    1.000E+00 #
   8       2.482E+02      1.000E+00 #    1.000E+00 #
   9       3.722E+02 *    1.000E+00 #    1.000E+00 #
  10       6.204E+02 *    1.000E+00 #    1.000E+00 #
-----------------------------------------------------
KEY: * = WARNING - TEMPERATURE OUT OF RANGE
                 - EXTRAPOLATION REQUIRED
     # = PARAMETER NOT USED IN CALCULATIONS
-----------------------------------------------------
PROTON IMPACT COLLISIONS         - NOT INCLUDED
IONIZATION RATES                 - NOT INCLUDED
NEUTRAL HYDROGEN CHARGE EXCHANGE - NOT INCLUDED
FREE ELECTRON RECOMBINATION      - NOT INCLUDED

INDEX    DENSITIES (UNITS: cm-3)      --------- RATIOS ---------
           ELECTRON        PROTON           NH/NE      N(Z+1)/N(Z)
             <NE>           <NP>
-------------------------------------------------------------------
   1       5.000E+08     0.000E+00 #     0.000E+00 #   0.000E+00 #
   2       1.000E+09     0.000E+00 #     0.000E+00 #   0.000E+00 #
   3       5.000E+09     0.000E+00 #     0.000E+00 #   0.000E+00 #
   4       7.000E+09     0.000E+00 #     0.000E+00 #   0.000E+00 #
   5       1.000E+10     0.000E+00 #     0.000E+00 #   0.000E+00 #
   6       3.000E+10     0.000E+00 #     0.000E+00 #   0.000E+00 #
   7       5.000E+10     0.000E+00 #     0.000E+00 #   0.000E+00 #
   8       1.000E+11     0.000E+00 #     0.000E+00 #   0.000E+00 #
   9       5.000E+11     0.000E+00 #     0.000E+00 #   0.000E+00 #
  10       1.000E+12     0.000E+00 #     0.000E+00 #   0.000E+00 #
-------------------------------------------------------------------
NOTE: NH/NE       = NEUTRAL HYDROGEN DENSITY / ELECTRON DENSITY
      N(Z+1)/N(Z) = STAGE ABUNDANCIES
-------------------------------------------------------------------

TABLE KEY:
----------
NE    = ELECTRON DENSITY
TE    = ELECTRON TEMPERATURE
I     = ENERGY   LEVEL INDEX
IMET  = METASTABLE     INDEX
IORD  = ORDINARY LEVEL INDEX

NUMBER OF PROTON IMPACT COLLISIONS       INCLUDED =    0
NUMBER OF FREE   ELECTRON RECOMBINATIONS INCLUDED =    0
NUMBER OF CHARGE EXCHANGE RECOMBINATIONS INCLUDED =    0


 NE(CM-3)=  5.0000E+08  1.0000E+09  5.0000E+09  7.0000E+09  1.0000E+10  3.0000E+10  5.0000E+10  1.0000E+11  5.0000E+11  1.0000E+12
-------------------------------------------------------------------------------------------------------------------------------

EQUILIBRIUM METASTABLE POPULATION DEPENDENCE ON DENSITY AT TE =  6.20E+00 EV  =   7.20E+04 KELVIN
   IMET  I
    1    1  1.0000E+00  1.0000E+00  1.0000E+00  1.0000E+00  1.0000E+00  1.0000E+00  1.0000E+00  1.0000E+00  1.0000E+00  1.0000E+00

1

POPULATION DEPENDENCE ON DENSITY AND METASTABLE  1
   IORD  I
    1    2  3.5702E-02  6.4051E-02  1.7348E-01  1.9990E-01  2.2753E-01  3.0458E-01  3.3343E-01  3.6302E-01  3.9534E-01  4.0019E-01
    2    3  1.1236E-01  1.4510E-01  2.5651E-01  2.8506E-01  3.1640E-01  4.1303E-01  4.5251E-01  4.9446E-01  5.4160E-01  5.4876E-01
    3    4  1.5481E-03  3.5078E-03  1.9077E-02  2.5262E-02  3.2908E-02  6.0392E-02  7.2627E-02  8.5957E-02  1.0120E-01  1.0353E-01
    4    5  1.2120E-03  2.8530E-03  1.9744E-02  2.8173E-02  3.9758E-02  8.9600E-02  1.1468E-01  1.4331E-01  1.7724E-01  1.8252E-01
       .       .       .
  135  136  4.0129E-14  1.2290E-13  1.3261E-12  2.1871E-12  3.7700E-12  2.1949E-11  5.0331E-11  1.4922E-10  1.3640E-09  3.1197E-09
  136  137  5.7230E-13  1.4768E-12  1.2145E-11  1.8708E-11  2.9601E-11  1.2228E-10  2.3609E-10  5.7205E-10  4.0351E-09  8.7625E-09
  137  138  1.6941E-12  4.0654E-12  3.4427E-11  5.4838E-11  9.0280E-11  4.2124E-10  8.5432E-10  2.1914E-09  1.6754E-08  3.6874E-08
  138  139  2.2710E-13  4.5525E-13  2.2986E-12  3.2288E-12  4.6320E-12  1.4139E-11  2.3800E-11  4.8360E-11  2.5759E-10  5.4491E-10
  139  140  3.6678E-13  7.3490E-13  3.7040E-12  5.2000E-12  7.4547E-12  2.2686E-11  3.8114E-11  7.7154E-11  3.9998E-10  8.1939E-10
  140  141  1.2189E-12  2.4407E-12  1.2265E-11  1.7199E-11  2.4622E-11  7.4508E-11  1.2481E-10  2.5155E-10  1.2803E-09  2.5741E-09
  141  142  7.1637E-10  1.7983E-09  1.4477E-08  2.2296E-08  3.5268E-08  1.4433E-07  2.7561E-07  6.5452E-07  4.4167E-06  9.4739E-06
  142  143  1.0925E-08  2.2234E-08  1.1747E-07  1.6696E-07  2.4281E-07  7.7717E-07  1.3393E-06  2.8064E-06  1.5424E-05  3.1625E-05
************************************************** EQUILIBRIUM  POPULATIONS **************************************************

 LEVEL =    1 - EQUILIBRIUM POPULATION
 ------------------------------------
NE (CM-3)      5.00E+08  1.00E+09  5.00E+09  7.00E+09  1.00E+10  3.00E+10  5.00E+10  1.00E+11  5.00E+11  1.00E+12
```

```
TE (EV)    ------------------------------------------------------------------------------------------------
  6.20E+00 |   1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
  1.24E+01 |   1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
  2.48E+01 |   1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
  3.72E+01 |   1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
  6.20E+01 |   1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
  1.24E+02 |   1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
  1.86E+02 |   1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
  2.48E+02 |   1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
  3.72E+02 |   1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
  6.20E+02 |   1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
        .       .       .

 LEVEL =  143 - EQUILIBRIUM POPULATION
 -------------------------------------
NE (CM-3)      5.00E+08  1.00E+09  5.00E+09  7.00E+09  1.00E+10  3.00E+10  5.00E+10  1.00E+11  5.00E+11  1.00E+12
TE (EV)    ------------------------------------------------------------------------------------------------
  6.20E+00 |   3.84E-16  7.90E-16  4.39E-15  6.30E-15  9.24E-15  3.00E-14  5.16E-14  1.06E-13  5.52E-13  1.11E-12
  1.24E+01 |   6.75E-12  1.38E-11  7.53E-11  1.08E-10  1.58E-10  5.09E-10  8.76E-10  1.81E-09  9.47E-09  1.91E-08
  2.48E+01 |   7.35E-10  1.50E-09  8.06E-09  1.15E-08  1.68E-08  5.38E-08  9.24E-08  1.91E-07  1.00E-06  2.02E-06
  3.72E+01 |   3.17E-09  6.45E-09  3.45E-08  4.91E-08  7.16E-08  2.29E-07  3.93E-07  8.15E-07  4.27E-06  8.61E-06
  6.20E+01 |   9.08E-09  1.85E-08  9.82E-08  1.40E-07  2.04E-07  6.50E-07  1.11E-06  2.31E-06  1.22E-05  2.46E-05
  1.24E+02 |   1.62E-08  3.29E-08  1.74E-07  2.47E-07  3.60E-07  1.15E-06  1.97E-06  4.09E-06  2.18E-05  4.41E-05
  1.86E+02 |   1.70E-08  3.46E-08  1.83E-07  2.60E-07  3.78E-07  1.21E-06  2.07E-06  4.32E-06  2.31E-05  4.70E-05
  2.48E+02 |   1.63E-08  3.31E-08  1.75E-07  2.48E-07  3.61E-07  1.15E-06  1.98E-06  4.13E-06  2.23E-05  4.53E-05
  3.72E+02 |   1.41E-08  2.88E-08  1.52E-07  2.16E-07  3.14E-07  1.00E-06  1.73E-06  3.61E-06  1.96E-05  4.00E-05
  6.20E+02 |   1.09E-08  2.22E-08  1.17E-07  1.67E-07  2.43E-07  7.77E-07  1.34E-06  2.81E-06  1.54E-05  3.16E-05
```

1.3.3 Demo (a-1) demo_a/demo_a_1_paper207.txt

Output summary text data set from interactive execution of ADAS207.

```
ADAS RELEASE: v4.0 PROGRAM: ADAS207 V1.12 DATE: 21/03/13 TIME: 09:20
************************* TABULAR OUTPUT FROM SPECTRUM LINE DIAGNOSTIC PROGRAM: ADAS207 - DATE: 21/03/13 ***************************

INPUT CONTOUR-PASSING FILE DSN: /home/hps/adas_central/adas/pass/contour.pass
ASSOCIATED   COPASE   FILE DSN: /home/hps/adas_central/adas/adf04/copch#26/chv6_ic#fe11.dat

 ION      NUCLEAR        RECOMBINING      ------- IONIZATION POTENTIAL -------
        CHARGE (Z0)    ION CHARGE (Z1)    (wave number <cm-1>)     (rydbergs)
-------------------------------------------------------------------------------
FE+11        26              12                2668150.          24.3140284


 ------------------------------------------------------ ENERGY LEVELS ------------------------------------------------------------------------------
 INDEX    CONFIGURATION   (2S+1)L(J)       ----- ENERGY RELATIVE TO LEVEL 1 ------    ENERGY RELATIVE TO IONISATION POTENTIAL
                                            (wave number <cm-1>)     (rydbergs)        (wave number <cm-1>)     (rydbergs)
-------------------------------------------------------------------------------------------------------------------------------------------
   1   3s2 3p3 4S3/2      (4)0( 1.5)                    0.           0.0000000              2668150.          24.3140284
   2   3s2 3p3 2D3/2      (2)2( 1.5)                44401.           0.4046125              2623750.          23.9094158
   3   3s2 3p3 2D5/2      (2)2( 2.5)                48820.           0.4448815              2619330.          23.8691469
   4   3s2 3p3 2P1/2      (2)1( 0.5)                76629.           0.6982963              2591522.          23.6157321
   5   3s2 3p3 2P3/2      (2)1( 1.5)                82567.           0.7524075              2585584.          23.5616209
   6   3s 3p4 4P5/2       (4)1( 2.5)               273532.           2.4926123              2394618.          21.8214161
       .       .       .
 141   3s2 3p 3d2 4D3/2   (4)2( 1.5)              1014502.           9.2448422              1653648.          15.0691861
 142   3s 3p3 3d 2S1/2    (2)0( 0.5)              1014750.           9.2471022              1653400.          15.0669262
 143   3s2 3p 3d2 4D1/2   (4)2( 0.5)              1015458.           9.2535540              1652692.          15.0604744

METASTABLE INFORMATION:
-----------------------
NUMBER OF ORDINARY LEVELS        = 142
NUMBER OF METASTABLES            =   1
---------------- METASTABLE DETAILS ----------------
METASTABLE     ENERGY LEVEL     ---- DESIGNATION -----
  INDEX           INDEX
----------------------------------------------------
    1              1          3s2 3p3 4S3/(4)S( 1.5)

***** NEUTRAL HYDROGEN CHARGE EXCHANGE  NOT INCLUDED *****
*****   FREE ELECTRON RECOMBINATION  NOT  INCLUDED   *****

INPUT PLASMA PARAMETERS:
------------------------

NUMBER OF ELECTRON TEMPERATURES = 10
NUMBER OF ELECTRON DENSITIES    = 10
INDEX   -------- TE:  ELECTRON TEMPERATURES --------          INDEX   -- NE: ELECTRON DENSITIES --
          (kelvin)         (eV)         (reduced)                        (cm-3)       (reduced)
-----------------------------------------------------          -----------------------------------
  1       7.200E+04      6.204E+00      5.000E+02                1       5.000E+08      1.395E+01
  2       1.440E+05      1.241E+01      1.000E+03                2       1.000E+09      2.791E+01
  3       2.880E+05      2.482E+01      2.000E+03                3       5.000E+09      1.395E+02
  4       4.320E+05      3.722E+01      3.000E+03                4       7.000E+09      1.954E+02
  5       7.200E+05      6.204E+01      5.000E+03                5       1.000E+10      2.791E+02
  6       1.440E+06      1.241E+02      1.000E+04                6       3.000E+10      8.372E+02
  7       2.160E+06      1.861E+02      1.500E+04                7       5.000E+10      1.395E+03
  8       2.880E+06      2.482E+02      2.000E+04                8       1.000E+11      2.791E+03
  9       4.320E+06      3.722E+02      3.000E+04                9       5.000E+11      1.395E+04
 10       7.200E+06      6.204E+02      5.000E+04               10       1.000E+12      2.791E+04
-----------------------------------------------------          -----------------------------------

TABLE KEY:
----------
```

```
NE    = ELECTRON DENSITY
TE    = ELECTRON TEMPERATURE
****************************************** SPECTRUM LINE INTENSITIES & RATIOS: CONTROL DATA ******************************************
TRANSIENT CONDITIONS: EQUILIBRIUM

---------- METASTABLE LEVEL SCALING FACTORS ----------
 INDEX  LEVEL       DESIGNATION        SCALING FACTOR
------------------------------------------------------
   1      1    3s2 3p3 4S3/(4)S( 1.5)     1.0000E+00

---------------------------------- FIRST  COMPOSITE LINE GROUP ASSEMBLY ----------------------------------
       TRANSTN   -- UPPER LEVEL -- -------------------- TRANSITION --------------------
INDEX   INDEX      INDEX    TYPE   ----- UPPER LEVEL ------   ----- LOWER LEVEL ------    A-VALUE (SEC-1)
-----------------------------------------------------------------------------------------------------
  1       29          30      ORD    <3s2 3p2(3P) (4)P( 0.5)> - <3s2 3p3 4S3/(4)S( 1.5)>       8.66E+10

--------------------------------- SECOND COMPOSITE LINE GROUP ASSEMBLY ---------------------------------
       TRANSTN   -- UPPER LEVEL -- -------------------- TRANSITION --------------------
INDEX   INDEX      INDEX    TYPE   ----- UPPER LEVEL ------   ----- LOWER LEVEL ------    A-VALUE (SEC-1)
-----------------------------------------------------------------------------------------------------
  1      177          37      ORD    <3s2 3p2(3P) (2)F( 2.5)> - <3s2 3p3 2D3/(2)D( 1.5)>       9.94E+10
  2      319          39      ORD    <3s2 3p2(3P) (2)F( 3.5)> - <3s2 3p3 2D5/(2)D( 2.5)>       1.06E+11
****************************************** SPECTRUM LINE INTENSITIES & RATIOS:  RESULTS ******************************************

FIRST  COMPOSITE LINE GROUP ASSEMBLY - SPECTRUM LINE INTENSITIES
----------------------------------------------------------------
NE  (CM-3)     5.00E+08  1.00E+09  5.00E+09  7.00E+09  1.00E+10  3.00E+10  5.00E+10  1.00E+11  5.00E+11  1.00E+12
TE (KELVIN)----------------------------------------------------------------------------------------------------
  7.20E+04 |   1.64E-04  3.29E-04  1.69E-03  2.38E-03  3.43E-03  1.06E-02  1.78E-02  3.60E-02  1.82E-01  3.66E-01
  1.44E+05 |   2.28E-02  4.58E-02  2.33E-01  3.28E-01  4.71E-01  1.44E+00  2.43E+00  4.91E+00  2.49E+01  4.99E+01
  2.88E+05 |   2.28E-01  4.58E-01  2.32E+00  3.26E+00  4.68E+00  1.43E+01  2.39E+01  4.83E+01  2.44E+02  4.89E+02
  4.32E+05 |   4.59E-01  9.21E-01  4.65E+00  6.53E+00  9.37E+00  2.85E+01  4.77E+01  9.62E+01  4.86E+02  9.74E+02
  7.20E+05 |   7.49E-01  1.50E+00  7.57E+00  1.06E+01  1.52E+01  4.61E+01  7.73E+01  1.56E+02  7.86E+02  1.57E+03
  1.44E+06 |   9.69E-01  1.94E+00  9.76E+00  1.37E+01  1.96E+01  5.93E+01  9.93E+01  2.00E+02  1.01E+03  2.02E+03
  2.16E+06 |   1.01E+00  2.02E+00  1.01E+01  1.42E+01  2.03E+01  6.14E+01  1.03E+02  2.07E+02  1.04E+03  2.09E+03
  2.88E+06 |   1.00E+00  2.01E+00  1.01E+01  1.41E+01  2.02E+01  6.11E+01  1.02E+02  2.06E+02  1.04E+03  2.08E+03
  4.32E+06 |   9.66E-01  1.93E+00  9.70E+00  1.36E+01  1.95E+01  5.88E+01  9.83E+01  1.98E+02  9.97E+02  2.00E+03
  7.20E+06 |   8.86E-01  1.77E+00  8.89E+00  1.25E+01  1.78E+01  5.38E+01  8.99E+01  1.81E+02  9.12E+02  1.83E+03


SECOND COMPOSITE LINE GROUP ASSEMBLY - SPECTRUM LINE INTENSITIES
----------------------------------------------------------------
NE  (CM-3)     5.00E+08  1.00E+09  5.00E+09  7.00E+09  1.00E+10  3.00E+10  5.00E+10  1.00E+11  5.00E+11  1.00E+12
TE (KELVIN)----------------------------------------------------------------------------------------------------
  7.20E+04 |   5.62E-05  1.56E-04  1.59E-03  2.51E-03  4.03E-03  1.61E-02  2.95E-02  6.46E-02  3.55E-01  7.20E-01
  1.44E+05 |   1.24E-02  3.40E-02  3.38E-01  5.35E-01  8.62E-01  3.53E+00  6.57E+00  1.47E+01  8.33E+01  1.70E+02
  2.88E+05 |   1.51E-01  4.10E-01  3.97E+00  6.29E+00  1.01E+01  4.18E+01  7.84E+01  1.78E+02  1.03E+03  2.10E+03
  4.32E+05 |   3.15E-01  8.56E-01  8.21E+00  1.30E+01  2.10E+01  8.69E+01  1.64E+02  3.74E+02  2.19E+03  4.49E+03
  7.20E+05 |   5.12E-01  1.40E+00  1.33E+01  2.11E+01  3.42E+01  1.43E+02  2.71E+02  6.25E+02  3.75E+03  7.73E+03
  1.44E+06 |   6.16E-01  1.73E+00  1.65E+01  2.62E+01  4.25E+01  1.81E+02  3.45E+02  8.09E+02  5.05E+03  1.05E+04
  2.16E+06 |   5.92E-01  1.69E+00  1.64E+01  2.60E+01  4.22E+01  1.81E+02  3.48E+02  8.23E+02  5.25E+03  1.10E+04
  2.88E+06 |   5.52E-01  1.60E+00  1.57E+01  2.49E+01  4.05E+01  1.75E+02  3.37E+02  8.02E+02  5.22E+03  1.10E+04
  4.32E+06 |   4.79E-01  1.42E+00  1.42E+01  2.26E+01  3.68E+01  1.60E+02  3.11E+02  7.46E+02  4.97E+03  1.06E+04
  7.20E+06 |   3.80E-01  1.16E+00  1.19E+01  1.91E+01  3.12E+01  1.38E+02  2.68E+02  6.50E+02  4.45E+03  9.57E+03


SPECTRUM LINE INTENSITY RATIO
-----------------------------
NE  (CM-3)     5.00E+08  1.00E+09  5.00E+09  7.00E+09  1.00E+10  3.00E+10  5.00E+10  1.00E+11  5.00E+11  1.00E+12
TE (KELVIN)----------------------------------------------------------------------------------------------------
  7.20E+04 |   2.91E+00  2.10E+00  1.06E+00  9.47E-01  8.50E-01  6.55E-01  6.03E-01  5.57E-01  5.14E-01  5.08E-01
  1.44E+05 |   1.83E+00  1.34E+00  6.90E-01  6.13E-01  5.47E-01  4.09E-01  3.70E-01  3.34E-01  2.99E-01  2.94E-01
  2.88E+05 |   1.51E+00  1.12E+00  5.84E-01  5.19E-01  4.62E-01  3.41E-01  3.05E-01  2.72E-01  2.38E-01  2.33E-01
  4.32E+05 |   1.46E+00  1.08E+00  5.67E-01  5.03E-01  4.47E-01  3.27E-01  2.92E-01  2.57E-01  2.22E-01  2.17E-01
  7.20E+05 |   1.46E+00  1.07E+00  5.68E-01  5.03E-01  4.45E-01  3.23E-01  2.85E-01  2.49E-01  2.09E-01  2.04E-01
  1.44E+06 |   1.57E+00  1.12E+00  5.91E-01  5.23E-01  4.61E-01  3.29E-01  2.88E-01  2.47E-01  2.00E-01  1.92E-01
  2.16E+06 |   1.70E+00  1.19E+00  6.19E-01  5.46E-01  4.81E-01  3.39E-01  2.95E-01  2.51E-01  1.99E-01  1.90E-01
  2.88E+06 |   1.82E+00  1.25E+00  6.44E-01  5.68E-01  4.99E-01  3.49E-01  3.03E-01  2.56E-01  1.99E-01  1.89E-01
  4.32E+06 |   2.02E+00  1.36E+00  6.84E-01  6.03E-01  5.29E-01  3.66E-01  3.16E-01  2.65E-01  2.01E-01  1.89E-01
  7.20E+06 |   2.33E+00  1.53E+00  7.45E-01  6.54E-01  5.72E-01  3.91E-01  3.35E-01  2.78E-01  2.05E-01  1.91E-01
```

1.3.4 Demo (a-2) demo_a/demo_a_2_pecfile.dat

Output pec data set from command line use of demo_a_2.pro.

```
  50    /FE+11 EMISSIVITY COEFFTS./
  191.7 A  10  10 /FILMEM = _ic#fe11/TYPE = EXCIT    /INDM = T/ISEL =    1
5.00E+08 1.00E+09 5.00E+09 7.00E+09 1.00E+10 3.00E+10 5.00E+10 1.00E+11
5.00E+11 1.00E+12
6.20E+00 1.24E+01 2.48E+01 3.72E+01 6.20E+01 1.24E+02 1.86E+02 2.48E+02
3.72E+02 6.20E+02
1.02E-12 1.27E-10 1.22E-09 2.43E-09 3.97E-09 5.29E-09 5.56E-09 5.59E-09
5.48E-09 5.17E-09
9.67E-13 1.19E-10 1.14E-09 2.27E-09 3.72E-09 4.97E-09 5.25E-09 5.29E-09
5.20E-09 4.93E-09
8.17E-13 9.61E-11 9.12E-10 1.82E-09 3.01E-09 4.11E-09 4.39E-09 4.46E-09
4.43E-09 4.25E-09
7.85E-13 9.11E-11 8.61E-10 1.72E-09 2.85E-09 3.90E-09 4.18E-09 4.25E-09
4.24E-09 4.08E-09
7.52E-13 8.59E-11 8.08E-10 1.61E-09 2.67E-09 3.67E-09 3.95E-09 4.03E-09
4.03E-09 3.89E-09
6.65E-13 7.18E-11 6.60E-10 1.31E-09 2.17E-09 3.00E-09 3.25E-09 3.33E-09
3.35E-09 3.27E-09
6.35E-13 6.67E-11 6.05E-10 1.20E-09 1.98E-09 2.72E-09 2.94E-09 3.02E-09
```

```
 3.05E-09 2.98E-09
 6.06E-13 6.17E-11 5.49E-10 1.08E-09 1.76E-09 2.40E-09 2.58E-09 2.65E-09
 2.67E-09 2.61E-09
 5.78E-13 5.65E-11 4.89E-10 9.44E-10 1.50E-09 1.98E-09 2.08E-09 2.10E-09
 2.08E-09 2.00E-09
 5.75E-13 5.58E-11 4.80E-10 9.24E-10 1.46E-09 1.90E-09 1.99E-09 2.00E-09
 1.97E-09 1.87E-09
   190.3 A  10  10 /FILMEM = _ic#fe11/TYPE = EXCIT    /INDM = T/ISEL =    2
 5.00E+08 1.00E+09 5.00E+09 7.00E+09 1.00E+10 3.00E+10 5.00E+10 1.00E+11
 5.00E+11 1.00E+12
 6.20E+00 1.24E+01 2.48E+01 3.72E+01 6.20E+01 1.24E+02 1.86E+02 2.48E+02
 3.72E+02 6.20E+02
        .        .        .

 3.42E-11 3.04E-11
 3.71E-15 8.32E-13 9.65E-12 1.96E-11 3.15E-11 3.94E-11 4.00E-11 3.92E-11
 3.71E-11 3.37E-11
C-----------------------------------------------------------------------
C
C  PHOTON EMISSIVITY COEFFICIENTS:
C
C
C  INFORMATION
C  -----------
C
C  NUCLEAR CHARGE = 26
C  ION CHARGE +1  = 12
C
C  SPECIFIC ION FILE  : /home/adas/adas/adf04/copch#26/chv6_ic#fe11.dat
C  EXPANSION FILE     : No projection data was used in this case.
C
C  No ionisation data has been included
C
C  OPTIONS  : LNORM=T  LPSEL=F  LZSEL=F  LIOSEL=F
C             LHSEL=F  LRSEL=F  LISEL=F  LNSEL =F
C
C
C   Configuration           (2s+1)l(w-1/2)          Energy (cm**-1)
C     1   3s2 3p3 4S3/2         (4)0( 1.5)             0.0
C     2   3s2 3p3 2D3/2         (2)2( 1.5)         44401.0
C     3   3s2 3p3 2D5/2         (2)2( 2.5)         48820.0
C     4   3s2 3p3 2P1/2         (2)1( 0.5)         76629.0
C     5   3s2 3p3 2P3/2         (2)1( 1.5)         82567.0
       .        .        .
C   140   3s2 3p 3d2 4D5/2      (4)2( 2.5)        1013361.0
C   141   3s2 3p 3d2 4D3/2      (4)2( 1.5)        1014502.0
C   142   3s 3p3 3d 2S1/2       (2)0( 0.5)        1014750.0
C   143   3s2 3p 3d2 4D1/2      (4)2( 0.5)        1015458.0
C
C
C
C  ISEL  WAVELENGTH       TRANSITION               TYPE   METASTABLE  IMET NMET  IP
C  ----  ----------  --------------------------  -----  ----------- ---- ----  --
C   1.     191.68     27(4)1( 2.5)-   1(4)0( 1.5)  EXCIT                T    1
C   2.     190.25     29(4)1( 1.5)-   1(4)0( 1.5)  EXCIT                T    1
C   3.     183.55     39(2)3( 3.5)-   3(2)2( 2.5)  EXCIT                T    1
C   4.     189.35     30(4)1( 0.5)-   1(4)0( 1.5)  EXCIT                T    1
C   5.     183.54     37(2)3( 2.5)-   2(2)2( 1.5)  EXCIT                T    1
C   6.     187.32     40(2)2( 2.5)-   5(2)1( 1.5)  EXCIT                T    1
C   7.     216.74     26(2)1( 1.5)-   3(2)2( 2.5)  EXCIT                T    1
       .        .        .

C  46.     242.95    114(2)3( 3.5)-  25(2)4( 4.5)  EXCIT                T    1
C  47.     186.72     31(2)2( 1.5)-   1(4)0( 1.5)  EXCIT                T    1
C  48.     182.98     32(2)2( 2.5)-   1(4)0( 1.5)  EXCIT                T    1
C  49.     215.31    111(4)4( 5.5)-  17(4)3( 4.5)  EXCIT                T    1
C  50.     224.61     28(2)1( 0.5)-   4(2)1( 0.5)  EXCIT                T    1
C
C  CODE     : ADAS208
C  PRODUCER : Hugh Summers
C  DATE     : 22/03/13
C
C-------------------------------------------------------------------------------
```

2 Demo (b) Building up contribution functions and the kernel

```
------------------------------
DEMO b: Building up contribution functions and the kernel.
------------------------------
PURPOSE: Build up the contribution functions G(Te(Ne)) using a model with constant
electron density or constant electron pressure (Pe~Ne*Te). The final scope is to
create a collection file, called kernel, which contains the G-functions for all the
lines observed by a spectrometer, e.g. SUMER and CDS onboard SoHO and EIS onbloard
Hinode.

The observed lines with their intensities are collected within the directory
/home/adas/adas/arch601/intensity/. An intensity file is created by hand by the
user. It contains the line specifications: elements, ionisation stages,
wavelengths, transitions, indices to detect the blends, indices to relate each line
to the respective contribution function (G-index), observed intensities and
observed errors.  In the intensity files, the link between observations and theory
is given by the G-index. These indices specify the transition as it appears in the
adf20 and it is kept in the kernel file. The kernel is a collection file (in
/home/adas/adas/arch601/kernel/), which contains the  G-functions for all the
selected transitions. Finally in /home/adas/adas/arch601/abundance/ there is a
collection of elemental abundances, which are needed  for the Differential Emission
Measure (DEM) analysis  (DEMO c).


EXAMPLE: In the solar case the intensity file
/home/adas/adas/arch601/intensity/sumer_cds_eis_qs.dat  contains intensities
observed by SoHO/SUMER, SoHO/CDS and Hinode/EIS. The G-functions are built up for
the lines present in that intensity file.
A model with constant electron density Ne=1.e10 cm-3 and a model with constant
pressure Pe=1.e14 K cm-3 are used.

The lines included in the demo are the following:
INSTRUMENT  ION    WAVEL.(Ang.) TRANSITION                      LOG(Te(K))
from CDS    O+4    629.732      2s2 1S0 - 2s 2p 1P1             5.35
from CDS    Ne+3   542.070      2s2 2p3 4S3/2 - 2s 2p4 4P3/2    5.20
from CDS    Ne+3   543.886      2s2 2p3 4S3/2 - 2s 2p4 4P5/2    5.20
from SUMER  Si+1  1304.370      3s2 3p 2P1/2 - 3s 3p2 2S1/2     4.45
from SUMER  Si+1  1309.276      3s2 3p 2P3/2 - 3s 3p2 2S1/2     4.45
from EIS    Si+6   275.353      2s2 2p4 3P2 - 2s 2p5 3P2        5.80
from EIS    Si+6   275.667      2s2 2p4 3P1 - 2s 2p5 3P1        5.80
from CDS    Si+11  520.662      2s 2S1/2 - 2p 2P1/2             6.30


The adf04 used for the demo are the following:
/home/adas/adas/adf04/adas#8/cop98#8_ls#o4.dat
/home/adas/adas/adf04/adas#10/cop98#10_ic#ne3.dat
/home/adas/adas/adf04/copch#14/chv6_ic#si1.dat
```

/home/adas/adas/adf04/copch#14/chv6_ic#si6.dat
/home/adas/adas/adf04/copch#14/chv6_ic#si11.dat

The adf11 are specified by 96.

The ration NH/Ne is taken from the tabulated value of McWhirter et
al.1975,A&A,40,63.

COMMENTS: The line have been chosen to cover a large temperature range. The output files of ADAS412 are a set of files .pass in the adf20 format and a set of files .ps. All of them are needed to build up the kernel (DEMO 5).

DEMO b-1: Exploiting arch601: abundance, intensity and kernel.
Look at the files collected in /home/adas/adas/arch601/abundance/,
/home/adas/adas/arch601/intensity/,/home/adas/adas/arch601/kernel/.

DEMO b-2: Using ADAS412 and looking at adf20.
1. Use ADAS412 with the interactive ADAS windows.
   (sample of output files: goft_o4_n1e10.pass and goft_o4_n1e10.ps)

2a. Use run_adas412.pro to produce the G(T).
2b. Use read_adf20.pro to read the file produced by point 2a.
2c. Plot the G(T) as a function of Te.
Program: demo_b_4.pro
Sample of output files: goft_idl_o4_n1e10.pass and goft_idl_o4_n1e10.ps

3. Produce a set of adf20 using methods 1. and 2. at Ne=1.e10 cm-3
   and at Pe=1.e14 K cm-3

DEMO b-3: Using ADAS506 to produce the kernel.
1. Using ADAS506 with the interactive ADAS windows to produce a kernel.
   The input files are the adf20 produced by DEMO 4.
   The output files are: kernel_n1e10.dat and kernel_p1e14.dat.
   (sample of output plots: plot_adas506_o4_n1e10.ps)

2.1 Demo (b) Figures

2.1.1 Demo (b-2) demo_b/demo_b_2_graph412.pdf

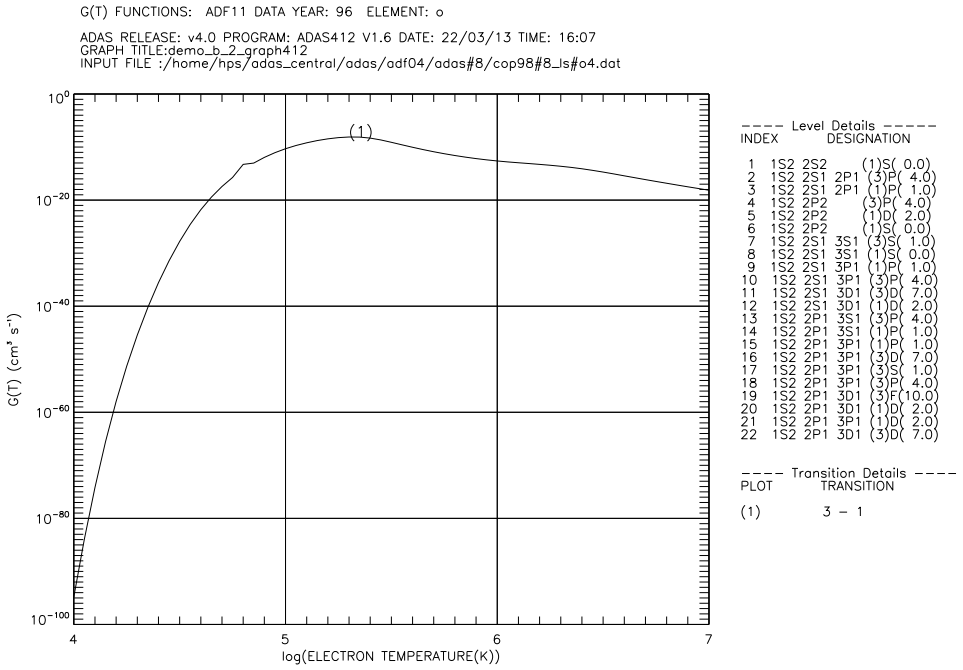

Figure 4: GTe-function plot vs Te for and O^{+4} transition

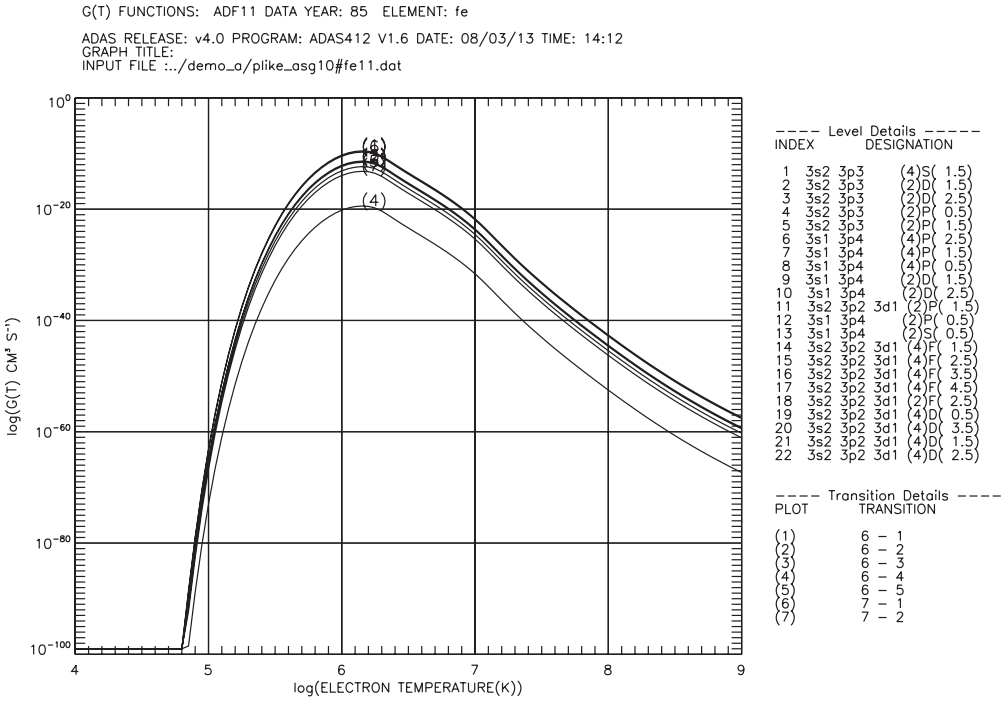

Figure 5: demo_b/goft.pdf

2.1.2 Demo (b-3) demo_b/demo_b_3_adas205.pdf

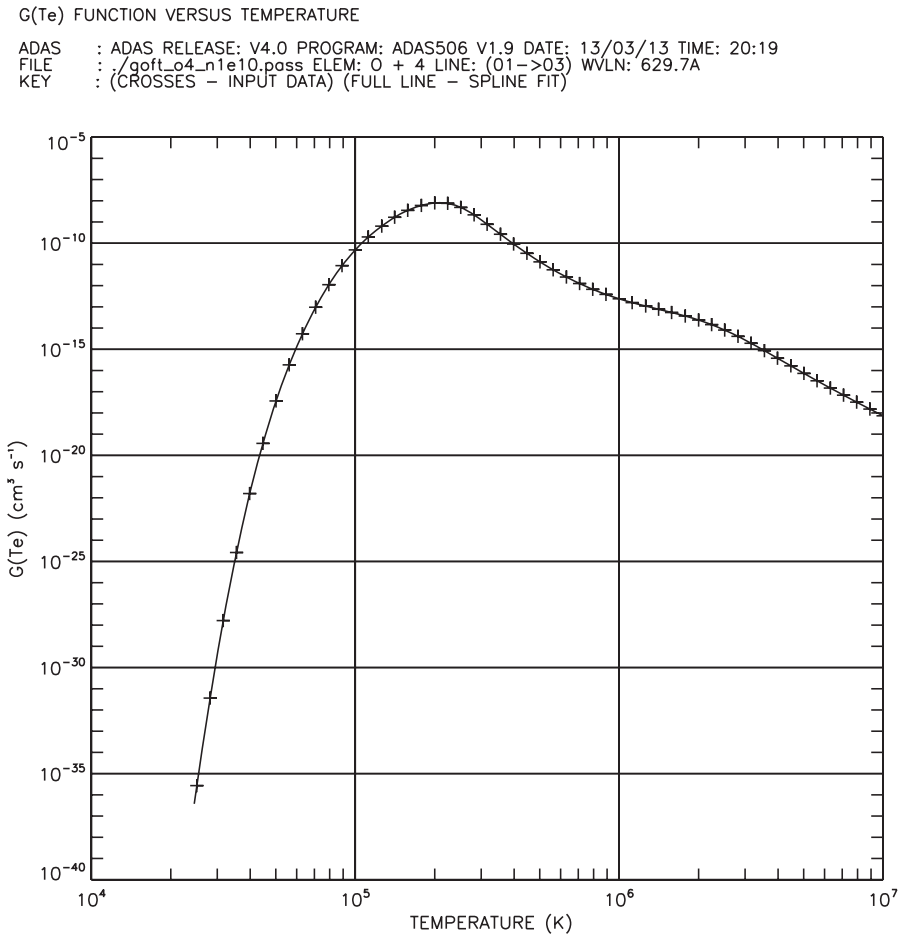

Figure 6: demo_b/plot_adas506_o4_n1e10.pdf

2.2 Demo (b) IDL procedures

2.2.1 Demo (b-2) demo_b_2.pro

```
pro demo_b_4
;using run_adas412.pro to build up the contribution functions

;define electron temperature array (Kelvin)
te=adas_vector(low=1.e4,high=1.e7,num=61)

;model with constant electron density at 1.e10 cm-3
dens=adas_vector(low=1.e10,high=1.e10,num=61)

;model with constant electron pressure (K cm-3)
pressure=adas_vector(low=1.e14,high=1.e14,num=61)

;build an array of files which include the adf04 required
adf04=['/home/adas/adas/adf04/adas#8/cop98#8_ls#o4.dat',    $
       '/home/adas/adas/adf04/adas#10/cop98#10_ic#ne3.dat', $
       '/home/adas/adas/adf04/copch#14/chv6_ic#si1.dat',    $
       '/home/adas/adas/adf04/copch#14/chv6_ic#si6.dat',    $
       '/home/adas/adas/adf04/copch#14/chv6_ic#si11.dat' ]

nadf04=n_elements(adf04)

year=96
elem=['o','ne','si']
ionstage=[4,3,1,3,11]
uid='ADAS'
;number of line for each adf04 file
nline=[1,2,2,2,1]


;indices of upper states
upper=[3,6,7,9,9,6,7,2]

;indices of lower states
lower=[1,1,1,1,2,1,2,1]

;spectroscopic wavelenghts
assigned=[629.732,543.886,542.070,1304.370,1309.276,275.353,275.667,520.662]


;use run_adas412.pro to produce the adf20

;model with constant density
;oxygen line O+4 629.732
run_adas412,adf04=adf04[0],year=year,elem=elem[0],uid=uid,                $
            te=te,dens=dens,                                              $
            upper=upper[0],lower=lower[0],                                $
```

```
            assigned=assigned[0],                                          $
            adf20='goft_idl_'+strtrim(elem[0],2)+strtrim(string(ionstage[0]),2)+'_n1e10.pa


;neon lines Ne+3 543.886,542.070
run_adas412,adf04=adf04[1],year=year,elem=elem[1],uid=uid,                 $
            te=te,dens=dens,                                               $
            upper=upper[1:2],lower=lower[1:2],                             $
            assigned=assigned[1:2],                                        $
            adf20='goft_idl_'+strtrim(elem[1],2) $
                  +strtrim(string(ionstage[1]),2)+'_n1e10.pass'

;silicon lines Si+1 1304.370,1309.276
run_adas412,adf04=adf04[2],year=year,elem=elem[2],uid=uid,                 $
            te=te,dens=dens,                                               $
            upper=upper[3:4],lower=lower[3:4],                             $
            assigned=assigned[3:4],                                        $
            adf20='goft_idl_'+strtrim(elem[2],2) $
                  +strtrim(string(ionstage[2]),2)+'_n1e10.pass'

;silicon lines Si+3 275.353,275.667
run_adas412,adf04=adf04[3],year=year,elem=elem[2],uid=uid,                 $
            te=te,dens=dens,                                               $
            upper=upper[5:6],lower=lower[5:6],                             $
            assigned=assigned[5:6],                                        $
            adf20='goft_idl_'+strtrim(elem[2],2) $
                  +strtrim(string(ionstage[3]),2)+'_n1e10.pass'

;silicon line Si+11 520.662
run_adas412,adf04=adf04[4],year=year,elem=elem[2],uid=uid,                 $
            te=te,dens=dens,                                               $
            upper=upper[7:7],lower=lower[7:7],                             $
            assigned=assigned[7:7],                                        $
            adf20='goft_idl_'+strtrim(elem[2],2) $
                  +strtrim(string(ionstage[4]),2)+'_n1e10.pass'



;model with constant pressure
;oxygen line O+4 629.732
run_adas412,adf04=adf04[0],year=year,elem=elem[0],uid=uid,                 $
            te=te,pressure=pressure,                                       $
            upper=upper[0],lower=lower[0],                                 $
            assigned=assigned[0],                                          $
            adf20='goft_idl_'+strtrim(elem[0],2) $
                  +strtrim(string(ionstage[0]),2)+'_p1e14.pass'


;neon lines Ne+3 543.886,542.070
run_adas412,adf04=adf04[1],year=year,elem=elem[1],uid=uid,                 $
```

```
            te=te,pressure=pressure,                                        $
            upper=upper[1:2],lower=lower[1:2],                              $
            assigned=assigned[1:2],                                         $
            adf20='goft_idl_'+strtrim(elem[1],2) $
                  +strtrim(string(ionstage[1]),2)+'_p1e14.pass'

;silicon lines Si+1 1304.370,1309.276
run_adas412,adf04=adf04[2],year=year,elem=elem[2],uid=uid,                  $
            te=te,pressure=pressure,                                        $
            upper=upper[3:4],lower=lower[3:4],                              $
            assigned=assigned[3:4],                                         $
            adf20='goft_idl_'+strtrim(elem[2],2) $
                  +strtrim(string(ionstage[2]),2)+'_p1e14.pass'

;silicon lines Si+3 275.353,275.667
run_adas412,adf04=adf04[3],year=year,elem=elem[2],uid=uid,                  $
            te=te,pressure=pressure,                                        $
            upper=upper[5:6],lower=lower[5:6],                              $
            assigned=assigned[5:6],                                         $
            adf20='goft_idl_'+strtrim(elem[2],2) $
                  +strtrim(string(ionstage[3]),2)+'_p1e14.pass'

;silicon line Si+11 520.662
run_adas412,adf04=adf04[4],year=year,elem=elem[2],uid=uid,                  $
            te=te,pressure=pressure,                                        $
            upper=upper[7:7],lower=lower[7:7],                              $
            assigned=assigned[7:7],                                         $
            adf20='goft_idl_'+strtrim(elem[2],2) $
                  +strtrim(string(ionstage[4]),2)+'_p1e14.pass'


;use read_adf20.pro to read adf20 for O+4 629.732 at n1e10 and plot it
file='goft_idl_o4_n1e10.pass'
block=1
read_adf20,file=file, block=block,te=te,data=gft,dens=dens,/kelvin


set_plot,'ps'
device, /isolatin1, font_index=8
device, bits=8, filename='goft_idl_o4_n1e10.ps',  $
        font_size = 14, xsize=18.0, ysize=16.0, $
        yoffset=7.0, /color
device, /helvetica
plot_io,alog10(te),gft,tit='G(T) FUNCTION FOR O!u+4!n 629.732 Ang.',$
                       xtit='log(TEMPERATURE(K))',            $
                       ytit='G(T) CM!u3!n S!u-1!n'

plot_io,alog10(te),gft,tit='G(T) FUNCTION FOR O!u+4!n 629.732 Ang.',$
                       xtit='log(TEMPERATURE(K))',            $
                       ytit='G(T) CM!u3!n S!u-1!n',            $
```

```
                    xs=1,xr=[4.,7.],ys=1,yr=[1.e-20,1.e-5]

device, /close
set_plot,'X'
!p.font=-1

end
```

2.3 Demo (b) Tables and datasets

2.3.1 Demo (b-1) arch601/intensity/sumer_cds_eis_qs.dat

```
|-------------------------------------------------------------------------------------------------------------------------------|
              spectr.        configuration             configuration    G-in blnd  observed     observed     uncert.
   |        | wavelength |                         |                   |    |    | wavelength | intensity  |
---|--------|R-----------|-------------------------|-------------------|----|----|------------|------------|------------|
\UNITS=PHOTONS/SEC/STER/CM2
-Lines for the integral inversion
 Si+1        N   1309.276          3s^2 3p ^2P_{3/2}-3s 3p^2 ^2S_{1/2}      2    0     1309.181   8.6928e+12   1.7812e+11
 Ne+3        E    543.886       $2s^22p^3~^4S_{3/2}-2s^22p^4~^4P_{5/2}     1    0      544.028   2.2161e+11   7.2878e+09
 O +4        N    629.732              2s^2~^1S_{0}-2s2p~^1P_{1}           1    0      629.750   1.4535e+13   4.5605e+11
 Si+6        N    275.667           2s^2 2p^4 ^3P_1-2s 2p^5 ^3P_1          2    0      275.708   3.8530e+10   4.6620e+09
 Si+11       E    520.662             $2s~^2S_{1/2}-2p~^2P_{1/2}           1    0      520.805   9.5996e+10   5.5300e+09
-
-Lines to be reconstructed
*from SoHO/SUMER
 Si+1        N   1304.370          3s^2 3p ^2P_{1/2}-3s 3p^2 ^2S_{1/2}     -1    0     1304.315   4.4333e+12   2.4451e+11
*from SoHO/CDS
 Ne+3        E    542.070       $2s^22p^3~^4S_{3/2}-2s2p^4~^4P_{3/2}      -2    0      542.211   1.4489e+11   6.0760e+09
*from Hinode/EIS
 Si+6        N    275.353           2s^2 2p^4 ^3P_2-2s 2p^5 ^3P_2         -1    0      275.394   2.2509e+11   8.4046e+09
```

2.3.2 Demo (b-1) arch601/abundance/abund.coronal_phillips08

```
H   12.00  12.00  12.00
HE  10.90  10.90  10.90
C    8.58   8.58   8.58
N    8.02   8.02   8.02
O    8.90   8.87   8.93
NE   8.10   8.10   8.10
NA   7.10   7.10   7.10
MG   8.15   8.15   8.15
AL   7.26   7.26   7.26
SI   8.14   8.12   8.16
S    7.34   7.34   7.34
AR   6.45   6.45   6.45
CA   7.14   7.14   7.14
FE   8.07   8.07   8.07
NI   7.02   7.02   7.02
```

2.3.3 Demo (b-1) arch601/kernel/kernel_n1e10.dat

```
NE+ 3  /ITRANS=   1/NTEMP=  94/APPWAV=     543.900/SPWAV=       0.000/
./goft_ne3_n1e10.pass
 4.35 4.40 4.45 4.50 4.55 4.60 4.65 4.70 4.75 4.80 4.85 4.90 4.95 5.00 5.05 5.10
5.15 5.20 5.25 5.30 5.35 5.40 5.45 5.50 5.55 5.60 5.65 5.70 5.75 5.80 5.85 5.90
5.95 6.00 6.05 6.10 6.15 6.20 6.25 6.30 6.35 6.40 6.45 6.50 6.55 6.60 6.65 6.70
6.75 6.80 6.85 6.90 6.95 7.00 7.05 7.10 7.15 7.20 7.25 7.30 7.35 7.40 7.45 7.50
7.55 7.60 7.65 7.70 7.75 7.80 7.85 7.90 7.95 8.00 8.05 8.10 8.15 8.20 8.25 8.30
8.35 8.40 8.45 8.50 8.55 8.60 8.65 8.70 8.75 8.80 8.85 8.90 8.95 9.00
 4.9910E-31 1.7790E-27 1.9190E-24 8.5530E-22 1.7940E-19 1.8440E-17 8.6820E-16
1.8260E-14 2.0420E-13 1.5190E-12 8.3470E-12 3.5090E-11 1.0980E-10 2.3890E-10
3.7510E-10 4.7370E-10 5.1760E-10 4.8990E-10 4.0140E-10 2.8650E-10 1.8160E-10
1.0310E-10 5.2620E-11 2.4370E-11 1.0380E-11 3.9770E-12 1.2320E-12 2.6970E-13
4.2010E-14 5.2300E-15 6.1350E-16 7.7100E-17 1.2020E-17 2.3330E-18 5.2620E-19
1.2870E-19 3.3400E-20 9.2650E-21 2.7600E-21 8.8040E-22 2.9520E-22 1.0190E-22
```

```
3.5530E-23 1.2270E-23 4.1290E-24 1.3260E-24 3.9890E-25 1.1240E-25 2.9920E-26
7.5930E-27 1.8930E-27 4.8190E-28 1.3020E-28 4.0680E-29 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00
NE+ 3  /ITRANS=   2/NTEMP=  94/APPWAV=     542.100/SPWAV=       0.000/
./goft_ne3_n1e10.pass
 4.35 4.40 4.45 4.50 4.55 4.60 4.65 4.70 4.75 4.80 4.85 4.90 4.95 5.00 5.05 5.10
5.15 5.20 5.25 5.30 5.35 5.40 5.45 5.50 5.55 5.60 5.65 5.70 5.75 5.80 5.85 5.90
5.95 6.00 6.05 6.10 6.15 6.20 6.25 6.30 6.35 6.40 6.45 6.50 6.55 6.60 6.65 6.70
6.75 6.80 6.85 6.90 6.95 7.00 7.05 7.10 7.15 7.20 7.25 7.30 7.35 7.40 7.45 7.50
7.55 7.60 7.65 7.70 7.75 7.80 7.85 7.90 7.95 8.00 8.05 8.10 8.15 8.20 8.25 8.30
8.35 8.40 8.45 8.50 8.55 8.60 8.65 8.70 8.75 8.80 8.85 8.90 8.95 9.00
 3.2110E-31 1.1500E-27 1.2450E-24 5.5720E-22 1.1720E-19 1.2080E-17 5.6990E-16
1.2010E-14 1.3450E-13 1.0020E-12 5.5110E-12 2.3200E-11 7.2710E-11 1.5840E-10
2.4900E-10 3.1480E-10 3.4440E-10 3.2620E-10 2.6740E-10 1.9090E-10 1.2100E-10
6.8660E-11 3.5020E-11 1.6210E-11 6.9000E-12 2.6570E-12 8.4390E-13 1.8770E-13
2.9230E-14 3.6070E-15 4.0850E-16 5.0910E-17 7.9300E-18 1.5360E-18 3.4610E-19
8.4530E-20 2.1910E-20 6.0680E-21 1.8050E-21 5.7500E-22 1.9250E-22 6.6410E-23
2.3110E-23 7.9770E-24 2.6800E-24 8.6000E-25 2.5850E-25 7.2760E-26 1.9360E-26
4.9080E-27 1.2220E-27 3.1090E-28 8.3950E-29 2.6190E-29 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00
O + 4  /ITRANS=   1/NTEMP=  94/APPWAV=     629.700/SPWAV=       0.000/
./goft_o4_n1e10.pass
 4.35 4.40 4.45 4.50 4.55 4.60 4.65 4.70 4.75 4.80 4.85 4.90 4.95 5.00 5.05
 6.1740E-41 2.7220E-36 3.6220E-32 1.6310E-28 2.6360E-25 1.5850E-22 3.6730E-2
SI+11  /ITRANS=   1/NTEMP=  94/APPWAV=     520.700/SPWAV=     520.600/
./goft_si11_n1e10_ch6.pass
 4.35 4.40 4.45 4.50 4.55 4.60 4.65 4.70 4.75 4.80 4.85 4.90 4.95 5.00 5.05
 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+0
SI+ 1  /ITRANS=   1/NTEMP=  94/APPWAV=    1248.300/SPWAV=    1304.300/
./goft_si1_n1e10_ch6.pass
 4.35 4.40 4.45 4.50 4.55 4.60 4.65 4.70 4.75 4.80 4.85 4.90 4.95 5.00 5.05
 8.5320E-12 5.1400E-12 3.5220E-12 2.7170E-12 2.1620E-12 1.5920E-12 9.1820E-1
SI+ 1  /ITRANS=   2/NTEMP=  94/APPWAV=    1253.600/SPWAV=    1309.200/
./goft_si1_n1e10_ch6.pass
 4.35 4.40 4.45 4.50 4.55 4.60 4.65 4.70 4.75 4.80 4.85 4.90 4.95 5.00 5.05
 1.6960E-11 1.0220E-11 7.0010E-12 5.4000E-12 4.2980E-12 3.1650E-12 1.8250E-1
SI+ 6  /ITRANS=   1/NTEMP=  94/APPWAV=     267.600/SPWAV=     275.300/
./goft_si6_n1e10_ch6.pass
 4.35 4.40 4.45 4.50 4.55 4.60 4.65 4.70 4.75 4.80 4.85 4.90 4.95 5.00 5.05
 1.0000E-99 2.1680E-97 1.3740E-86 1.2000E-76 1.2170E-67 1.1740E-59 8.8490E-5
SI+ 6  /ITRANS=   2/NTEMP=  94/APPWAV=     268.000/SPWAV=     275.600/
./goft_si6_n1e10_ch6.pass
 4.35 4.40 4.45 4.50 4.55 4.60 4.65 4.70 4.75 4.80 4.85 4.90 4.95 5.00 5.05
 1.0000E-99 3.4010E-98 2.2000E-87 1.9590E-77 2.0180E-68 1.9740E-60 1.5070E-5
XX
```

2.3.4 Demo (b-2) demo_b/demo_b_2_paper412.txt

```
O + 4  /NLEVELS=  44/NKNOTS=  61/NLINES=   1/

  SOURCE FILES:
  -------------
  IONISATION BALANCE DATA   - /home/hps/adas_central/adas/adf11/.<>cd96#O.dat
  SPECIFIC ION FILE DATA    - /home/hps/adas_central/adas/adf04/adas#8/cop98#8_ls#o4.dat


  PROCESSING CODE                   DATE            USER IDENTIFIER
  -------------------------------   ---------       ---------------
  ADAS 412                          22/03/13        Hugh Summers

  ENERGY LEVEL INDEXING
  ---------------------
  INDX     CODE              S L  IJ
  ----     ----------------  - -  --
    1      1S2 2S2           1(0) 0.0
    2      1S2 2S1 2P1       3(1) 4.0
    3      1S2 2S1 2P1       1(1) 1.0
    4      1S2 2P2           3(1) 4.0
```

```
   5      1S2 2P2            1(2) 2.0
   6      1S2 2P2            1(0) 0.0
   7      1S2 2S1 3S1        3(0) 1.0
      .        .       .
  40      1S2 2S1 5D1        1(2) 2.0
  41      1S2 2S1 5G1        3(4)13.0
  42      1S2 2S1 5G1        1(4) 4.0
  43      1S2 2S1 5F1        3(3)10.0
  44      1S2 2S1 5F1        1(3) 3.0

 PLASMA MODEL   (FINITE DENSITY IONISATION BALANCE =YES)
 ------------
 TE(K)      NE(CM-3)   P(KCM-3)   NH/NE      TIME(S)   LOG(TE)   LOG(NE)   LOG(P)
 --------   --------   --------   --------   -------   -------   -------   -------
 1.00E+04   1.00E+10   1.00E+14   1.61E+00               4.00     10.00     14.00
 1.12E+04   1.00E+10   1.12E+14   1.43E+00               4.05     10.00     14.05
 1.26E+04   1.00E+10   1.26E+14   1.33E+00               4.10     10.00     14.10
 1.41E+04   1.00E+10   1.41E+14   1.24E+00               4.15     10.00     14.15
 1.58E+04   1.00E+10   1.58E+14   1.17E+00               4.20     10.00     14.20
       .        .          .
 6.31E+06   1.00E+10   6.31E+16   8.29E-01               6.80     10.00     16.80
 7.08E+06   1.00E+10   7.08E+16   8.29E-01               6.85     10.00     16.85
 7.94E+06   1.00E+10   7.94E+16   8.29E-01               6.90     10.00     16.90
 8.91E+06   1.00E+10   8.91E+16   8.29E-01               6.95     10.00     16.95
 1.00E+07   1.00E+10   1.00E+17   8.29E-01               7.00     10.00     17.00

 TABLE OF G(T) VALUES (CM3 S-1) FOR O  V
 ------------------------------------------------
TRANS INDEX          1          2          3          4          5          6          7          8          9         10
APPROX WLENGTH    629.7        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
SPECTR WLENGTH    629.700      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000
TRANSITION         1- 3       0- 0       0- 0       0- 0       0- 0       0- 0       0- 0       0- 0       0- 0       0- 0
LOG(TE(K))
----------
     4.00       1.481E-95  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
     4.05       1.218E-84  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
     4.10       6.776E-75  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
     4.15       2.972E-66  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
     4.20       1.101E-58  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
      .          .          .
     6.80       1.490E-17  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
     6.85       6.876E-18  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
     6.90       3.219E-18  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
     6.95       1.526E-18  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
     7.00       7.322E-19  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00

C-----------------------------------------------------------------------------------------------------------------------------
C
C  TRANSITION LIST FOR O  V
C----------------------------------
C  IND   TRANSITION    APP. WVL.(A)    EXACT WVL.(A)     LOWER ST.     UPPER ST.
C  ---   ----------    ------------    -------------     ----------    ----------
C   1      1 -   3         629.7            629.7        1(0) 0.0      1(1) 1.0
C
C  CODE     : ADAS412
C  PRODUCER : Hugh Summers
C  DATE     : 22/03/13
C
C-----------------------------------------------------------------------------------------------------------------------------
```

3 Demo (c) Differential Emission Measure (DEM) analysis

```
------------------------------
DEMO C: Differential Emission Measure (DEM) analysis.
------------------------------
PURPOSE: Evaluate the DEM as a function of electron temperature, once a set
of observed spectral line intensities (archived in
/home/adas/adas/arch601/intensity/), G(Te) functions (produced by DEMO b and
archived in /home/adas/adas/arch601/kernel/) and
elemental abundances (archived in /home/adas/adas/arch601/abundance/) are given.
See Lanzafame et al.2002,A&A,384,242 for details on the technique.

Furthermore, once a first estimate of DEM is evaluated, it is possible to perform
the elemental abundance analysis.
The method is described by Lanzafame et al. 2005,A&A,432,1063.

The directory arch601 is exploited in DEMO b. This provide the input files for the
DEM analysis:
1. ELEMENTAL ABUNDANCES: /home/adas/adas/arch601/abundance/
   The file can appear in a logarithmic scale A(E) or linear scale N(E), with the
   hydrogen abundance N(H)=1.

   The logarithmic scale is given by the following:
   A(H)=logN(H)=12.
   A(E)=logN(E)=log[N(E)/N(H)] + 12.

2. OBSERVED INTENSITIES:/home/adas/adas/arch601/intensity/
   The line intensities come from observations (see DEMO b). They are divided into
   two sets:
   a. lines used for the inversion
   b. lines used in the forward sense (i.e.to compare the
   reconstructed intensities to the observed intensities).

   The main criteria for the selection of suitable lines fo point a. are the
   following: a) free from blends; b) optically thin; c) density insensitive; d)
   corresponding accurate atomic data; e) large temperature coverage.


3. SET OF CONTRIBUTION FUNCTIONS: /home/adas/adas/arch601/kernel/
   This is done in DEMO b.


EXAMPLE: The observed lines used for this demo are already listed in the EXAMPLE
of DEMO b.
They are collected in the intensity file:
/home/adas/adas/arch601/intensity/sumer_cds_eis_qs.dat

LINES SELECTED FOR THE INVERSION (using the criteria of point 2.):
```

```
ION   WAVELENGTH(Ang.)     LOG(Te(K))
Si+1  1309.276             4.45
Ne+3   543.886             5.20
O+4    629.732             5.35
Si+6   275.667             5.80
Si+11  520.662             6.30
s
LINES USED IN THE FORWARD SENSE
ION   WAVELENGTH(Ang.)     LOG(Te(K))
Si+1  1304.370             4.45
Ne+3   542.070             5.20
Si+6   275.353             5.80
```

Note that at the lines which arise from Si+1 are slighly affected by opacity. However, using an escape factor approach (see also DEMO D), the observed intesities have been corrected to be consistent with the optically thin study.

Regarding the elemental abundances, there are three test files:

1.Abundances from Phillips et al. 2008, that is the most recent collection of coronal abumndances:
/home/adas/adas/arch601/abundance/abund.coronal_phillips08

2.Abundances from Meyer et al. 1985, that is an example of high-FIP depletion (i.e. elements with their First Ionisation Potential, FIP, greater than 10 eV are depleted compared to their photospheric values):
/home/adas/adas/arch601/abundance/abundance.coronal_meyer85

3. Abundances from Fludra & Schmelz 1999, that is an example or hybrid abundances:
/home/adas/adas/arch601/abundance/abund.hydrid_fludra99

COMMENTS: The DEM technique is one of the most widely used methods available for the interpretation of astronomical spectral lines. However, although this method is less familiar in spectroscopic studies of fusion plasma, it can be applied to determine impurity concentration, impurity variation in time and impurity influx in fusion.

DEMO c-1: Choice of the lines for the integral inversion

The choice of the line used for integral inversion is done in the intensity file (/home/adas/adas/arch601/intensity/sumer_cds_eis_qs.dat) by removing the minus in front of the G-index.

e.g.: LINE USED FOR INTEGRAL INVERSION

```
                              G-ind
      Si+1...N...1309.276 ... 2    0     1309.181   8.6928e+12   1.7812e+11
      LINE USED IN THE FORWARD SENSE
                              G-ind
```

```
              Si+1...N...1304.370 .. -1    0     1309.181   8.6928e+12   1.7812e+11


        The G-index (2 or the first line and 1 for the second line of the previous
        example) connect the intensity file to the kernel (kernel_n1e10.dat or
        kernel_p1e14.dat) produced in DEMO b.

DEMO c-2: Using ADAS601: DEM inversion and abundance analysis
        1. Run ADAS601 from the interactive windows.
        2. Select the input files:
          (e.g. abundance: /home/adas/adas/arch601/abundance/abund.coronal_phillips08
                intensity: /home/adas/adas/arch601/intensity/sumer_cds_eis_qs.dat
                kernel:    /home/adas/adas/arch601/kernel/kernel_n1e10.dat)
        3. Selet Run --> execute integral inversion
           (output files: demap_output.dat,demo_c_dem.ps,demo_c_gft.ps)
        If values for elemental abundance are sought, then:
        4. Select Run --> abundance analysis
           (output files: demap_abund.dat,demap_abund.log)
           The output  demap_abund.dat can be used as input for abundance. It
           provides the new values of elemental abundances and the error bar (max
           and min values).



\end{document}
```

3.1 Demo (c) Figures

3.1.1 demo_c/demo_c_gft.pdf

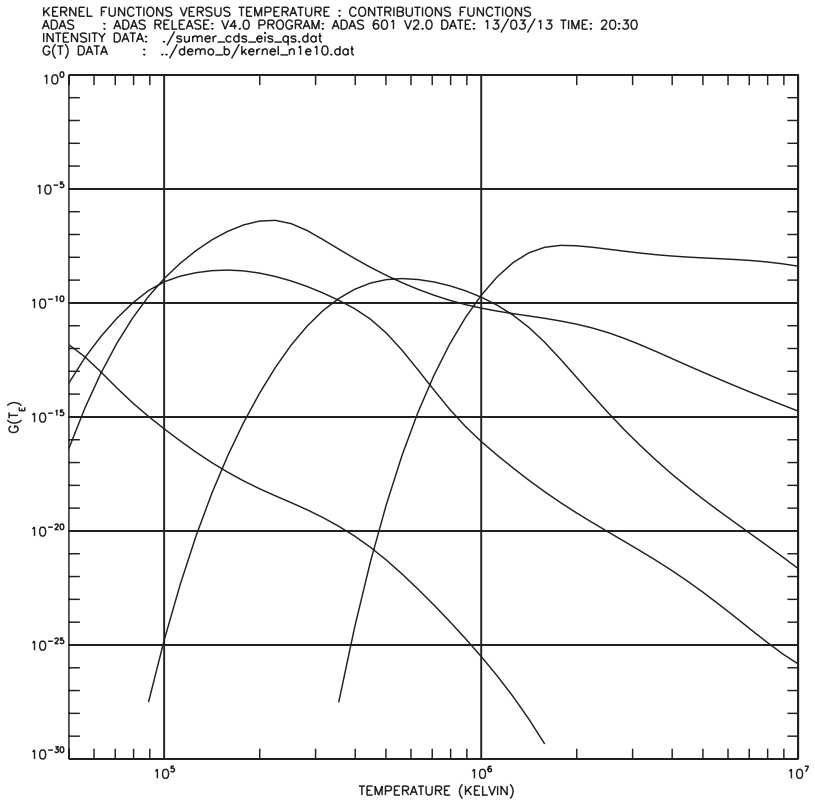

Figure 7: demo_c/demo_c_gft.pdf

3.1.2 demo_c/demo_c_dem.pdf

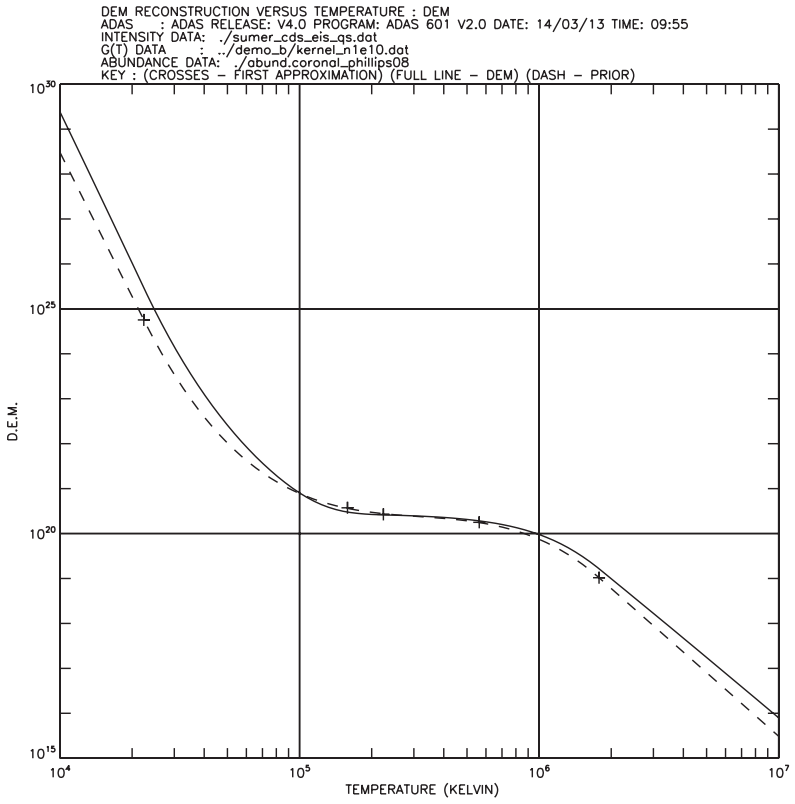

Figure 8: demo_c/demo_c_dem.pdf

3.2 Demo (c) datasets

3.2.1 demap_output.dat

```
 ADAS RELEASE: v4.0 PROGRAM: ADAS 601 V2.0 DATE: 14/03/13 TIME: 09:59
******************** TABULAR OUTPUT FROM INTEGRAL INVERSION - PROGRAM: ADAS 601 V2.0 - DATE: 14/03/13 ********************

INTENSITY DATA FILE NAME: ./sumer_cds_eis_qs.dat
   KERNEL DATA FILE NAME: ../demo_b/kernel_n1e10.dat
ABUNDANCE DATA FILE NAME: ./abund.coronal_phillips08


  CONSTANT VARIANCE =     0.0023993561
SMOOTHING PARAMETER =       0.17788084
```

SINGLE LINES

ION	SPECTROSCOP. WAVELENGTH	PEAK TEMP log(T)	RECONSTR. INTENSITY erg/cm2/s	OBSERVED INTENSITY erg/cm2/s	QFR	RECONSTR. INTENSITY ph/cm2/s	OBSERVED INTENSITY ph/cm2/s	EPS	SIG	DEV
Si+ 1	1309.276	4.35	131.889	131.889	1.000	8.693e+12	8.693e+12	4.028e+11	8.725e+09	8.966e-08
Ne+ 3	543.886	5.20	8.094	8.094	1.000	2.216e+11	2.216e+11	5.368e+10	3.570e+08	4.873e-07
O + 4	629.732	5.35	458.492	458.502	1.000	1.453e+13	1.453e+13	3.470e+12	2.234e+10	4.443e-07
Si+ 6	275.667	5.75	2.777	2.776	1.000	3.853e+10	3.853e+10	7.671e+09	2.284e+08	2.403e-07
Si+11	520.662	6.25	3.662	3.663	1.000	9.600e+10	9.600e+10	1.366e+10	2.709e+08	6.514e-09

BLENDS

ION	SPECTROSCOP. WAVELENGTH	PEAK TEMP log(T)	Iblnd	RECONSTR. INTENSITY erg/cm2/s	OBSERVED INTENSITY erg/cm2/s	QFR	RECONSTR. INTENSITY ph/cm2/s	OBSERVED INTENSITY ph/cm2/s	EPS	SIG	DEV

```
CHISQUARE =   0.000528555
NUMBER OF TRANSITION USED FOR THE INTEGRAL INVERSION =        5
```

PREDICTED INTENSITIES

ION	SPECTROSCOP. WAVELENGTH	PEAK TEMP log(T)	RECONSTR. INTENSITY erg/cm2/s	OBSERVED INTENSITY erg/cm2/s	QFR	RECONSTR. INTENSITY ph/cm2/s	OBSERVED INTENSITY ph/cm2/s	DEV
Si+ 1	1304.370	4.35	66.592	67.516	0.986	4.373e+12	4.433e+12	6.162e-02
Ne+ 3	542.070	5.15	5.399	5.310	1.017	1.473e+11	1.449e+11	1.610e-01
Si+ 6	275.353	5.70	15.073	16.239	0.928	2.089e+11	2.251e+11	3.695e+00

DIFFERENTIAL EMISSION MEASURE

N	TEMP	DEM	N	TEMP	DEM	N	TEMP	DEM	N	TEMP	DEM	N	TEMP	DEM
1	1.0e+04	2.4e+29	11	2.0e+04	1.0e+26	21	4.0e+04	1.2e+23	31	8.1e+04	1.8e+21	41	1.6e+05	2.9e+20
2	1.1e+04	1.1e+29	12	2.2e+04	4.5e+25	22	4.3e+04	7.0e+22	32	8.7e+04	1.4e+21	42	1.7e+05	2.8e+20
3	1.1e+04	5.1e+28	13	2.3e+04	2.1e+25	23	4.6e+04	4.3e+22	33	9.3e+04	1.0e+21	43	1.9e+05	2.7e+20
4	1.2e+04	2.4e+28	14	2.5e+04	9.7e+24	24	5.0e+04	2.7e+22	34	1.0e+05	8.0e+20	44	2.0e+05	2.7e+20
5	1.3e+04	1.1e+28	15	2.7e+04	4.7e+24	25	5.3e+04	1.7e+22	35	1.1e+05	6.4e+20	45	2.2e+05	2.6e+20
6	1.4e+04	5.0e+27	16	2.8e+04	2.4e+24	26	5.7e+04	1.1e+22	36	1.1e+05	5.2e+20	46	2.3e+05	2.6e+20
7	1.5e+04	2.3e+27	17	3.1e+04	1.2e+24	27	6.1e+04	7.5e+21	37	1.2e+05	4.4e+20	47	2.5e+05	2.6e+20
8	1.6e+04	1.0e+27	18	3.3e+04	6.5e+23	28	6.6e+04	5.1e+21	38	1.3e+05	3.8e+20	48	2.7e+05	2.5e+20
9	1.7e+04	4.8e+26	19	3.5e+04	3.6e+23	29	7.1e+04	3.6e+21	39	1.4e+05	3.4e+20	49	2.8e+05	2.5e+20
10	1.9e+04	2.2e+26	20	3.8e+04	2.0e+23	30	7.6e+04	2.5e+21	40	1.5e+05	3.1e+20	50	3.1e+05	2.5e+20
51	3.3e+05	2.4e+20	61	6.6e+05	1.7e+20	71	1.3e+06	4.8e+19	81	2.7e+06	2.9e+18	91	5.3e+06	1.3e+17
52	3.5e+05	2.4e+20	62	7.1e+05	1.6e+20	72	1.4e+06	3.9e+19	82	2.8e+06	2.1e+18	92	5.7e+06	9.6e+16

53	3.8e+05	2.3e+20	63	7.6e+05	1.5e+20	73	1.5e+06	3.1e+19	83	3.1e+06	1.5e+18	93	6.1e+06	7.0e+16
54	4.0e+05	2.3e+20	64	8.1e+05	1.3e+20	74	1.6e+06	2.4e+19	84	3.3e+06	1.1e+18	94	6.6e+06	5.2e+16
55	4.3e+05	2.2e+20	65	8.7e+05	1.2e+20	75	1.7e+06	1.8e+19	85	3.5e+06	8.4e+17	95	7.1e+06	3.8e+16
56	4.6e+05	2.1e+20	66	9.3e+05	1.1e+20	76	1.9e+06	1.3e+19	86	3.8e+06	6.1e+17	96	7.6e+06	2.8e+16
57	5.0e+05	2.1e+20	67	1.0e+06	9.5e+19	77	2.0e+06	9.7e+18	87	4.0e+06	4.5e+17	97	8.1e+06	2.0e+16
58	5.3e+05	2.0e+20	68	1.1e+06	8.2e+19	78	2.2e+06	7.1e+18	88	4.3e+06	3.3e+17	98	8.7e+06	1.5e+16
59	5.7e+05	1.9e+20	69	1.1e+06	7.0e+19	79	2.3e+06	5.3e+18	89	4.6e+06	2.4e+17	99	9.3e+06	1.1e+16
60	6.1e+05	1.8e+20	70	1.2e+06	5.9e+19	80	2.5e+06	3.9e+18	90	5.0e+06	1.8e+17	100	1.0e+07	7.9e+15

4 Demo (d) Evaluating escape factors

```
----------------------------
DEMO D: Evaluating escape factors for spectral line emission and for
        collisional-radiative  population calculations of excited states
----------------------------
PURPOSE: To treat line affected by moderate optically thickness (e.g. C II,
CIII or Si II lines in the solar case). The opacity alters the emergent flux,
because of the loss of photons out of the line of sight due to scattering and
absorption. Additionally, it affects the population distribution within the
absorbing atoms (leading to modification to the population structure caused by
photo-absorptions) and may cause partial frequency redistribution, which can
modify the emission profiles. Two type of escape factor are calculated by the
program:
1. line escape fasctor, which describes the emitted radiance along the line of
sight;
2. population escape factor, which modifies in practice the A-values (i.e.the
radiative transition probabilities in the adf04 are reduced with respect to the
values they assume when the plasma is optically thin).

The input of the program is an adf04 data file.
The outputs are the following:
1. a modified adf04, where the A-value take into account the effects of the
opacity.
2. three plots (normalised escape factor as a function of optical depth, line
profile with modified profiles for a range of optical depths, the emergent flux
ratio between specific transitions as a function of column density when selected0

EXAMPLE: In the solar case, the escape factor approach is used for the nalysis of
lines which arise from ions such as C+1, C+2, Si+1 (See Fischbacher et
al.2000,A&A, 357,767  and Brooks et al.2000,A&A,357,697).

The lines include in the demo are the following:
ION    WAVEL.(Ang.) TRANSITION             INTENSITY
C+2    1174.93      2s 2p 3P1 - 2p2 3P2    I(1-2)
C+2    1175.26      2s 2p 3P0 - 2p2 3P1    I(0-1)
C+2    1175.71      2s 2p 3P2 - 2p2 3P2    I(2-2)
C+2    1176.37      2s 2p 3P1 - 2p2 3P2    I(1-2)

These lines are observed by SoHO/SUMER and provide a good example of opacity
sentitive and insensitive line ratios.

The input adf04 is /home/adas/adas/adf04/copjl#be/copjl#be_jl#c2j.dat.
The output adf04 is adas214.pass.

Assuming a plane parallel atmosphere, the input parameters for the demo are the
following:
LINE PROFILE: Doppler
DENSITY DISTRIBUTION: Homogeneous (through the layer)
PLASMA GEOMETRY: Disk (large slab,similar to plane parallel geometry of the solar
```

atmosphere)
DENSITY: 5.e10 cm-3
DIMENSION(b): 1000. cm
ION TEMPERATURE: 80000. K
ELECTRON TEMPERATURE: 80000. K
ASPECT RATIO (a/b - where a is the radius of the disk and 2b the thickness):
10000.
SCAN: if selected YES --> NO.SPEPS:10; MIN FACTOR: 0.10; MAX FACTOR: 100.

OBSERVED SPECTRUM LINES:	UPPER LEVEL	LOWER LEVEL	WAVEL.(Ang.)
	8	3	1174.93
	7	2	1175.26
	8	4	1175.71
	7	4	1176.37

In the case of C+2 the line ratio I(2-2)/I(1-2) is opacity sensitive while
I(0-1)/I(2-1) is opacity insensitive. The plot demo_d.ps can be compared with the
observed intensity ratios of Fig.1 in the paper of Brooks et al.2000,A&A,357,697.
The ratio I(2-2)/I(1-2) close to the limb approaches the value 0.9, while it is
2.0-2.5 going to the disk centre. On the disk, the emitting llayer is only
moderately thick and so the value is close to the optically thin value, which is
˜3.

COMMENTS: This approach works for moderate opacity only, otherwise, if the
optical depth is to big, the A-values is set equals to zero.

DEMO 8: Using ADAS214
1. Use ADAS214 with the interactive ADAS windows. Select all the parameters as
   above. (output files: adas214.pass, adas214_escape.ps, adas214_profile.ps,
   adas214_ratio.ps)

DEMO 9: Looking at the modified line ratios
1. Use run_adas208.pro to produce the PEC from
   - optically thin adf04: /home/adas/adas/adf04/copjl#be/copjl#be_jl#c2j.dat
   - optically thick adf04 produce by DEMO 8: adas214.pass
2. Read the PEC file using read_adf15.pro
3. Plot the opacity sentitive and insensitive line ratios and compare them.
Program: demo_d.pro
Output files: demo_d.ps, demo_d_pec.dat, demo_d_pec_adas214.dat

4.1 Demo (d-1) Figures

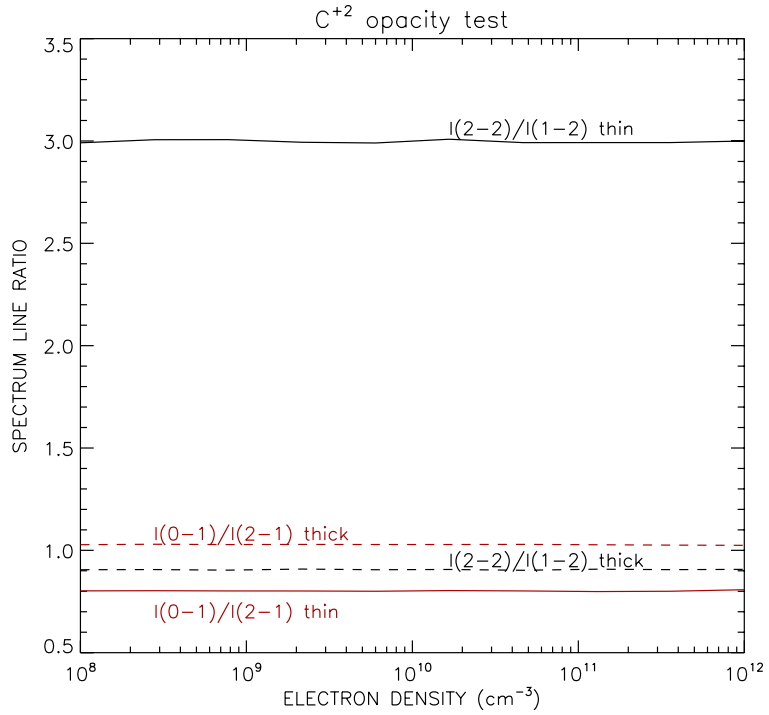

Figure 9: demo_d/demo_d_line_ratios.pdf

4.2 Demo (d-1) IDL procedure

```
pro demo_d
;To compare line ratios affected by opacity to the respective optically thin ratios.

;define electron temperature (K) and electron density array (cm-3)
tek=[1.e4,4.e4,8.e4,1.e5,4.e5,8.e5,1.e6,4.e6,8.e6,1.e7]
;Te in eV
te=tek/11604.
dens=adas_vector(low=1.e8,high=1.e12,num=10)

nte=n_elements(te)
ndens=n_elements(dens)

;Define input parameters for run_adas208.pro
unit_te   = 'eV'
unit_dens = 'cm-3'
```

```
wmin      = 1170.
wmax      = 1180.
amin      = 1.0e3

;optically thin adf04
adf04='/home/adas/adas/adf04/copjl#be/copjl#be_jl#c2j.dat'
;optically thick adf04 produced by ADAS214
adf04_adas214='adas214.pass'

;define the metastables
meta_list=[1]

;run_adas208.pro for the population structure using
;the optically thin and thick adf04 files
run_adas208, adf04=adf04,                                          $
             te=te,dens=dens, unit_te=unit_te,unit_dens=unit_dens,  $
             meta=meta_list,                                       $
             wmin=wmin, wmax=wmax, amin=amin,                      $
             /pec, pass_dir='.',pop=pop

file_move,'pec.pass','demo_d_pec.dat',/overwrite

run_adas208, adf04=adf04_adas214,                                                $
             te=te,dens=dens, unit_te=unit_te,unit_dens=unit_dens,  $
             meta=meta_list,                                       $
             wmin=wmin, wmax=wmax, amin=amin,                      $
             /pec, pass_dir='.',pop=pop

file_move,'pec.pass','demo_d_pec_adas214.dat',/overwrite

;define output PEC files in the format of adf15
file='demo_d_pec.dat'
fileop='demo_d_pec_adas214.dat'

;define input parameters for read_adf15.pro
block=[3,1,4,2]
blockop=[1,2,5,6]
nblock=n_elements(block)

data=fltarr(nblock,nte,ndens)
dataop=fltarr(nblock,nte,ndens)

;use read_adf15.pro to read the PEC files
for i=0,nblock-1 do begin
  read_adf15,file=file,block=block[i],te=te,dens=dens,   $
             data=idata,wlngth=wlngth,/all
  data[i,*,*]=idata
  read_adf15,file=fileop,block=blockop[i],te=te,dens=dens,   $
             data=idataop,wlngth=wlngth,/all
  dataop[i,*,*]=idataop
```

```
endfor


;plot the line ratios as a function of electron density
loadct,3
set_plot,'ps'
device, /isolatin1, font_index=8
device, bits=8, filename='demo_d.ps',  $
        font_size = 14, xsize=18.0, ysize=16.0, $
        yoffset=7.0, /color
device, /helvetica

plot_oi,dens,data[1,2,*]/data[0,2,*],ys=1,yr=[0.5,3.5],    $
        tit='C!u+2!n opacity test',     $
        xtit='ELECTRON DENSITY (cm!u-3!n)',            $
        ytit='SPECTRUM LINE RATIO'
oplot,dens,dataop[1,2,*]/dataop[0,2,*],line=2


oplot,dens,data[2,2,*]/data[3,2,*],color=120
oplot,dens,dataop[2,2,*]/dataop[3,2,*],line=2,color=120

xyouts,dens[5],3.03,'I(2-2)/I(1-2) thin'
xyouts,dens[5],0.92,'I(2-2)/I(1-2) thick'

xyouts,dens[1],0.67,'I(0-1)/I(2-1) thin',color=120
xyouts,dens[1],1.05,'I(0-1)/I(2-1) thick',color=120

device, /close
set_plot,'X'
!p.font=-1

end
```

4.3 Demo (d-2) Figures

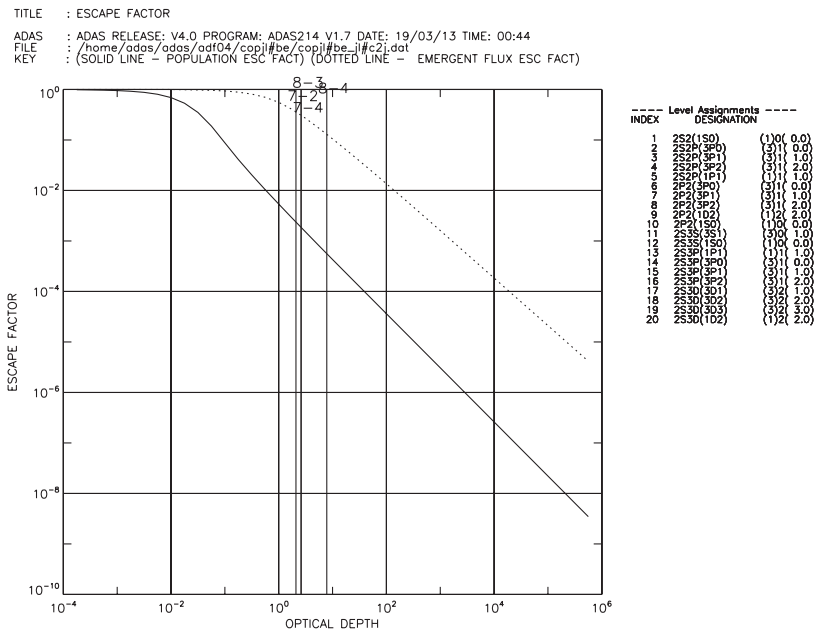

Figure 10: demo_d/demo_d_adas214_escape.pdf

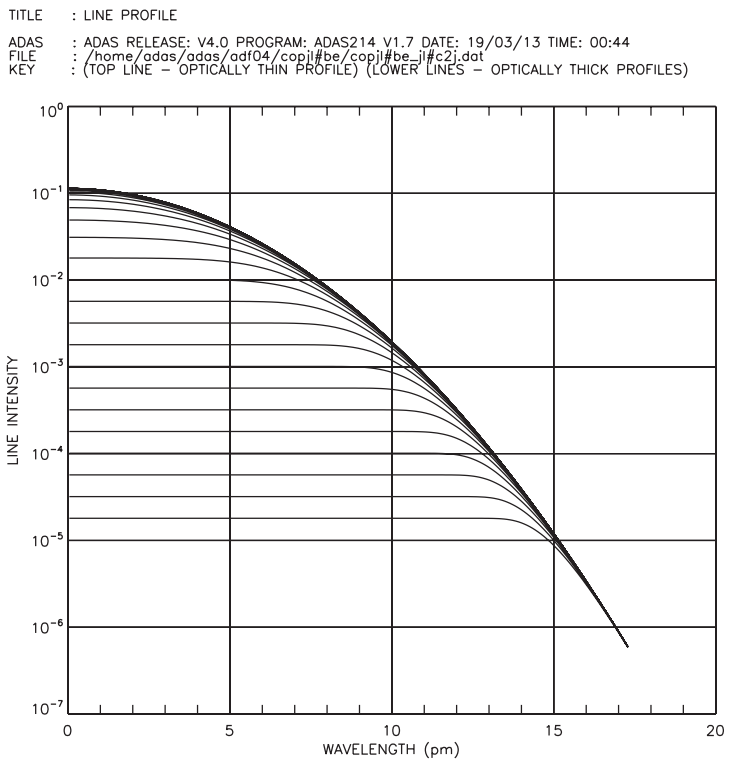

Figure 11: demo_d/demo_d_adas214_profile.pdf

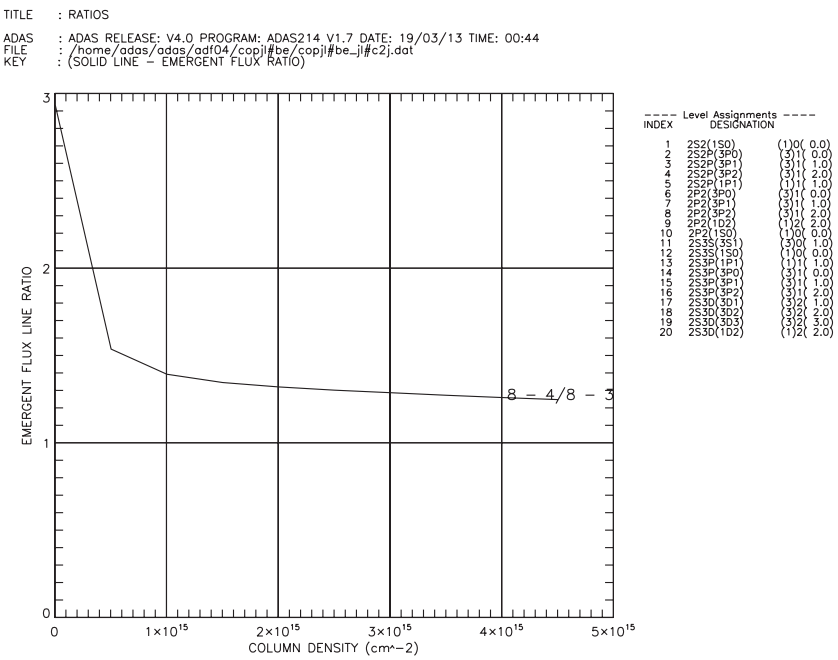

Figure 12: demo_d/demo_d_adas214_ratio.pdf

4.4 Demo (d-2) Tables

4.4.1 demo_d-2/adas214.pass

```
C + 2         6          3        386241.
    1   2S2(1S0)        (1)0( 0.0)        0.0
    2   2S2P(3P0)       (3)1( 0.0)    52367.1
    3   2S2P(3P1)       (3)1( 1.0)    52390.8
    4   2S2P(3P2)       (3)1( 2.0)    52447.1
    5   2S2P(1P1)       (1)1( 1.0)   102352.0
    6   2P2(3P0)        (3)1( 0.0)   137425.7
    7   2P2(3P1)        (3)1( 1.0)   137454.4
    8   2P2(3P2)        (3)1( 2.0)   137502.0
    9   2P2(1D2)        (1)2( 2.0)   145876.1
   10   2P2(1S0)        (1)0( 0.0)   182519.9
   11   2S3S(3S1)       (3)0( 1.0)   238213.0
   12   2S3S(1S0)       (1)0( 0.0)   247170.3
   13   2S3P(1P1)       (1)1( 1.0)   258931.3
   14   2S3P(3P0)       (3)1( 0.0)   259705.6
   15   2S3P(3P1)       (3)1( 1.0)   259711.2
   16   2S3P(3P2)       (3)1( 2.0)   259724.3
   17   2S3D(3D1)       (3)2( 1.0)   270010.8
   18   2S3D(3D2)       (3)2( 2.0)   270011.9
   19   2S3D(3D3)       (3)2( 3.0)   270014.7
   20   2S3D(1D2)       (1)2( 2.0)   276482.9
   -1
 3.00    3       9.00+03 1.80+04 4.50+04 9.00+04 1.80+05 4.50+05 9.00+05 1.80+06
   2   1 1.00-30 1.19-01 1.13-01 1.08-01 9.51-02 7.81-02 5.44-02 3.84-02 2.44-02
   3   1 1.04+02 3.58-01 3.40-01 3.23-01 2.85-01 2.34-01 1.63-01 1.15-01 7.32-02
   4   1 5.22-03 5.96-01 5.67-01 5.39-01 4.75-01 3.91-01 2.72-01 1.92-01 1.22-01
   5   1 5.23+04 3.75+00 3.88+00 4.10+00 4.48+00 5.15+00 6.64+00 8.07+00 9.93+00
   6   1 1.00-30 1.30-03 1.75-03 2.47-03 2.53-03 2.17-03 1.46-03 9.75-04 7.55-04
   7   1 9.23-04 3.89-03 5.25-03 7.41-03 7.60-03 6.50-03 4.38-03 2.93-03 2.27-03
   8   1 3.83-02 6.48-03 8.75-03 1.24-02 1.27-02 1.08-02 7.31-03 4.88-03 3.78-03
   9   1 2.37+03 3.85-01 3.89-01 3.94-01 3.84-01 3.63-01 3.38-01 3.15-01 3.02-01
  10   1 1.00-30 7.12-02 7.71-02 8.29-02 8.01-02 7.70-02 7.89-02 7.70-02 7.64-02
  11   1 1.00-30 2.67-01 2.28-01 1.55-01 1.06-01 7.12-02 4.20-02 2.80-02 1.60-02
  12   1 1.00-30 3.24-01 3.03-01 2.68-01 2.52-01 2.60-01 3.04-01 3.40-01 3.44-01
  13   1 9.88+05 1.66-01 1.51-01 1.13-01 9.47-02 9.71-02 1.40-01 2.15-01 2.50-01
  14   1 1.00-30 1.81-02 1.54-02 1.08-02 8.29-03 6.85-03 5.34-03 3.99-03 2.44-03
  15   1 4.72+05 5.43-02 4.63-02 3.25-02 2.49-02 2.05-02 1.60-02 1.20-02 7.33-03
  16   1 1.00-30 9.05-02 7.72-02 5.42-02 4.14-02 3.42-02 2.67-02 2.00-02 1.22-02
  17   1 1.00-30 4.51-02 4.13-02 3.66-02 3.39-02 2.99-02 2.23-02 1.61-02 1.05-02
  18   1 1.00-30 7.52-02 6.89-02 6.10-02 5.64-02 4.99-02 3.72-02 2.69-02 1.74-02
  19   1 1.00-30 1.05-01 9.64-02 8.53-02 7.90-02 6.98-02 5.21-02 3.76-02 2.44-02
  20   1 1.00-30 1.68-01 1.61-01 1.68-01 1.95-01 2.53-01 3.75-01 4.79-01 4.93-01
   3   2 6.28-07 9.62-01 1.02+00 1.11+00 1.03+00 8.41-01 5.67-01 5.41-01 5.41-01
   4   2 1.00-30 7.18-01 8.31-01 1.09+00 1.06+00 8.70-01 6.10-01 5.88-01 5.88-01
   5   2 1.45-03 3.29-01 3.40-01 3.21-01 2.72-01 2.11-01 1.33-01 8.63-02 5.25-02
   6   2 1.00-30 3.17-02 3.02-02 3.20-02 3.51-02 3.99-02 5.05-02 6.02-02 7.26-02
   7   2 1.07+06 2.12+00 2.02+00 2.14+00 2.34+00 2.67+00 3.37+00 4.03+00 4.85+00
   8   2 1.00-30 6.94-02 6.60-02 6.99-02 7.67-02 8.72-02 1.10-01 1.32-01 1.59-01
   9   2 1.00-30 1.42-01 1.40-01 1.40-01 1.42-01 1.36-01 1.06-01 7.76-02 5.52-02
  10   2 1.00-30 2.44-02 2.34-02 2.24-02 2.02-02 1.66-02 1.13-02 7.79-03 4.93-03
  11   2 1.63+07 4.23-01 3.32-01 2.09-01 1.42-01 1.08-01 1.04-01 1.27-01 1.32-01
  12   2 1.00-30 8.85-02 7.73-02 5.28-02 3.86-02 2.98-02 2.05-02 1.37-02 7.94-03
  13   2 1.00-30 1.06-01 9.34-02 6.77-02 5.13-02 3.87-02 2.56-02 1.74-02 1.02-02
  14   2 1.00-30 3.30-01 2.93-01 2.37-01 2.09-01 1.97-01 1.99-01 2.04-01 2.04-01
  15   2 1.00-30 9.91-02 8.80-02 7.10-02 6.27-02 5.90-02 5.95-02 6.11-02 6.12-02
  16   2 1.00-30 1.04-01 9.23-02 7.45-02 6.58-02 6.18-02 6.24-02 6.40-02 6.42-02
  17   2 1.83+07 4.39-01 4.21-01 4.25-01 4.68-01 5.57-01 7.77-01 1.03+00 1.31+00
  18   2 1.00-30 5.36-02 5.14-02 5.19-02 5.71-02 6.80-02 9.49-02 1.25-01 1.60-01
  19   2 1.00-30 4.63-02 4.45-02 4.49-02 4.94-02 5.88-02 8.21-02 1.08-01 1.39-01
  20   2 1.00-30 8.33-02 7.55-02 6.41-02 5.52-02 4.48-02 3.02-02 2.01-02 1.22-02
   4   3 3.72-06 2.78+00 3.10+00 3.79+00 3.62+00 2.97+00 2.05+00 1.97+00 1.97+00
   5   3 1.09-03 9.88-01 1.02+00 9.63-01 8.14-01 6.32-01 4.00-01 2.59-01 1.58-01
   6   3 3.19+06 2.12+00 2.02+00 2.14+00 2.34+00 2.67+00 3.37+00 4.03+00 4.85+00
   7   3 1.10+06 1.75+00 1.66+00 1.76+00 1.93+00 2.19+00 2.78+00 3.31+00 3.99+00
   8   3 6.26+05 2.78+00 2.64+00 2.80+00 3.07+00 3.49+00 4.42+00 5.27+00 6.35+00
   9   3 4.85+03 4.27-01 4.20-01 4.19-01 4.26-01 4.07-01 3.18-01 2.33-01 1.66-01
  10   3 1.85+03 7.31-02 7.03-02 6.72-02 6.07-02 4.98-02 3.39-02 2.34-02 1.48-02
  11   3 1.31+07 1.27+00 9.96-01 6.27-01 4.26-01 3.25-01 3.11-01 3.82-01 3.95-01
  12   3 1.00-30 2.66-01 2.32-01 1.58-01 1.16-01 8.95-02 6.16-02 4.11-02 2.38-02
  13   3 1.00-30 3.17-01 2.80-01 2.03-01 1.54-01 1.16-01 7.67-02 5.23-02 3.06-02
```

```
14   3 1.00-30 9.91-02 8.80-02 7.10-02 6.27-02 5.90-02 5.95-02 6.11-02 6.12-02
15   3 1.00-30 1.14+00 1.02+00 8.20-01 7.25-01 6.81-01 6.88-01 7.05-01 7.07-01
16   3 1.00-30 3.54-01 3.15-01 2.54-01 2.24-01 2.11-01 2.13-01 2.18-01 2.19-01
17   3 1.89+07 4.01-01 3.85-01 3.88-01 4.27-01 5.09-01 7.09-01 9.36-01 1.20+00
18   3 1.01+07 1.04+00 9.97-01 1.00+00 1.11+00 1.32+00 1.84+00 2.42+00 3.11+00
19   3 1.00-30 1.68-01 1.61-01 1.63-01 1.79-01 2.13-01 2.97-01 3.93-01 5.03-01
20   3 1.00-30 2.50-01 2.27-01 1.92-01 1.66-01 1.35-01 9.06-02 6.04-02 3.65-02
 5   4 1.81-03 1.65+00 1.70+00 1.61+00 1.36+00 1.05+00 6.67-01 4.31-01 2.63-01
 6   4 1.00-30 6.94-02 6.60-02 6.99-02 7.67-02 8.72-02 1.10-01 1.32-01 1.59-01
 7   4 1.04+06 2.82+00 2.68+00 2.84+00 3.11+00 3.54+00 4.48+00 5.34+00 6.44+00
 8   4 5.67+05 8.09+00 7.69+00 8.15+00 8.94+00 1.02+01 1.29+01 1.54+01 1.85+01
 9   4 2.97+04 7.11-01 7.01-01 6.98-01 7.10-01 6.79-01 5.31-01 3.88-01 2.76-01
10   4 1.00-30 1.22-01 1.17-01 1.12-01 1.01-01 8.30-02 5.65-02 3.90-02 2.47-02
11   4 1.22+07 2.12+00 1.66+00 1.05+00 7.09-01 5.41-01 5.18-01 6.37-01 6.58-01
12   4 1.00-30 4.43-01 3.87-01 2.64-01 1.93-01 1.49-01 1.03-01 6.86-02 3.97-02
13   4 1.00-30 5.29-01 4.67-01 3.38-01 2.56-01 1.94-01 1.28-01 8.72-02 5.10-02
14   4 1.00-30 1.05-01 9.35-02 7.55-02 6.67-02 6.27-02 6.33-02 6.49-02 6.50-02
15   4 1.00-30 3.57-01 3.17-01 2.56-01 2.26-01 2.12-01 2.14-01 2.20-01 2.20-01
16   4 1.00-30 2.22+00 1.97+00 1.59+00 1.40+00 1.32+00 1.33+00 1.37+00 1.37+00
17   4 3.43+07 1.32-01 1.27-01 1.28-01 1.41-01 1.67-01 2.33-01 3.08-01 3.95-01
18   4 1.14+07 5.26-01 5.05-01 5.09-01 5.61-01 6.68-01 9.32-01 1.23+00 1.58+00
19   4 6.85+06 2.03+00 1.95+00 1.96+00 2.16+00 2.57+00 3.59+00 4.74+00 6.07+00
20   4 1.00-30 4.17-01 3.78-01 3.21-01 2.76-01 2.24-01 1.51-01 1.01-01 6.09-02
 6   5 2.10+02 9.74-02 9.71-02 9.62-02 9.00-02 7.81-02 5.70-02 4.10-02 2.74-02
 7   5 1.47+01 2.92-01 2.91-01 2.89-01 2.70-01 2.34-01 1.71-01 1.23-01 8.23-02
 8   5 1.37+03 4.87-01 4.85-01 4.81-01 4.50-01 3.91-01 2.85-01 2.05-01 1.37-01
 9   5 2.01+05 1.10+01 1.14+01 1.23+01 1.35+01 1.52+01 1.89+01 2.18+01 2.59+01
10   5 6.76+06 3.39+00 3.51+00 3.82+00 4.20+00 4.83+00 6.31+00 7.73+00 9.49+00
11   5 1.00-30 1.28+00 1.02+00 6.40-01 4.08-01 2.51-01 1.30-01 7.77-02 4.24-02
12   5 6.80+07 6.60-01 5.75-01 3.88-01 2.74-01 2.10-01 1.89-01 2.20-01 2.26-01
13   5 1.00-30 1.25+00 1.12+00 8.41-01 7.02-01 6.48-01 6.61-01 6.95-01 6.99-01
14   5 1.00-30 1.12-01 1.01-01 7.62-02 5.84-02 4.43-02 2.89-02 1.93-02 1.13-02
15   5 1.00-30 3.36-01 3.04-01 2.29-01 1.75-01 1.33-01 8.68-02 5.79-02 3.38-02
16   5 1.00-30 5.60-01 5.06-01 3.81-01 2.92-01 2.22-01 1.45-01 9.65-02 5.63-02
17   5 1.00-30 2.52-01 2.16-01 1.73-01 1.45-01 1.16-01 7.78-02 5.21-02 3.10-02
18   5 1.00-30 4.19-01 3.60-01 2.88-01 2.41-01 1.93-01 1.30-01 8.68-02 5.16-02
19   5 1.00-30 5.87-01 5.04-01 4.04-01 3.38-01 2.70-01 1.82-01 1.22-01 7.22-02
20   5 1.32+07 1.60+00 1.65+00 1.91+00 2.35+00 3.05+00 4.49+00 5.92+00 7.78+00
 7   6 1.00-30 8.44-01 8.16-01 7.38-01 6.65-01 5.75-01 4.31-01 4.16-01 4.16-01
 8   6 1.00-30 4.97-01 4.80-01 4.39-01 4.10-01 3.82-01 3.48-01 3.45-01 3.45-01
 9   6 1.00-30 3.82-01 3.75-01 3.59-01 3.51-01 3.30-01 2.55-01 1.81-01 1.24-01
10   6 1.00-30 4.08-02 3.92-02 3.73-02 3.62-02 3.25-02 2.41-02 1.69-02 1.12-02
11   6 1.00-30 7.48-02 6.93-02 4.94-02 3.27-02 2.00-02 9.76-03 5.72-03 5.28-03
12   6 1.00-30 1.11-02 1.00-02 6.73-03 4.45-03 2.82-03 1.52-03 1.11-03 6.35-04
13   6 1.00-30 1.19-01 1.01-01 6.59-02 4.25-02 2.60-02 1.28-02 7.22-03 3.90-03
14   6 1.00-30 4.12-02 3.33-02 2.10-02 1.36-02 8.74-03 4.93-03 2.94-03 2.90-03
15   6 7.75+05 3.24-01 2.62-01 1.65-01 1.07-01 6.87-02 3.88-02 2.31-02 2.28-02
16   6 1.00-30 1.53-01 1.24-01 7.80-02 5.08-02 3.25-02 1.83-02 1.09-02 1.08-02
17   6 1.00-30 1.07-01 9.11-02 6.09-02 4.15-02 2.72-02 1.52-02 9.61-03 8.96-03
18   6 1.00-30 2.38-01 2.03-01 1.35-01 9.21-02 6.03-02 3.37-02 2.14-02 1.99-02
19   6 1.00-30 9.13-02 7.76-02 5.19-02 3.53-02 2.31-02 1.29-02 8.19-03 7.64-03
20   6 1.00-30 1.47-01 1.18-01 7.50-02 5.11-02 3.38-02 1.85-02 1.12-02 6.22-03
 8   7 1.00-30 2.16+00 2.09+00 1.91+00 1.76+00 1.57+00 1.31+00 1.28+00 1.28+00
 9   7 1.00-30 1.15+00 1.12+00 1.08+00 1.05+00 9.89-01 7.64-01 5.44-01 3.72-01
10   7 1.00-30 1.22-01 1.18-01 1.12-01 1.09-01 9.76-02 7.22-02 5.08-02 3.37-02
11   7 1.00-30 2.24-01 2.08-01 1.48-01 9.82-02 5.99-02 2.93-02 1.72-02 1.58-02
12   7 1.00-30 3.34-02 3.01-02 2.04-02 1.34-02 8.47-03 4.57-03 3.32-03 1.90-03
13   7 1.00-30 3.56-01 3.02-01 1.98-01 1.28-01 7.79-02 3.84-02 2.16-02 1.17-02
14   7 2.33+06 3.24-01 2.62-01 1.65-01 1.07-01 6.87-02 3.88-02 2.31-02 2.28-02
15   7 5.82+05 4.79-01 3.87-01 2.44-01 1.59-01 1.02-01 5.73-02 3.41-02 3.37-02
16   7 5.70+05 7.47-01 6.04-01 3.80-01 2.47-01 1.58-01 8.95-02 5.33-02 5.26-02
17   7 1.00-30 3.97-01 3.38-01 2.26-01 1.54-01 1.01-01 5.61-02 3.56-02 3.32-02
18   7 1.00-30 3.93-01 3.34-01 2.23-01 1.52-01 9.96-02 5.56-02 3.53-02 3.29-02
19   7 1.00-30 5.16-01 4.39-01 2.93-01 2.00-01 1.31-01 7.30-02 4.63-02 4.32-02
20   7 1.00-30 4.40-01 3.52-01 2.25-01 1.53-01 1.01-01 6.17-02 3.37-02 1.87-02
 9   8 1.00-30 1.91+00 1.87+00 1.79+00 1.75+00 1.65+00 1.27+00 9.06-01 6.20-01
10   8 1.00-30 2.04-01 1.96-01 1.87-01 1.81-01 1.63-01 1.20-01 8.46-02 5.61-02
11   8 1.00-03 3.74-01 3.46-01 2.47-01 1.64-01 9.98-02 4.88-02 2.86-02 2.64-02
12   8 1.00-30 5.56-02 5.01-02 3.40-02 2.23-02 1.41-02 7.62-03 5.53-03 3.17-03
13   8 1.00-30 5.94-01 5.04-01 3.29-01 2.13-01 1.30-01 6.40-02 3.61-02 1.95-02
14   8 1.00-30 1.53-01 1.24-01 7.80-02 5.08-02 3.25-02 1.83-02 1.09-02 1.08-02
15   8 9.51+05 8.24-01 6.66-01 4.19-01 2.73-01 1.75-01 9.86-02 5.87-02 5.80-02
16   8 1.66+06 1.74+00 1.41+00 8.85-01 5.76-01 3.69-01 2.08-01 1.24-01 1.22-01
17   8 1.00-30 3.06-01 2.60-01 1.74-01 1.18-01 7.74-02 4.32-02 2.74-02 2.56-02
```

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  18   8 1.00-30 6.75-01 5.74-01 3.83-01 2.61-01 1.71-01 9.54-02 6.05-02 5.64-02
  19   8 1.00-30 1.23+00 1.05+00 6.99-01 4.76-01 3.12-01 1.74-01 1.10-01 1.03-01
  20   8 1.00-30 7.33-01 5.87-01 3.75-01 2.55-01 1.69-01 1.03-01 5.62-02 3.11-02
  10   9 4.34+01 6.31-01 6.40-01 6.79-01 7.18-01 7.51-01 8.09-01 8.39-01 8.41-01
  11   9 1.00-30 1.54+00 1.16+00 7.05-01 4.35-01 2.50-01 1.13-01 6.06-02 3.18-02
  12   9 1.00-30 6.22-01 5.32-01 3.40-01 2.27-01 1.61-01 1.28-01 1.25-01 1.25-01
  13   9 1.96+07 1.66+00 1.53+00 1.16+00 9.69-01 9.31-01 1.09+00 1.32+00 1.44+00
  14   9 1.00-30 2.25-01 2.08-01 1.43-01 9.16-02 5.45-02 2.60-02 1.44-02 7.78-03
  15   9 1.00-30 6.75-01 6.23-01 4.28-01 2.75-01 1.63-01 7.81-02 4.32-02 2.33-02
  16   9 1.00-30 1.13+00 1.04+00 7.13-01 4.58-01 2.72-01 1.30-01 7.19-02 3.89-02
  17   9 1.00-30 4.93-01 4.02-01 2.52-01 1.61-01 9.89-02 5.06-02 2.94-02 1.60-02
  18   9 1.00-30 8.21-01 6.70-01 4.20-01 2.69-01 1.65-01 8.43-02 4.91-02 2.61-02
  19   9 1.00-30 1.15+00 9.38-01 5.88-01 3.76-01 2.31-01 1.18-01 6.87-02 3.73-02
  20   9 1.00-30 1.39+00 1.20+00 9.28-01 7.92-01 6.99-01 6.32-01 5.99-01 5.94-01
  11  10 1.00-30 5.32-01 4.48-01 2.86-01 1.79-01 1.05-01 5.09-02 2.84-02 1.51-02
  12  10 1.00-30 4.71-01 4.12-01 2.81-01 1.98-01 1.41-01 1.00-01 8.91-02 8.82-02
  13  10 1.64+07 2.19-01 2.21-01 1.90-01 1.66-01 1.61-01 1.90-01 2.48-01 2.71-01
  14  10 1.00-30 2.96-02 2.72-02 1.89-02 1.28-02 8.28-03 4.45-03 2.63-03 1.43-03
  15  10 1.00-30 8.80-02 8.16-02 5.67-02 3.84-02 2.49-02 1.33-02 7.88-03 4.30-03
  16  10 1.00-30 1.48-01 1.36-01 9.46-02 6.40-02 4.14-02 2.22-02 1.31-02 7.17-03
  17  10 1.00-30 5.50-02 4.99-02 3.81-02 2.84-02 2.00-02 1.16-02 7.18-03 4.05-03
  18  10 1.00-30 9.17-02 8.31-02 6.35-02 4.74-02 3.34-02 1.93-02 1.20-02 6.75-03
  19  10 1.00-30 1.28-01 1.16-01 8.89-02 6.63-02 4.67-02 2.70-02 1.68-02 9.45-03
  20  10 1.00-30 4.38-01 3.86-01 3.11-01 2.82-01 2.78-01 2.91-01 2.96-01 2.96-01
  12  11 1.00-30 3.56+00 2.70+00 1.58+00 9.87-01 6.16-01 3.29-01 1.97-01 1.05-01
  13  11 1.00-30 2.47+00 1.81+00 1.05+00 6.94-01 4.62-01 2.60-01 1.59-01 8.59-02
  14  11 1.99+06 6.90+00 7.31+00 7.04+00 8.19+00 1.04+01 1.42+01 1.72+01 2.03+01
  15  11 5.50+05 2.07+01 2.19+01 2.11+01 2.46+01 3.12+01 4.27+01 5.15+01 6.10+01
  16  11 3.10+05 3.45+01 3.65+01 3.52+01 4.09+01 5.20+01 7.12+01 8.59+01 1.02+02
  17  11 1.00-30 1.96+00 2.04+00 2.19+00 2.35+00 2.56+00 2.78+00 2.84+00 2.84+00
  18  11 1.00-30 3.27+00 3.39+00 3.65+00 3.92+00 4.27+00 4.64+00 4.73+00 4.73+00
  19  11 1.00-30 4.58+00 4.75+00 5.10+00 5.49+00 5.98+00 6.50+00 6.63+00 6.63+00
  20  11 1.00-30 7.99-01 7.34-01 6.27-01 5.33-01 4.20-01 2.66-01 1.67-01 9.88-02
  13  12 1.11+05 1.32+01 1.41+01 1.78+01 2.44+01 3.33+01 4.64+01 5.52+01 6.51+01
  14  12 1.00-30 2.41-01 1.84-01 1.12-01 7.41-02 4.91-02 2.72-02 1.64-02 8.85-03
  15  12 1.00-30 7.23-01 5.53-01 3.36-01 2.22-01 1.47-01 8.17-02 4.92-02 2.66-02
  16  12 1.00-30 1.20+00 9.22-01 5.60-01 3.70-01 2.45-01 1.36-01 8.21-02 4.42-02
  17  12 1.00-30 3.29-01 2.62-01 1.79-01 1.30-01 9.14-02 5.23-02 3.15-02 1.73-02
  18  12 1.00-30 5.49-01 4.36-01 2.98-01 2.17-01 1.52-01 8.71-02 5.25-02 2.89-02
  19  12 1.00-30 7.68-01 6.10-01 4.17-01 3.03-01 2.13-01 1.22-01 7.36-02 4.04-02
  20  12 1.00-30 3.03+00 3.10+00 3.44+00 3.83+00 4.22+00 4.58+00 4.63+00 4.63+00
  14  13 1.00-30 1.08+00 8.55-01 5.36-01 3.59-01 2.40-01 1.36-01 8.30-02 4.50-02
  15  13 1.00-30 3.25+00 2.57+00 1.61+00 1.08+00 7.21-01 4.07-01 2.49-01 1.35-01
  16  13 1.00-30 5.42+00 4.28+00 2.68+00 1.80+00 1.20+00 6.79-01 4.15-01 2.25-01
  17  13 1.00-30 8.07-01 6.58-01 4.82-01 3.78-01 2.83-01 1.68-01 1.03-01 5.75-02
  18  13 1.00-30 1.35+00 1.10+00 8.03-01 6.30-01 4.72-01 2.80-01 1.71-01 9.58-02
  19  13 1.00-30 1.88+00 1.54+00 1.12+00 8.81-01 6.60-01 3.92-01 2.39-01 1.34-01
  20  13 2.54+05 3.20+01 3.38+01 4.09+01 5.03+01 6.28+01 8.31+01 1.01+02 1.20+02
  17  14 1.05+05 9.58+00 1.06+01 1.40+01 1.84+01 2.36+01 3.13+01 3.79+01 4.45+01
  18  14 1.00-30 1.82-01 2.01-01 2.66-01 3.49-01 4.48-01 5.94-01 7.20-01 8.46-01
  19  14 1.00-30 2.30-01 2.54-01 3.36-01 4.40-01 5.56-01 7.50-01 9.10-01 1.07+00
  20  14 1.00-30 3.10-01 2.88-01 2.53-01 2.15-01 1.66-01 9.92-02 6.02-02 3.50-02
  17  15 1.12+05 7.19+00 7.95+00 1.05+01 1.38+01 1.77+01 2.34+01 2.84+01 3.34+01
  18  15 5.48+04 2.44+01 2.70+01 3.57+01 4.68+01 6.01+01 7.97+01 9.66+01 1.14+02
  19  15 1.00-30 7.09-01 7.84-01 1.04+00 1.36+00 1.74+00 2.31+00 2.80+00 3.30+00
  20  15 1.00-30 9.30-01 8.64-01 7.58-01 6.44-01 4.98-01 2.98-01 1.81-01 1.05-01
  17  16 1.34+05 9.58-01 1.06+00 1.40+00 1.84+00 2.36+00 3.13+00 3.79+00 4.45+00
  18  16 6.67+04 8.91+00 9.86+00 1.30+01 1.71+01 2.19+01 2.91+01 3.52+01 4.14+01
  19  16 3.60+04 4.36+01 4.82+01 6.36+01 8.35+01 1.07+02 1.42+02 1.72+02 2.03+02
  20  16 1.00-30 1.55+00 1.44+00 1.26+00 1.07+00 8.30-01 4.96-01 3.01-01 1.75-01
  20  17 1.00-30 1.83+00 1.69+00 1.46+00 1.22+00 9.35-01 5.63-01 3.49-01 2.03-01
  20  18 1.00-30 3.04+00 2.82+00 2.43+00 2.04+00 1.56+00 9.38-01 5.81-01 3.39-01
  20  19 1.00-30 4.26+00 3.94+00 3.40+00 2.85+00 2.18+00 1.31+00 8.13-01 4.74-01
  -1
  -1  -1
C------------------------------------------------------------------------
C
C   Energy Levels
C   The results from NSRDS NBS3 SECT 3 were used. These were the same
C   as the results of Edlen (Phys. Scr 32, 86, 1985 and  28, 51, 1983)
C   who only considered n=2 levels. The NSRDS values are also those of
C   Moore and Gallacher "Tables of Spectra of hydrogen, carbon, nitrogen
C   and oxygen atoms and ions" CRC press 1993.
C
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C   Ionisation Potential
C   As energy levels.
C
C   A Values
C   For transitions between n = 2 levels the results of the compilation
C   by Allard et al (Astron Astrophys Suppl Ser 84, 563, 1990) were used
C   and for values not given by them the results of Nussbaumer and Storey
C   (Astron Astrophys 74, 244, 1979) were used. The Nusssbaumer and Storey
C   results were adopted for forbidden transitions by Allard et al.
C   For the 2-3 and 3-4 transitions the results of Idrees and Das (J Phys B
C   22, 3609, 1989 were used.
C   For transitions involving n = 3 levels again the results of Allard et al
C   were adopted.
C   For the important 2s2 1S - 2s2p 3P1 transition Allard et al recommend a
C   value of 93.98 s-1.  Recently Kwong et al (Ap J 411, 431, 1993) have
C   published a measured value of 121 +/- 7 s-1. There have been two recent
C   calculation of this rate, Fleming et al (Phys. Scr 49, 316, 1994) giving
C   104 +/-4 s-1 and Fischer (Phys Scr 49, 323, 1994) giving 103 +/- 3 s-1.
C   Here we adopt 104 s-1.
C
C   Collision Data
C   The data recommended in a review by Berrington (ADNDT 57, 71, 1994) are
C   adopted.
C   The results of Berrington (J Phys B, 18, L395, 1985) and Berrington et al
C   (J Phys B 22, 665, 1989 and JET Report JT7/11345) were adopted for
C   transitions between n=2 levels and for transitions involving levels 3
C   respectively. These results were obtained from a 12 eigenstate R-matrix
C   calculation. The 12 states correspond to the 20 lowest fine structure
C   levels. For transitions betweeen n = 2 levels the partial wave expansion
C   was for total angular momentum L <= 9. For some transitions the partial
C   wave expansion is slowly convergent and care was taken to allow for this.
C   For transitions involving n=3 levels it appears that partial waves up to
C   L <= 11 ware included. However, the slow convergence of the partial
C   wave expansion was a problem which was dealt with by writing a new no-
C   exchange R-matrix package. In addition for dipole allowed transitions a
C   top-up procedure was adopted, care being taken that the Coulomb-Bethe
C   approximation was valid when it was applied.
C   These calculations gave effective collision strengths between LS terms.
C   Berrington (ADNDT 57, 71, 1994) in a review recommends the work of
C   Berrington et al (ADNDT 33, 195, 1985) for fine structure transitions
C   involving 2s2p 3P or 2p2 3P. These recommendations were adopted.
C   For the former Keenan et al (Ap J 389, 443, 1992) give the unpublished
C   rates from Berrington's 1985 calculation. However they are at most 7%
C   different (2-4, lowest temperature value) and the Keenan et al results
C   are only at three low close temperature.
C   To obtain the fine structure collision rates statistical weight factors
C   were used except for the transitions given in the tables below.
C
C   The tables give the percentages of the total collision strength going into
C   each of the fine structure transitions at a reduced temperature of 1e4.
C
C
C   2s2p 3Pj - 2p2 3Pj'
C
C    j j'   NIV     OV     OV   NeVII  NeVII  AQ        Use
C           (CC)   (CC)   (DW)   (CC)   (DW)
C    0 0    0.16   0.115  0.09   0.08   0.07            0.16
C    0 1   10.67  10.8   11.23  10.79  11.07  11.1     10.7
C    0 2    0.35   0.214  0.11   0.12   0.09            0.35
C
C    1 0   10.72  10.76  11.23  10.79  10.88  11.1     10.7
C    1 1    8.82   8.65   7.71   8.56   8.57   8.33     8.8
C    1 2   13.99  13.93  12.56  14.19  14.02  12.89    14.0
C
C    2 0    0.35   0.21   0.11   0.12   0.08            0.35
C    2 1   14.15  13.99  14.26  14.19  14.02  13.89    14.2
C    2 2   40.81  41.38  42.72  41.16  41.22  41.67    40.8
C
C   The values adopted are close to that of N IV. The N IV calculation is
C   by Ramsbottom et al (see adf04 file), the O V CC data are from Kato, Lang
C   and Berrington (see adf04 file). The DW calculations are Sampson (see
C   copsm#be). The Ne VII data are from ADF04 file (JL95).
C
C
```

```
C   2s2p 3Pj - 2s3d 3Dj'
C
C    j j'   NIV     OV     OV     AQ
C           (CC)   (CC)   (CC1)  NeVII
C    0 1    9.09   9.04   9.74  11.11
C    0 2    1.11   1.13   0.78
C    0 3    0.96   1.01   0.77
C
C    1 1    8.30   8.26   8.37   8.33
C    1 2   21.48  21.32  22.88  25.00
C    1 3    3.48   3.61   2.62
C
C    2 1    2.73   2.75   2.22   0.56
C    2 2   10.91  10.72  10.23   8.33
C    2 3   41.95  42.17  42.39  46.67
C
C   The values adopted are those of N IV. The N IV calculation is by
C   Ramsbottom et al (see adf04 file), the O V CC data are from Kato, Lang
C   and Berrington (see adf04 file) and CC1 is adf04 from 89 (or 90).
C
C
C   2s2p 3Pj - 2s3p 3Pj'
C
C    j j'   NIV     OV     OV    NeVII
C           (CC)   (CC)   (CC1)  (DW)
C    0 0    6.87   7.00   8.24   5.51
C    0 1    2.06   1.89   1.05   0.54
C    0 2    2.16   2.36   1.78   1.12
C
C    1 0    2.06   1.92   1.04   0.51
C    1 1   23.77  24.52  26.88  17.46
C    1 2    7.37   7.36   5.33  39.96
C
C    2 0    2.19   2.45   1.79   1.11
C    2 1    7.42   7.66   5.31   2.44
C    2 2   46.09  44.86  48.58  31.39
C
C   The values adopted are those of N IV. The N IV calculation is by
C   Ramsbottom et al (see adf04 file), the O V CC data are from Kato, Lang
C   and Berrington (see adf04 file) and CC1 is adf04 from 89 (or90). The DW
C   calculation for Ne VII is from Sampson et al (1984) from JL95.
C
C
C   2p2 3Pj - 2s3p 3Pj'
C
C    j j'   NIV     OV    NeVII  AQ
C           (CC)   (CC)   (DW)
C    0 0    0.86   0.14   0.24
C    0 1    6.75   0.84  10.19  11.1
C    0 2    3.23   0.77   0.72
C
C    1 0    6.76   0.85  10.11  11.11
C    1 1   10.00   1.76   8.87   8.33
C    1 2   15.64   3.08  14.67  12.89
C
C    2 0    3.22   0.72   0.68
C    2 1   17.23   2.80  13.92  13.89
C    2 2   36.31  89.04  40.61  41.67
C
C   The values adopted are those of N IV. The N IV calculation is by
C   Ramsbottom et al (see adf04 file), the O V CC data are from  Kato, Lang
C   and Berrington (see adf04 file). The DW calculation for Ne VII is from
C   Sampson et al (1984) from JL95.
C
C
C   2p2 3Pj - 2s3d 3Dj'
C
C    j j'   NIV     OV    NeVII
C           (CC)   (CC)   (DW)
C    0 1    2.73   3.61   2.94
C    0 2    5.98   4.33   6.36
C    0 3    2.28   3.09   2.02
C
C    1 1   10.19   8.49  10.80
```

```
C    1 2    9.87  12.32  10.00
C    1 3   12.89  12.32  12.74
C
C    2 1    7.69   7.79   7.18
C    2 2   17.27  16.50  17.46
C    2 3   31.11  31.56  30.51
C
C   The values adopted are essentially that of N V. The N IV calculation
C   is by Ramsbottom et al (see adf04 file), the O V CC data are from Kato,
C   Lang and Berrington (see adf04 file). The DW data for Ne VII are from
C   Sampson et al (1984) from JL95.
C
C
C   2s3p 3Pj - 2s3d 3Dj'
C
C    j j'    OV     AQ
C           (CC)
C    0 1    9.98  11.11
C    0 2    0.19
C    0 3    0.24
C
C    1 1    7.54   8.33
C    1 2   25.52  25.00
C    1 3    0.74
C
C    2 1    1.02   0.56
C    2 2    9.29   8.33
C    2 3   45.48  46.17
C
C   The values adopted are for O V. The O V CC data are from Kato, Lang
C   and Berrington (see adf04 file).
C
C
C   In processing the 2p2 3P - 2s3p 3P data, it was noted that this is given
C   as a forbidden transition. However, it has a fairly large A value.
C   So allowed behaviour was forced on it when running ADAS 102. At the
C   highest temperature given here this gives a 1% increase in the effective
C   collision strength between the LS terms.
C
C   J LANG    June 1995.
C
C  Update:  03/06/02  A D Whiteford - amended ion charge from 3 to 2.
C
C-----------------------------------------------------------------------

C-------------------------------------------------------------------------------
C ADAS ADF04 DATA - SCCS info: @(#)$Header:
/home/adascvs/adas/adf04/copjl#be/copjl#be_jl#c2j.dat,v 2.2 2004/07/06 21:27:01
whitefor Exp $ D
C-------------------------------------------------------------------------------
C-------------------------------------------------------------------------------
C  18/03/13
C  produced with ADAS214 and the following data:
C  input data file: /home/adas/adas/adf04/copjl#be/copjl#be_jl#c2j.dat
C  dens distn: Homogeneous
C  geometry: Disk
C  profile: Doppler
C  m =  6., Te =   80000.0K, Tg =   80000.0K, l =   1.00E+03cm,
C  na or nion =   2.50E+12cm-3
C-------------------------------------------------------------------------------
```

4.4.2 demo_d-2/demo_d_pec_adas214.dat

```
   6    /C + 2 EMISSIVITY COEFFTS./
 1174.9 A  10  10 /FILMEM = 214.pass/TYPE = EXCIT    /INDM = T/ISEL =    1
1.00E+08 2.78E+08 7.74E+08 2.15E+09 5.99E+09 1.67E+10 4.64E+10 1.29E+11
3.59E+11 1.00E+12
8.62E-01 3.45E+00 6.89E+00 8.62E+00 3.45E+01 6.89E+01 8.62E+01 3.45E+02
6.89E+02 8.62E+02
1.84E-16 1.47E-10 8.97E-10 1.21E-09 1.96E-09 1.48E-09 1.29E-09 4.19E-10
2.34E-10 1.95E-10
2.30E-16 1.70E-10 1.00E-09 1.34E-09 2.11E-09 1.59E-09 1.38E-09 4.45E-10
2.47E-10 2.06E-10
3.41E-16 2.25E-10 1.24E-09 1.63E-09 2.48E-09 1.87E-09 1.63E-09 5.16E-10
2.82E-10 2.33E-10
5.51E-16 3.23E-10 1.64E-09 2.14E-09 3.23E-09 2.51E-09 2.20E-09 7.04E-10
3.77E-10 3.10E-10
8.24E-16 4.41E-10 2.11E-09 2.73E-09 4.35E-09 3.64E-09 3.27E-09 1.17E-09
6.32E-10 5.19E-10
1.04E-15 5.32E-10 2.46E-09 3.18E-09 5.43E-09 4.95E-09 4.63E-09 2.15E-09
1.27E-09 1.06E-09
1.16E-15 5.85E-10 2.67E-09 3.45E-09 6.17E-09 5.99E-09 5.78E-09 3.64E-09
2.56E-09 2.26E-09
1.21E-15 6.20E-10 2.82E-09 3.65E-09 6.68E-09 6.70E-09 6.57E-09 5.09E-09
4.21E-09 3.92E-09
1.20E-15 6.51E-10 2.97E-09 3.84E-09 7.02E-09 7.14E-09 7.06E-09 5.98E-09
5.27E-09 5.04E-09
1.10E-15 6.59E-10 3.01E-09 3.88E-09 6.98E-09 7.14E-09 7.08E-09 6.22E-09
5.59E-09 5.37E-09
 1175.7 A  10  10 /FILMEM = 214.pass/TYPE = EXCIT    /INDM = T/ISEL =    2
1.00E+08 2.78E+08 7.74E+08 2.15E+09 5.99E+09 1.67E+10 4.64E+10 1.29E+11
3.59E+11 1.00E+12
8.62E-01 3.45E+00 6.89E+00 8.62E+00 3.45E+01 6.89E+01 8.62E+01 3.45E+02
6.89E+02 8.62E+02
1.66E-16 1.33E-10 8.12E-10 1.09E-09 1.78E-09 1.34E-09 1.16E-09 3.79E-10
2.12E-10 1.77E-10
2.09E-16 1.54E-10 9.06E-10 1.21E-09 1.91E-09 1.44E-09 1.25E-09 4.03E-10
2.24E-10 1.86E-10
3.09E-16 2.03E-10 1.12E-09 1.47E-09 2.24E-09 1.70E-09 1.47E-09 4.67E-10
2.55E-10 2.11E-10
4.99E-16 2.92E-10 1.49E-09 1.94E-09 2.93E-09 2.28E-09 2.00E-09 6.38E-10
3.42E-10 2.81E-10
7.47E-16 3.99E-10 1.91E-09 2.47E-09 3.94E-09 3.29E-09 2.96E-09 1.06E-09
5.73E-10 4.70E-10
9.46E-16 4.82E-10 2.23E-09 2.88E-09 4.92E-09 4.49E-09 4.19E-09 1.95E-09
1.15E-09 9.63E-10
1.05E-15 5.30E-10 2.41E-09 3.12E-09 5.59E-09 5.43E-09 5.23E-09 3.30E-09
2.32E-09 2.05E-09
1.09E-15 5.61E-10 2.56E-09 3.31E-09 6.05E-09 6.07E-09 5.95E-09 4.61E-09
3.81E-09 3.55E-09
1.08E-15 5.89E-10 2.69E-09 3.48E-09 6.36E-09 6.47E-09 6.39E-09 5.42E-09
4.77E-09 4.56E-09
9.97E-16 5.97E-10 2.73E-09 3.51E-09 6.32E-09 6.46E-09 6.41E-09 5.64E-09
5.06E-09 4.87E-09
 1176.0 A  10  10 /FILMEM = 214.pass/TYPE = EXCIT    /INDM = T/ISEL =    3
1.00E+08 2.78E+08 7.74E+08 2.15E+09 5.99E+09 1.67E+10 4.64E+10 1.29E+11
3.59E+11 1.00E+12
8.62E-01 3.45E+00 6.89E+00 8.62E+00 3.45E+01 6.89E+01 8.62E+01 3.45E+02
6.89E+02 8.62E+02
1.62E-17 1.09E-11 6.55E-11 8.85E-11 1.42E-10 1.04E-10 8.86E-11 2.43E-11
1.23E-11 9.90E-12
3.69E-17 2.27E-11 1.28E-10 1.70E-10 2.47E-10 1.76E-10 1.49E-10 3.87E-11
1.90E-11 1.51E-11
8.59E-17 4.99E-11 2.69E-10 3.54E-10 5.06E-10 3.61E-10 3.06E-10 7.80E-11
3.74E-11 2.97E-11
1.79E-16 9.92E-11 5.16E-10 6.78E-10 1.04E-09 7.80E-10 6.72E-10 1.83E-10
8.81E-11 6.98E-11
3.01E-16 1.59E-10 7.98E-10 1.05E-09 1.83E-09 1.52E-09 1.35E-09 4.42E-10
2.24E-10 1.80E-10
4.00E-16 2.04E-10 1.00E-09 1.33E-09 2.59E-09 2.37E-09 2.21E-09 9.86E-10
5.65E-10 4.68E-10
4.55E-16 2.31E-10 1.12E-09 1.50E-09 3.09E-09 3.03E-09 2.92E-09 1.81E-09
1.26E-09 1.11E-09
4.81E-16 2.48E-10 1.21E-09 1.61E-09 3.40E-09 3.46E-09 3.39E-09 2.62E-09
2.15E-09 2.00E-09
```

```
4.92E-16 2.66E-10 1.29E-09 1.71E-09 3.60E-09 3.72E-09 3.68E-09 3.12E-09
2.74E-09 2.62E-09
4.90E-16 2.81E-10 1.35E-09 1.78E-09 3.63E-09 3.75E-09 3.73E-09 3.28E-09
2.94E-09 2.82E-09
 1175.6 A  10  10 /FILMEM = 214.pass/TYPE = EXCIT    /INDM = T/ISEL =    4
1.00E+08 2.78E+08 7.74E+08 2.15E+09 5.99E+09 1.67E+10 4.64E+10 1.29E+11
3.59E+11 1.00E+12
8.62E-01 3.45E+00 6.89E+00 8.62E+00 3.45E+01 6.89E+01 8.62E+01 3.45E+02
6.89E+02 8.62E+02
6.81E-17 5.57E-11 3.47E-10 4.71E-10 7.87E-10 5.87E-10 5.07E-10 1.58E-10
8.57E-11 7.08E-11
8.71E-17 6.53E-11 3.90E-10 5.25E-10 8.51E-10 6.34E-10 5.48E-10 1.69E-10
9.11E-11 7.51E-11
1.32E-16 8.76E-11 4.89E-10 6.48E-10 1.01E-09 7.55E-10 6.53E-10 1.98E-10
1.05E-10 8.65E-11
2.18E-16 1.28E-10 6.60E-10 8.63E-10 1.33E-09 1.03E-09 8.98E-10 2.77E-10
1.45E-10 1.18E-10
3.30E-16 1.76E-10 8.57E-10 1.11E-09 1.82E-09 1.51E-09 1.35E-09 4.72E-10
2.51E-10 2.04E-10
4.21E-16 2.14E-10 1.00E-09 1.30E-09 2.28E-09 2.07E-09 1.93E-09 8.80E-10
5.15E-10 4.30E-10
4.71E-16 2.36E-10 1.09E-09 1.42E-09 2.60E-09 2.51E-09 2.41E-09 1.50E-09
1.05E-09 9.26E-10
4.96E-16 2.52E-10 1.16E-09 1.51E-09 2.81E-09 2.81E-09 2.75E-09 2.11E-09
1.74E-09 1.62E-09
5.08E-16 2.69E-10 1.24E-09 1.60E-09 2.98E-09 3.01E-09 2.97E-09 2.49E-09
2.19E-09 2.09E-09
5.08E-16 2.86E-10 1.30E-09 1.67E-09 3.01E-09 3.05E-09 3.02E-09 2.62E-09
2.34E-09 2.25E-09
 1175.3 A  10  10 /FILMEM = 214.pass/TYPE = EXCIT    /INDM = T/ISEL =    5
1.00E+08 2.78E+08 7.74E+08 2.15E+09 5.99E+09 1.67E+10 4.64E+10 1.29E+11
3.59E+11 1.00E+12
8.62E-01 3.45E+00 6.89E+00 8.62E+00 3.45E+01 6.89E+01 8.62E+01 3.45E+02
6.89E+02 8.62E+02
6.63E-17 5.42E-11 3.37E-10 4.58E-10 7.66E-10 5.71E-10 4.93E-10 1.53E-10
8.34E-11 6.89E-11
8.47E-17 6.36E-11 3.80E-10 5.11E-10 8.28E-10 6.17E-10 5.33E-10 1.64E-10
8.86E-11 7.30E-11
1.29E-16 8.52E-11 4.75E-10 6.30E-10 9.81E-10 7.34E-10 6.35E-10 1.93E-10
1.03E-10 8.42E-11
2.12E-16 1.24E-10 6.42E-10 8.40E-10 1.30E-09 1.00E-09 8.73E-10 2.69E-10
1.41E-10 1.15E-10
3.21E-16 1.72E-10 8.33E-10 1.08E-09 1.77E-09 1.47E-09 1.32E-09 4.59E-10
2.44E-10 1.99E-10
4.09E-16 2.08E-10 9.75E-10 1.27E-09 2.22E-09 2.01E-09 1.88E-09 8.56E-10
5.01E-10 4.18E-10
4.59E-16 2.30E-10 1.06E-09 1.38E-09 2.53E-09 2.44E-09 2.35E-09 1.46E-09
1.02E-09 9.01E-10
4.82E-16 2.45E-10 1.13E-09 1.47E-09 2.74E-09 2.73E-09 2.68E-09 2.06E-09
1.69E-09 1.57E-09
4.94E-16 2.62E-10 1.20E-09 1.56E-09 2.89E-09 2.93E-09 2.89E-09 2.43E-09
2.13E-09 2.03E-09
4.94E-16 2.78E-10 1.26E-09 1.63E-09 2.93E-09 2.97E-09 2.94E-09 2.55E-09
2.28E-09 2.19E-09
 1176.4 A  10  10 /FILMEM = 214.pass/TYPE = EXCIT    /INDM = T/ISEL =    6
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3.59E+11 1.00E+12
8.62E-01 3.45E+00 6.89E+00 8.62E+00 3.45E+01 6.89E+01 8.62E+01 3.45E+02
6.89E+02 8.62E+02
6.44E-17 5.27E-11 3.28E-10 4.45E-10 7.44E-10 5.55E-10 4.79E-10 1.49E-10
8.10E-11 6.70E-11
8.24E-17 6.18E-11 3.69E-10 4.96E-10 8.05E-10 6.00E-10 5.18E-10 1.59E-10
8.61E-11 7.10E-11
1.25E-16 8.28E-11 4.62E-10 6.12E-10 9.54E-10 7.14E-10 6.17E-10 1.87E-10
9.97E-11 8.18E-11
2.06E-16 1.21E-10 6.24E-10 8.16E-10 1.26E-09 9.72E-10 8.49E-10 2.62E-10
1.37E-10 1.12E-10
3.12E-16 1.67E-10 8.10E-10 1.05E-09 1.72E-09 1.43E-09 1.28E-09 4.46E-10
2.37E-10 1.93E-10
3.98E-16 2.02E-10 9.48E-10 1.23E-09 2.16E-09 1.96E-09 1.82E-09 8.32E-10
4.87E-10 4.06E-10
4.46E-16 2.23E-10 1.03E-09 1.34E-09 2.45E-09 2.37E-09 2.28E-09 1.42E-09
9.95E-10 8.76E-10
4.69E-16 2.38E-10 1.10E-09 1.43E-09 2.66E-09 2.66E-09 2.60E-09 2.00E-09
```

```
 1.64E-09 1.53E-09
 4.80E-16 2.55E-10 1.17E-09 1.52E-09 2.81E-09 2.85E-09 2.81E-09 2.36E-09
 2.07E-09 1.98E-09
 4.80E-16 2.70E-10 1.23E-09 1.58E-09 2.85E-09 2.89E-09 2.85E-09 2.48E-09
 2.21E-09 2.13E-09
C-----------------------------------------------------------------------
C
C  PHOTON EMISSIVITY COEFFICIENTS:
C
C
C  INFORMATION
C  -----------
C
C  NUCLEAR CHARGE =  6
C  ION CHARGE +1  =  3
C
C  SPECIFIC ION FILE  : adas214.pass
C  EXPANSION FILE     : No projection data was used in this case.
C
C  No ionisation data has been included
C
C  OPTIONS  : LNORM=T  LPSEL=F  LZSEL=F  LIOSEL=F
C             LHSEL=F  LRSEL=F  LISEL=F  LNSEL =F
C
C
C   Configuration           (2s+1)l(w-1/2)          Energy (cm**-1)
C     1   2S2(1S0)             (1)0( 0.0)             0.0
C     2   2S2P(3P0)            (3)1( 0.0)          52367.1
C     3   2S2P(3P1)            (3)1( 1.0)          52390.8
C     4   2S2P(3P2)            (3)1( 2.0)          52447.1
C     5   2S2P(1P1)            (1)1( 1.0)         102352.0
C     6   2P2(3P0)             (3)1( 0.0)         137425.7
C     7   2P2(3P1)             (3)1( 1.0)         137454.4
C     8   2P2(3P2)             (3)1( 2.0)         137502.0
C     9   2P2(1D2)             (1)2( 2.0)         145876.1
C    10   2P2(1S0)             (1)0( 0.0)         182519.9
C    11   2S3S(3S1)            (3)0( 1.0)         238213.0
C    12   2S3S(1S0)            (1)0( 0.0)         247170.3
C    13   2S3P(1P1)            (1)1( 1.0)         258931.3
C    14   2S3P(3P0)            (3)1( 0.0)         259705.6
C    15   2S3P(3P1)            (3)1( 1.0)         259711.2
C    16   2S3P(3P2)            (3)1( 2.0)         259724.3
C    17   2S3D(3D1)            (3)2( 1.0)         270010.8
C    18   2S3D(3D2)            (3)2( 2.0)         270011.9
C    19   2S3D(3D3)            (3)2( 3.0)         270014.7
C    20   2S3D(1D2)            (1)2( 2.0)         276482.9
C
C
C
C  ISEL  WAVELENGTH       TRANSITION                TYPE   METASTABLE  IMET NMET  IP
C  ----  ----------  ----------------------------  -----  ----------- ---- ----  --
C   1.    1174.93      8(3)1( 2.0)-   3(3)1( 1.0)  EXCIT               T    1
C   2.    1175.71      8(3)1( 2.0)-   4(3)1( 2.0)  EXCIT               T    1
C   3.    1175.99      6(3)1( 0.0)-   3(3)1( 1.0)  EXCIT               T    1
C   4.    1175.59      7(3)1( 1.0)-   3(3)1( 1.0)  EXCIT               T    1
C   5.    1175.26      7(3)1( 1.0)-   2(3)1( 0.0)  EXCIT               T    1
C   6.    1176.37      7(3)1( 1.0)-   4(3)1( 2.0)  EXCIT               T    1
C
C  CODE     : ADAS208
C  PRODUCER : Alessandra Giunta
C  DATE     : 19/03/13
C
C-------------------------------------------------------------------------------
```

5 Demo (e) Working with Non-Maxwellians

```
------------------------------
DEMO E: Non-Maxwellian rates
------------------------------
PURPOSE: To generate adf04 data files type 4 (Non-Maxwellian averaged)
and calculate the population of excited state using run_adas218.pro
population code.

The ADAS format which delivers fundamental electron-ion collision data and atomic
structure calculations is adf04. As discussed in Module 1 Demo c, there are five
types of adf04. The most common is the type 3, which provides the Maxwellian
averaged Upsilon (effective collision strength) as a function of
electron temperature. Cross sections unaveraged over a distributions are collected
in adf04 type 1 and adf04 type 5. Type 1 gives the collision strengths as a
function of the threshold parameter X (see Module 1 Demo c for more details),
while type 5 contains the collision strengthsas a function
of the final state energy.

For Non-Maxwellian case, type 4 adf04 is introduced.
This adf04 provides the effective collision strengths convolved with a
defined Non-Maxwellian distribution as a function of the effective temperature.
Non_Maxwellian distributions (analytic distributions, such as Kappa and
Druyvestyn, or numerical distributions) are collected in the adf37 ADAS data
format.

Type 1 and type 5 adf04 data files are used together with adf37 to produce adf04
type 4.

While the population calculation for a Maxwellian type 3 adf04 is performed by
ADAS208 (or run_adas208.pro from the command line), the code to compute
the population of excited states for Non-Maxwellian type 4
adf04 is run_adas218.pro

EXAMPLE: For this demo C2+ is considered. The input file is the following
adf04 type 5:
/home/adas/adas/adf04/cophps#be/dw/ls#c2_t5.dat
The free electron distributions included in the demo are:
- Maxwellian distribution
- Kappa distribution, with the parameter kappa=5
- Druyvestyn istribution, with the parameter x=2.5
- a numerical distribution EEDF (for JET discharge #74380 -
  block 1 : 0.033m from outer divertor, Te(maxw) ~ 4eV)

To generate the adf04 convolved with Maxwellian (type 3) and Non-Maxwellian
(type 4) distributions, /home/adas/offline_adas/adas7#3/bin/adf04_om2ups.x
is used. The input and output files for this run are the following:

- for Maxwellian distribution:
  output file=c2_max.dat (type 3 adf04)
```

```
- for Kappa distribution:
  input file=instruction.kappa
  output file=c2_kappa.dat
- for Druyvestyn istribution:
  input file=instruction.dru
  output file=c2_dru.dat
- for numerical distribution:
  input file=adf37_DT_1.dat
  output file=c2_num.dat

To calculate the populations of excited level run_adas208.pro is used for the
Maxwellian case and run_adas218.pro for the three Non-Maxwellian cases.


COMMENTS: Note that for the numerical distribution a single temperature is used.


DEMO e1: Converting adf04 type 5 to adf04 type 4 using ADAS7#3
         and run ADAS218 for non-Maxwellian populations.
1. Specify the type 5 adf04.
2. Convolve the four adf04 with the defined free electron distributions.
3. Use run_adas208.pro to calculate the population for
   the Maxwellian case.
4. Use run_adas218.pro to calculate the population for
   the Non-Maxwellian case.
5. Plot the populations as a function of excited states for the four cases.
Program: demo_e.pro
Input files: instruction.kappa, instruction.dru, adf37_DT_1.dat
Output file: c2_max.dat, c2_kappa.dat, c2_dru.dat, c2_num.dat, demo_e.ps
```

5.1 Demo (e) Figures

5.1.1 Demo (e-1) demo_e/nonmax_c2.pdf

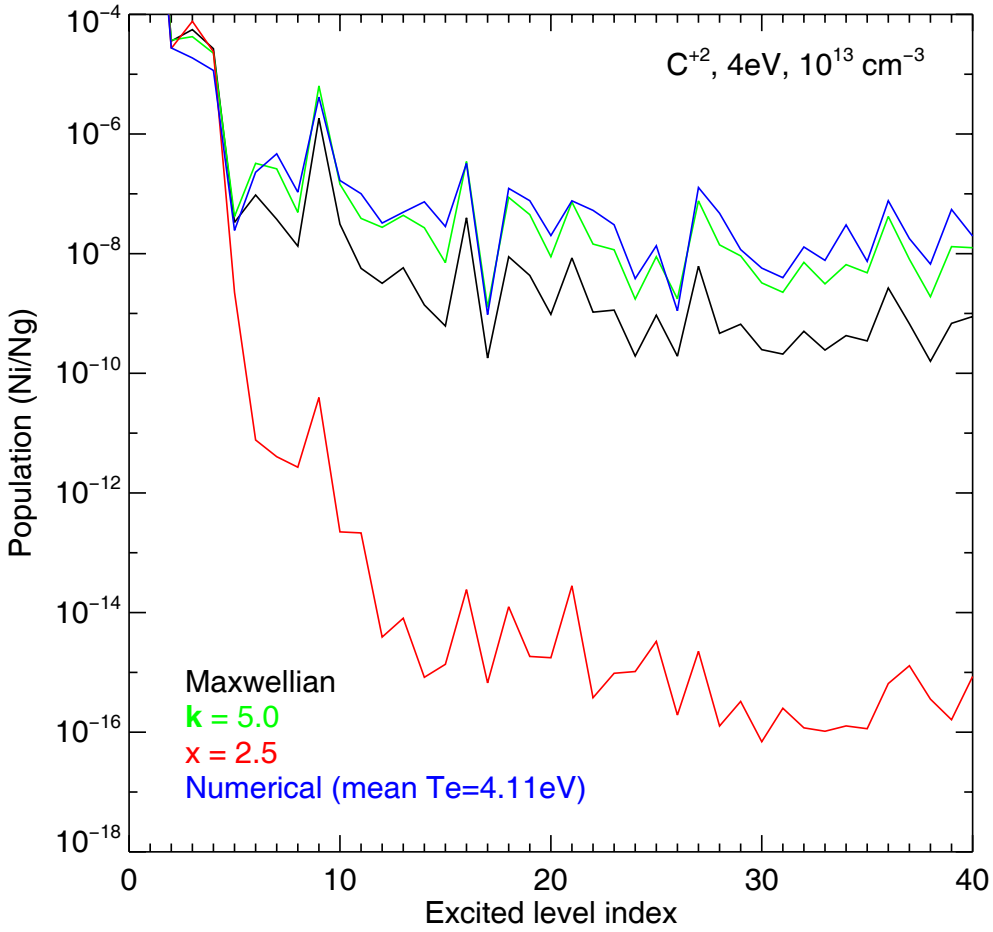

Figure 13: Comparison of populations with different distribution functions .

5.2 Demo (e) IDL procedures

5.2.1 Demo (e-1) demo_e/demo_e.pro

```
pro demo_e
;Compare the excited populations of C+2 at 4eV (max abundance for Maxwellian)
;against kappa, Druyvesteyn and numerical EEDFs

;Specify the adf04 type 5 file for C2+

adf04_in = '/home/adas/adas/adf04/cophps#be/dw/ls#c2_t5.dat'

;-----------------------------------------------
; Run adas7#3 adf04_om2ups to generate an adf04 with
;  (a) Maxwellian
;  (b) kappa=5.0
;  (c) Druyvesteyn, x=2.5
;  (d) numerical adf37
;---------------------------------------

exe = '/home/adas/offline_adas/adas7#3/bin/adf04_om2ups.x'

cmd_a = exe + ' ' + adf04_in + ' c2_max.dat'
spawn, cmd_a


all = [' &instruction',                                          $  ; fortran namelist
       '   adf04_in  = ''' + adf04_in + ''',',                   $  ; input adf04 file name
       '   adf04_out = ''c2_kappa.dat'',',                       $  ; output adf04 file name
       '   numte=5, te= 1e4, 2e4, 5e4, 7e4, 1e5, ittype=1,',     $  ; temperatures in K
       '   kappa=5.0',                                           $  ; kappa value
       ' &end'                                                   ]

adas_writefile, file='instruction.kappa', all=all

cmd_b = exe + ' -finstruction.kappa'
spawn, cmd_b


all = [' &instruction',                                          $  ; fortran namelist
       '   adf04_in  = ''' + adf04_in + ''',',                   $  ; input adf04 file name
       '   adf04_out = ''c2_dru.dat'',',                         $  ; output adf04 file name
       '   numte=5, te= 1e4, 2e4, 5e4, 7e4, 1e5, ittype=1,',     $  ; temperatures in K
       '   x=2.5',                                               $  ; Druyvesteyn x value
       ' &end'                                                   ]

adas_writefile, file='instruction.dru', all=all

cmd_c = exe + ' -finstruction.dru'
spawn, cmd_c
```

```
cmd_d = exe + ' ' + adf04_in + ' c2_num.dat adf37_DT_1.dat 4'
; spawn, cmd_d

;---------------------------------------
; Run population code at 4eV, 1e13 cm-3
;    (a) adas208
;    (b),(c), (d) adas218
;---------------------------------------


te        = 4.0
dens      = 1e13
unit_te   = 'ev'
unid_dens = 'cm-3'
meta_list = [1]

;Use run-adas208.pro to calulate the population
;from the type 3 Maxwellian adf04
run_adas208, adf04='c2_max.dat',                                        $
             te=te,dens=dens, unit_te=unit_te,unit_dens=unit_dens,      $
             meta=meta_list,                                            $
             log='paper-208.txt', pass_dir='.', pop=pop_max


;Use run-adas218.pro to calulate the population
;from the type 4 Non-Maxwellian adf04
;for a Kappa distribution
run_adas218, adf04='c2_kappa.dat',                                      $
             te=te,dens=dens, unit_te=unit_te,unit_dens=unit_dens,      $
             meta=meta_list,                                            $
             log='paper-208.txt', pass_dir='.', pop=pop_kappa

;Use run-adas218.pro to calulate the population
;from the type 4 Non-Maxwellian adf04
;for a Druyvesteyn distribution
run_adas218, adf04='c2_dru.dat',                                        $
             te=te,dens=dens, unit_te=unit_te,unit_dens=unit_dens,      $
             meta=meta_list,                                            $
             log='paper-208.txt', pass_dir='.', pop=pop_dru

;Use run-adas218.pro to calulate the population
;from the type 4 Non-Maxwellian adf04
;for a numerical distribution
te = 4.118  ; EEDF mean Te
run_adas218, adf04='c2_num.dat',                                        $
             te=te,dens=dens, unit_te=unit_te,unit_dens=unit_dens,      $
             meta=meta_list,                                            $
             log='paper-208.txt', pass_dir='.', pop=pop_num
```

```
;-----------------
; Plot populations
;-----------------

index     = indgen(pop_max.numlev) + 1
dep_max   = pop_max.dependence
dep_kappa = pop_kappa.dependence
dep_dru   = pop_dru.dependence
dep_num   = pop_num.dependence

xmin = 1
xmax = 40
ymin = 1e-18
ymax = 1e-4

set_plot,'ps'
device, /isolatin1, font_index=8
device, bits=8, filename='demo_e.ps',  $
        font_size = 14, xsize=18.0, ysize=16.0, $
        yoffset=7.0, /color
device, /helvetica



plot_io, [xmin, xmax], [ymin, ymax], /nodata, ystyle=1,$
         xtitle = 'Excited level index', $
         ytitle = 'Population (Ni/Ng)'

oplot, index, dep_max, thick=3
oplot, index, dep_kappa, line=1
oplot, index, dep_dru, line=2
oplot, index, dep_num, line=3

device, /close
set_plot,'X'
!p.font=-1



end
```

5.3 Demo (e-1) Tables and drivers

5.3.1 demo_e-1/instruction.kappa

```
 &instruction
   adf04_in  = '/home/adas/adas/adf04/cophps#be/dw/ls#c2_t5.dat',
   adf04_out = 'c2_kappa.dat',
   numte=5, te= 1e4, 2e4, 5e4, 7e4, 1e5, ittype=1,
   kappa=5.0
 &end
```

5.3.2 demo_e-1/instruction.dru

```
 &instruction
   adf04_in  = '/home/adas/adas/adf04/cophps#be/dw/ls#c2_t5.dat',
   adf04_out = 'c2_dru.dat',
   numte=5, te= 1e4, 2e4, 5e4, 7e4, 1e5, ittype=1,
   x=2.5
 &end
```

5.3.3 demo_e-1/adf37_DT_1.dat

```
ADF37 - Non-Maxwellian distribution FE_1
       2          ; format of file 1 => superposition; 2 => numerical
       2          ; energy units 1 => K; 2 => eV
     116          ; number of tabulated values
       1          ; number of tabulated temperatures
    1             ; cutoff threshold
    3  1.00e+00   ; high energy behaviour
  1.00e-01  1.00e+01  2.01e+01  3.01e+01  4.01e+01  5.01e+01  6.02e+01
  7.02e+01  8.02e+01  9.02e+01  1.00e+02  1.10e+02  1.20e+02  1.30e+02
  1.40e+02  1.50e+02  1.60e+02  1.70e+02  1.80e+02  1.90e+02  2.01e+02
  2.11e+02  2.21e+02  2.31e+02  2.41e+02  2.51e+02  2.61e+02  2.71e+02
  2.81e+02  2.91e+02  3.01e+02  3.11e+02  3.21e+02  3.31e+02  3.41e+02
  3.51e+02  3.61e+02  3.71e+02  3.81e+02  3.91e+02  4.01e+02  4.11e+02
  4.21e+02  4.31e+02  4.41e+02  4.51e+02  4.61e+02  4.71e+02  4.81e+02
  4.91e+02  5.01e+02  5.11e+02  5.21e+02  5.31e+02  5.41e+02  5.51e+02
  5.61e+02  5.71e+02  5.81e+02  5.91e+02  6.02e+02  6.12e+02  6.22e+02
  6.32e+02  6.42e+02  6.52e+02  6.62e+02  6.72e+02  6.82e+02  6.92e+02
  7.02e+02  7.12e+02  7.22e+02  7.32e+02  7.42e+02  7.52e+02  7.62e+02
  7.72e+02  7.82e+02  7.92e+02  8.02e+02  8.12e+02  8.22e+02  8.32e+02
  8.42e+02  8.52e+02  8.62e+02  8.72e+02  8.82e+02  8.92e+02  9.02e+02
  9.12e+02  9.22e+02  9.32e+02  9.42e+02  9.52e+02  9.62e+02  9.72e+02
  9.82e+02  9.92e+02  1.00e+03  1.01e+03  1.02e+03  1.03e+03  1.04e+03
  1.05e+03  1.06e+03  1.07e+03  1.08e+03  1.09e+03  1.10e+03  1.11e+03
  1.12e+03  1.13e+03  1.14e+03  1.15e+03
  2.00e-01  2.34e-02  2.04e-03  3.78e-04  2.10e-04  1.73e-04  1.55e-04
  1.44e-04  1.34e-04  1.23e-04  1.12e-04  1.03e-04  9.22e-05  8.45e-05
  7.77e-05  7.19e-05  6.42e-05  6.00e-05  5.50e-05  5.02e-05  4.61e-05
  4.18e-05  3.75e-05  3.50e-05  3.23e-05  2.92e-05  2.62e-05  2.49e-05
  2.22e-05  2.11e-05  1.88e-05  1.72e-05  1.55e-05  1.40e-05  1.31e-05
  1.14e-05  1.04e-05  9.00e-06  8.32e-06  7.98e-06  7.10e-06  6.56e-06
  5.83e-06  5.24e-06  4.51e-06  4.30e-06  4.08e-06  3.71e-06  3.13e-06
  2.79e-06  2.71e-06  2.45e-06  2.41e-06  2.24e-06  1.81e-06  1.63e-06
  1.51e-06  1.34e-06  1.36e-06  1.13e-06  1.02e-06  8.61e-07  8.93e-07
  9.20e-07  7.19e-07  6.44e-07  5.61e-07  5.05e-07  3.99e-07  3.98e-07
  3.27e-07  2.85e-07  2.99e-07  2.80e-07  1.93e-07  2.25e-07  2.10e-07
  2.48e-07  1.67e-07  1.24e-07  1.55e-07  9.10e-08  7.78e-08  8.18e-08
  1.06e-07  9.46e-08  8.88e-08  8.37e-08  9.00e-08  4.28e-08  5.39e-08
  3.16e-08  3.71e-08  2.35e-08  2.57e-08  2.27e-08  1.38e-08  2.03e-08
  2.62e-08  1.31e-08  1.56e-08  2.52e-08  9.63e-09  6.93e-09  2.29e-09
  1.08e-08  1.33e-08  1.53e-08  1.74e-08  8.72e-09  1.82e-08  1.23e-08
  1.06e-08  2.00e-08  2.82e-09  2.42e-09
C-----------------------------------------------------------------------
C
C  Description: Example EEDF from David Tskhakaya.
C               For JET discharge #74380
C                 block 1 : 0.033m from outer divertor, Te(maxw) ~ 4eV
C
C  Author : Martin O'Mullane
C  Date   : 26-09-2010
C
C-----------------------------------------------------------------------
```

5.3.4 demo_e-1/c2_max.dat

```
C + 2         6         3    386267.9284(1s)
    1 522                 (1)0(  0.0)         0.0000    {X}
    2 512513              (3)1(  4.0)     53491.3156    {X}
    3 512513              (1)1(  1.0)    110439.0290    {X}
    4 523                 (3)1(  4.0)    139893.6726    {X}
    5 523                 (1)2(  2.0)    152571.3874    {X}
    6 523                 (1)0(  0.0)    193818.1952    {X}
        .       .       .
   44 513515              (1)0(  0.0)    361672.4582    {X}
   -1    21.5297 3.13997 2.53196 1.23495 1.08165 1.00320 0.65687 0.59645 0.56432
 3.00    3       9.00+02 1.80+03 4.50+03 9.00+03 1.80+04 4.50+04 9.00+04 1.80+05
   2   1 1.00-30 1.11+00 1.11+00 1.10+00 1.08+00 1.04+00 9.52-01 8.46-01 7.08-01
   3   1 2.23+09 3.76+00 3.77+00 3.79+00 3.85+00 3.97+00 4.29+00 4.74+00 5.48+00
   3   2 1.00-30 2.57+00 2.57+00 2.55+00 2.51+00 2.43+00 2.22+00 1.96+00 1.60+00
   4   1 1.00-30 5.39-02 5.38-02 5.35-02 5.28-02 5.14-02 4.76-02 4.23-02 3.48-02
   4   2 1.56+09 2.17+01 2.17+01 2.19+01 2.21+01 2.27+01 2.42+01 2.63+01 2.98+01
   4   3 1.00-30 9.84-01 9.82-01 9.75-01 9.59-01 9.27-01 8.48-01 7.53-01 6.30-01
   5   1 2.75+03 7.93-02 7.94-02 7.97-02 8.04-02 8.19-02 8.64-02 9.37-02 1.06-01
   5   2 1.00-30 1.72+00 1.72+00 1.70+00 1.68+00 1.63+00 1.49+00 1.33+00 1.12+00
        .       .       .
  44  43 6.93-16 8.13-01 8.09-01 7.84-01 7.33-01 6.42-01 4.92-01 4.02-01 3.53-01
  -1
  -1  -1
c-------------------------------------------------------------------------------
c comments from original adf04 file
c-------------------------------------------------------------------------------
c  Autostructure distorted wave production of adf04 datasets
c
c
c  Script  : /home/adas/offline_adas/adas7#3/scripts/
c                          process_ion_dw_adf27_to_adf04.pl
c
c  Codes   : /home/adas/offline_adas/adas7#1/bin/as25.x
c            /home/adas/offline_adas/adas7#3/bin/adf04_om2ups.x
c  Driver  : /home/adas/adas/adf27/dw/belike/cophps#be/ls#c2.dat
c  Outputs : /home/adas/adas/adf04/cophps#be/dw/ls#c2.dat.
c            /home/adas/adas/adf04/cophps#be/dw/ls#c2_t5.dat.
c
c  Producer: Alessandra Giunta
c  Date    : 11-09-2012
c
c-------------------------------------------------------------------------------
c-------------------------------------------------------------------------------
c
c  Conversion of an adf04 dataset from type 5 to type 3
c
c  Parameter: Cowan ion threshold shift = F
c
c
c  Producer : Alessandra Giunta
c  Date     : 19-07-2013
c
c-------------------------------------------------------------------------------
```

5.3.5 demo_e-1/c2_kappa.dat

```
C + 2         6         3    386267.9284(1s)
    1 522                 (1)0(  0.0)         0.0000    {X}
    2 512513              (3)1(  4.0)     53491.3156    {X}
    3 512513              (1)1(  1.0)    110439.0290    {X}
    4 523                 (3)1(  4.0)    139893.6726    {X}
    5 523                 (1)2(  2.0)    152571.3874    {X}
    6 523                 (1)0(  0.0)    193818.1952    {X}

        .       .       .
   44 513515              (1)0(  0.0)    361672.4582    {X}
   -1    21.5297 3.13997 2.53196 1.23495 1.08165 1.00320 0.65687 0.59645 0.56432
 3.00    4       1.00+04 2.00+04 5.00+04 7.00+04 1.00+05
   2   1 1.00-30 7.32+00 1.25+00 7.60-01 7.42-01 7.31-01 0.00+00
   1   2 0.00+00 1.19+00 1.16+00 1.06+00 1.01+00 9.53-01-3.27+00
   3   1 2.23+09 7.25+03 3.66+01 4.87+00 4.21+00 4.17+00 0.00+00
   1   3 0.00+00 4.24+00 4.36+00 4.70+00 4.90+00 5.17+00 0.00+00
```

```
   3   2 1.00-30 2.25+01 3.14+00 1.77+00 1.71+00 1.67+00-1.43+01
   2   3 0.00+00 2.77+00 2.69+00 2.48+00 2.36+00 2.21+00 0.00+00
   4   1 1.00-30 2.00+03 1.34+00 5.71-02 3.99-02 3.31-02 2.31-01
       .       .       .
  43  44 0.00+00 8.14-01 7.26-01 5.73-01 5.20-01 4.71-01 0.00+00
  -1
  -1  -1
c-------------------------------------------------------------------------------
c comments from original adf04 file
c-------------------------------------------------------------------------------
c  Autostructure distorted wave production of adf04 datasets
c
c
c  Script  : /home/adas/offline_adas/adas7#3/scripts/
c                           process_ion_dw_adf27_to_adf04.pl
c
c  Codes   : /home/adas/offline_adas/adas7#1/bin/as25.x
c            /home/adas/offline_adas/adas7#3/bin/adf04_om2ups.x
c  Driver  : /home/adas/adas/adf27/dw/belike/cophps#be/ls#c2.dat
c  Outputs : /home/adas/adas/adf04/cophps#be/dw/ls#c2.dat.
c            /home/adas/adas/adf04/cophps#be/dw/ls#c2_t5.dat.
c
c  Producer: Alessandra Giunta
c  Date    : 11-09-2012
c
c-------------------------------------------------------------------------------
c-------------------------------------------------------------------------------
c
c  Conversion of an adf04 dataset from type 5 to type 4
c
c  Parameter: Cowan ion threshold shift = F
c  kappa distribution :   5.0000E+00
c
c  Producer : Alessandra Giunta
c  Date     : 19-07-2013
c
c-------------------------------------------------------------------------------
```

5.3.6 demo_e-1/c2_dru.dat

```
C + 2         6         3    386267.9284(1s)
    1 522                 (1)0(  0.0)         0.0000    {X}
    2 512513              (3)1(  4.0)     53491.3156    {X}
    3 512513              (1)1(  1.0)    110439.0290    {X}
    4 523                 (3)1(  4.0)    139893.6726    {X}
    5 523                 (1)2(  2.0)    152571.3874    {X}
    6 523                 (1)0(  0.0)    193818.1952    {X}
        .       .       .
   44 513515              (1)0(  0.0)    361672.4582    {X}
   -1    21.5297 3.13997 2.53196 1.23495 1.08165 1.00320 0.65687 0.59645
 3.00    4       1.00+04 2.00+04 5.00+04 7.00+04 1.00+05
   2   1 1.00-30 4.00-08 1.63-01 1.22+00 1.14+00 9.82-01 0.00+00
   1   2 0.00+00 9.44-01 9.00-01 7.97-01 7.45-01 6.82-01-3.27+00
   3   1 2.23+09 1.00-30 2.69-08 1.68+00 4.05+00 5.58+00 0.00+00
   1   3 0.00+00 3.43+00 3.57+00 3.94+00 4.15+00 4.45+00 0.00+00
   3   2 1.00-30 3.33-09 2.31-01 2.82+00 2.70+00 2.32+00-1.43+01
   2   3 0.00+00 2.19+00 2.10+00 1.86+00 1.73+00 1.57+00 0.00+00
   4   1 1.00-30 1.00-30 1.01-17 5.48-03 2.96-02 5.03-02 2.31-01
   1   4 0.00+00 4.63-02 4.47-02 4.02-02 3.76-02 3.42-02 0.00+00
   4   2 1.56+09 3.05-27 2.21-03 1.93+01 2.86+01 3.25+01-6.38+00
   2   4 0.00+00 1.97+01 2.03+01 2.21+01 2.31+01 2.45+01 0.00+00
   4   3 1.00-30 6.59-02 9.94-01 1.02+00 8.91-01 7.63-01 9.65-03
   3   4 0.00+00 8.38-01 8.00-01 7.11-01 6.65-01 6.08-01 0.00+00
   5   1 2.75+03 1.00-30 9.64-22 3.84-03 3.71-02 8.83-02-3.18+00
   1   5 0.00+00 7.14-02 7.31-02 7.83-02 8.18-02 8.69-02 0.00+00
       .       .       .
  43  44 0.00+00 6.19-01 5.07-01 3.60-01 3.25-01 3.02-01 0.00+00
  -1
  -1  -1
c-------------------------------------------------------------------------------
c comments from original adf04 file
c-------------------------------------------------------------------------------
c  Autostructure distorted wave production of adf04 datasets
c
```

```
c
c  Script  : /home/adas/offline_adas/adas7#3/scripts/
c                          process_ion_dw_adf27_to_adf04.pl
c
c  Codes   : /home/adas/offline_adas/adas7#1/bin/as25.x
c            /home/adas/offline_adas/adas7#3/bin/adf04_om2ups.x
c  Driver  : /home/adas/adas/adf27/dw/belike/cophps#be/ls#c2.dat
c  Outputs : /home/adas/adas/adf04/cophps#be/dw/ls#c2.dat.
c            /home/adas/adas/adf04/cophps#be/dw/ls#c2_t5.dat.
c
c  Producer: Alessandra Giunta
c  Date    : 11-09-2012
c
c-------------------------------------------------------------------------------
c-------------------------------------------------------------------------------
c
c  Conversion of an adf04 dataset from type 5 to type 4
c
c  Parameter: Cowan ion threshold shift = F
c  Druyvesteyn distribution :   2.5000E+00
c
c  Producer : Alessandra Giunta
c  Date     : 19-07-2013
c
```

5.3.7 demo_e-1/c2_num.dat

```
C + 2         6         3    386267.9284(1s)
    1 522                 (1)0(  0.0)         0.0000    {X}
    2 512513              (3)1(  4.0)     53491.3156    {X}
    3 512513              (1)1(  1.0)    110439.0290    {X}
    4 523                 (3)1(  4.0)    139893.6726    {X}
    5 523                 (1)2(  2.0)    152571.3874    {X}
    6 523                 (1)0(  0.0)    193818.1952    {X}
        .       .       .
   44 513515              (1)0(  0.0)    361672.4582    {X}
   -1    21.5297 3.13997 2.53196 1.23495 1.08165 1.00320 0.65687 0.59645
 3.00    4       4.78+04
   2   1 1.00-30 9.24-01 0.00+00
   1   2 0.00+00 2.62+00-3.27+00
   3   1 2.23+09 3.48+00 0.00+00
   1   3 0.00+00 1.04+01 0.00+00
   3   2 1.00-30 2.00+00-1.43+01
   2   3 0.00+00 6.07+00 0.00+00
   4   1 1.00-30 2.89-02 2.31-01
   1   4 0.00+00 1.28-01 0.00+00
   4   2 1.56+09 1.60+01-6.38+00
   2   4 0.00+00 5.92+01 0.00+00
   4   3 1.00-30 1.32+00 9.65-03
   3   4 0.00+00 2.33+00 0.00+00
   5   1 2.75+03 1.16-01-3.18+00
   1   5 0.00+00 2.14-01 0.00+00
       .       .       .
  43  44 0.00+00 1.79+00 0.00+00
  -1
  -1  -1
c-------------------------------------------------------------------------------
c comments from original adf04 file
c-------------------------------------------------------------------------------
c  Autostructure distorted wave production of adf04 datasets
c
c
c  Script  : /home/adas/offline_adas/adas7#3/scripts/
c                          process_ion_dw_adf27_to_adf04.pl
c
c  Codes   : /home/adas/offline_adas/adas7#1/bin/as25.x
c            /home/adas/offline_adas/adas7#3/bin/adf04_om2ups.x
c  Driver  : /home/adas/adas/adf27/dw/belike/cophps#be/ls#c2.dat
c  Outputs : /home/adas/adas/adf04/cophps#be/dw/ls#c2.dat.
c            /home/adas/adas/adf04/cophps#be/dw/ls#c2_t5.dat.
c
c  Producer: Alessandra Giunta
c  Date    : 11-09-2012
```

```
c
c-------------------------------------------------------------------------------
c-------------------------------------------------------------------------------
c
c  Conversion of an adf04 dataset from type 5 to type 4
c
c  Parameter: Cowan ion threshold shift = F
c  adf37 distribution : adf37_DT_1.dat
c
c  Producer : Martin O'Mullane
c  Date     : 28-05-2013
c
c-------------------------------------------------------------------------------
```