

4b. Beam stopping and beam emission spectroscopy

- Extracting effective beam stopping coefficients or beam emission coefficients using ADAS304.
- Calculating the beam population structure using ADAS310
- Details of beam emission with [adas305_get_stark.pro](#)

Interrogating effective beam stopping coefficients

- Datasets of class ADF21 contain effective stopping data as a function of beam and plasma parameters for different plasma species.
- Datasets of class ADF22 contain effective beam emission data as a function of beam and plasma parameters for different plasma species.
- Code ADAS304 interrogates ADF21 or ADF22 data sets to provide coefficients at beam and plasma conditions of your choice.

ADF21 beam stopping coefficients

reference stopping coefficient

stopping species

reference temperature

```
9 /SVREF=1.798E-07 /SPEC=F /DATE=19/03/97 /CODE=ADAS310
-----
25 25 /TREF=2.000E+03
-----
5.000E+03 1.000E+04 1.500E+04 2.000E+04 2.500E+04 3.000E+04 3.500E+04 4.000E+04
4.500E+04 5.000E+04 5.500E+04 6.000E+04 6.500E+04 7.000E+04 7.500E+04 8.000E+04
8.500E+04 9.000E+04 9.500E+04 1.000E+05 1.050E+05 1.100E+05 1.150E+05 1.200E+05
1.250E+05
1.000E+12 2.000E+12 3.000E+12 5.000E+12 6.000E+12 7.000E+12 8.000E+12 9.000E+12
1.000E+13 2.000E+13 3.000E+13 5.000E+13 6.000E+13 7.000E+13 8.000E+13 9.000E+13
1.000E+14 2.000E+14 3.000E+14 5.000E+14 6.000E+14 7.000E+14 8.000E+14 9.000E+14
1.000E+15
-----
1.036E-07 1.228E-07 1.330E-07 1.404E-07 1.469E-07 1.521E-07 1.557E-07 1.593E-07
1.622E-07 1.641E-07 1.655E-07 1.657E-07 1.652E-07 1.654E-07 1.666E-07 1.683E-07
1.698E-07 1.697E-07 1.692E-07 1.691E-07 1.695E-07 1.703E-07 1.718E-07 1.739E-07
1.766E-07
-----
1.222E-07 1.434E-07 1.546E-07 1.625E-07 1.693E-07 1.747E-07 1.785E-07 1.826E-07
1.861E-07 1.891E-07 1.921E-07 1.942E-07 1.960E-07 1.984E-07 2.017E-07 2.057E-07
2.095E-07 2.119E-07 2.138E-07 2.161E-07 2.189E-07 2.222E-07 2.261E-07 2.306E-07
2.356E-07
-----
20 /EREF=6.500E+04 /NREF=6.000E+13
-----
1.000E+02 2.000E+02 3.000E+02 5.000E+02 6.000E+02 7.000E+02 8.000E+02 8.966E+02
1.000E+03 2.000E+03 3.000E+03 5.000E+03 6.000E+03 7.000E+03 8.000E+03 8.966E+03
1.000E+04 2.000E+04 3.000E+04 5.000E+04
-----
2.021E-07 2.017E-07 1.992E-07 1.945E-07 1.926E-07 1.909E-07 1.894E-07 1.881E-07
1.869E-07 1.798E-07 1.761E-07 1.719E-07 1.706E-07 1.695E-07 1.687E-07 1.680E-07
1.673E-07 1.638E-07 1.623E-07 1.608E-07
-----
```

energy scan

density scan

reference conditions

temperature scan

ADAS304 Input

ADAS 304 INPUT

Input Stopping Ion File Details:-

Data Root

Group name for input files : (Usually - bms97#<beam>)

Class prefix for input member : (Up to 3 characters - Blank=none)

Stopping Ion List : Be4 C6 H1
(maximum of 10)

Edit the processing options data and press Done to proceed

sub-library
of data for
beam
species

Select Stopping Ions

B5

Be4

C6

F9

H1

He2

Li3

N7

Ne10

O8

Make a Maximum of 10 selections

click to
choose
stopping
elements

ADAS304 Processing

ADAS304 PROCESSING OPTIONS

Title for run:

Stopping ion list: Be4 C6 H1

Polynomial Fitting

Fit Polynomial value % :

Select co-ordinate type for output graph:-

Energy

Density

Temperature

Output values:

INDEX	Output Beam Energies (Units : eV)	Input Beam Energies (Units : eV)	Output Electron Densities (Units : cm-3)	Input Elect Densi (Unit
1	5.000E+03		6.000E+13	
2	1.000E+04	MIN RANGE	6.000E+13	MIN
3	1.500E+04	-----	6.000E+13	----

Stopping ion fractions:

INDEX	Ion Symbol	Ion Charge	Fraction
1	Be	4	0.100
2	C	6	0.100
3	H	1	0.800
4			

Note: Total fraction should = 1.00
(Otherwise values will be renormalised)

select type of graph display

specify beam and plasma conditions

set fractions for each stopping species

Obtaining effective beam stopping or emission coefficients (contd.)

- The composite stopping for a mixed composition plasma is assembled as

$$N_e S_{CR}^{(A)}(E_B, N_I, T_I) \approx \sum_{i=1}^I N_{e,i} [S_{CR}^{(i,e)}(E_B, N_I, T_I) + (1/z_{0i}) S_{CR}^{(i,z_0)}(E_B, N_I, T_I)]$$

ADAS304 output

ADAS304 OUTPUT OPTIONS

Graphical output

Graph Title

Beam energy plot:-

Explicit scaling

X-min: X-max:

Y-min: Y-max:

Enable Hard Copy Replace

Select Device

File Name :

Post-Script

Post-Script

HP-PCL

HP-GL

Text Output Replace

File Name :

beam energy plot selected

ADAS304 graph



specified conditions

Each contribution to stopping and total

Computing effective beam coefficients

- The first step is the calculation of the full collisional-radiative population structure of the hydrogen beam atoms.
- Code ADAS310 performs these calculations in the bundle-n model.
- It executes these repeatedly for the sets of plasma parameters required to construct tables containing the excited population structure and beam stopping.

Computing effective beam coefficients (contd.)

- The full population structures are archived in ADF26 according to (single) impurity.
- Code ADAS312 post-processes the ADF25 files to extract the beam stopping and beam emission coefficients of choice.
- The output is structured according to the ADF21 (beam stopping) and ADF22 (beam emission) specifications.

Computing effective beam coefficients (contd.)

- File selection
 - » Two input files may be selected.
 - » The first, called the expansion file, gives the pathway for storing condensed collisional-radiative matrices.
 - » The second, charge exchange file, is not important for the beam case. ADAS310 can compute hydrogen populations in the plasma (including CX) as well as beams

ADAS310 Input

ADAS 310 INPUT

Please enter beam species details:-

Beam species element symbol : Beam species ion charge :

Expansion File Details:-

Data Root

Edit Path Name

Data File

Charge Exchange File Details:-

Data Root

Edit Path Name

Data File

beam species

expansion file for high n-shell handling

advanced usage not applicable to simple stopping

Computing effective beam coefficients (contd.)

- Processing options
 - » There are many parameters to specify but most are set with defaults.
 - » The main user data are the impurity specifications and the plasma parameter scans.
 - » ADAS310 can work with mixed impurities but main tabulations are for single impurities which are linearly combined for mixtures at the spectral analysis stage

ADAS310 Processing

ADAS310 PROCESSING OPTIONS

Select which parameters to display : General Switches (I) Switches(II)

Please enter the following parameters:-

Radiation field temperature (eV) : [Blank for default]

General radiation field dilution : [Blank for default]

Multiplier for ionisation cross-sections : [Blank for default]

Multiplier for Regemorter cross-sections : [Blank for default]

Ionising radiation field dilution : [Blank for default]

Beam species isotope mass : [Blank for default]

Select table for display:-

Impurity information

Representative N-shells

Enter limits on N-shells:

Minimum N-shell:

Maximum N-shell:

Note:
The first representative N-shell is set equal to the minimum N-shell

INDEX	N Shell
1	1
2	2
3	3

Edit Table

Clear Table

Select table for display:-

Electron/proton density scan

Electron/proton temperature scan

Beam energy scan

Electron/proton densities (units: cm⁻³)

INDEX	Electron density	Proton density
1	5.000E+12	5.000E+12
2	7.000E+12	7.000E+12

Edit Table

Clear Table

Enter index of reference densities :

Cancel Done

three sets of switches - defaults are set

specify details of bundle-n model for hydrogen

general parameters controlling x-sect. use

specify scans in key parameters

note use of reference conditions

ADAS310 Processing (contd.)

third
switch
set

ADAS310 PROCESSING OPTIONS

Select which parameters to display : General Switches (I) Switches(II)

Please enter the following parameter switches:-

Activate ion impact cross-sections : YES

Delta N range for ion impact cross-sections : 2

Use Lodge ion impact cross-sections : YES [NO defaults to Vainshtein X-sections]

Use beam energy in forming ion cross-sections : YES

Select table for display:-

Impurity information

Representative N-shells

Select mode of operation: Multiple impurities

Multiple impurities (total fraction must be <= 1.0)

INDEX	Symbol	Atomic Mass no.	Fraction
1			
2			
3			

Edit Table

Select table for display:-

Electron/proton density scan

Electron/proton temperature scan

Beam energy scan

Electron/proton densities (units: cm⁻³)

INDEX	Electron density	Proton density
1	5.000E+12	5.000E+12
2	7.000E+12	7.000E+12

Edit Table

Clear Table

Enter index of reference densities : 8

Cancel Done

Computing effective beam coefficients (contd.)

- Output options
 - » There is no graphical display from ADAS310.
 - » Several pass files are created
 - » .pass4 is the population structure (ADF26)
 - » Execution time can be ~ 10 mins.

ADAS310 Output

extended
set of
passing
files for
post-
processing

ADAS310 OUTPUT OPTIONS

Title for run: |

Run Summary Output

File Name : | paper.txt

File Name : |

File Name : |

File Name : |

File Name : |

Beam emission and the Balmer alpha Stark multiplet structure

- The calculation of local Stark/Zeeman emission feature from H (D/T) beams into play as an IDL procedure call *adas305_get_stark.pro* or within FORTRAN by calling the *stark.for* routine in the adas3xx library.
- The beam, plasma, E and B fields and observation orientation must be specified. General geometry specification is defined by direction cosines. The polarisation can be specified by multipliers on the pi and sigma components.
- The feature is returned as either a collection of component wavelengths and emissivities or a Doppler broadened feature over a specified wavelength range (specify minimum and maximum wavelengths and number of pixels).

adas305_get_stark.pro

PRO stark_figure

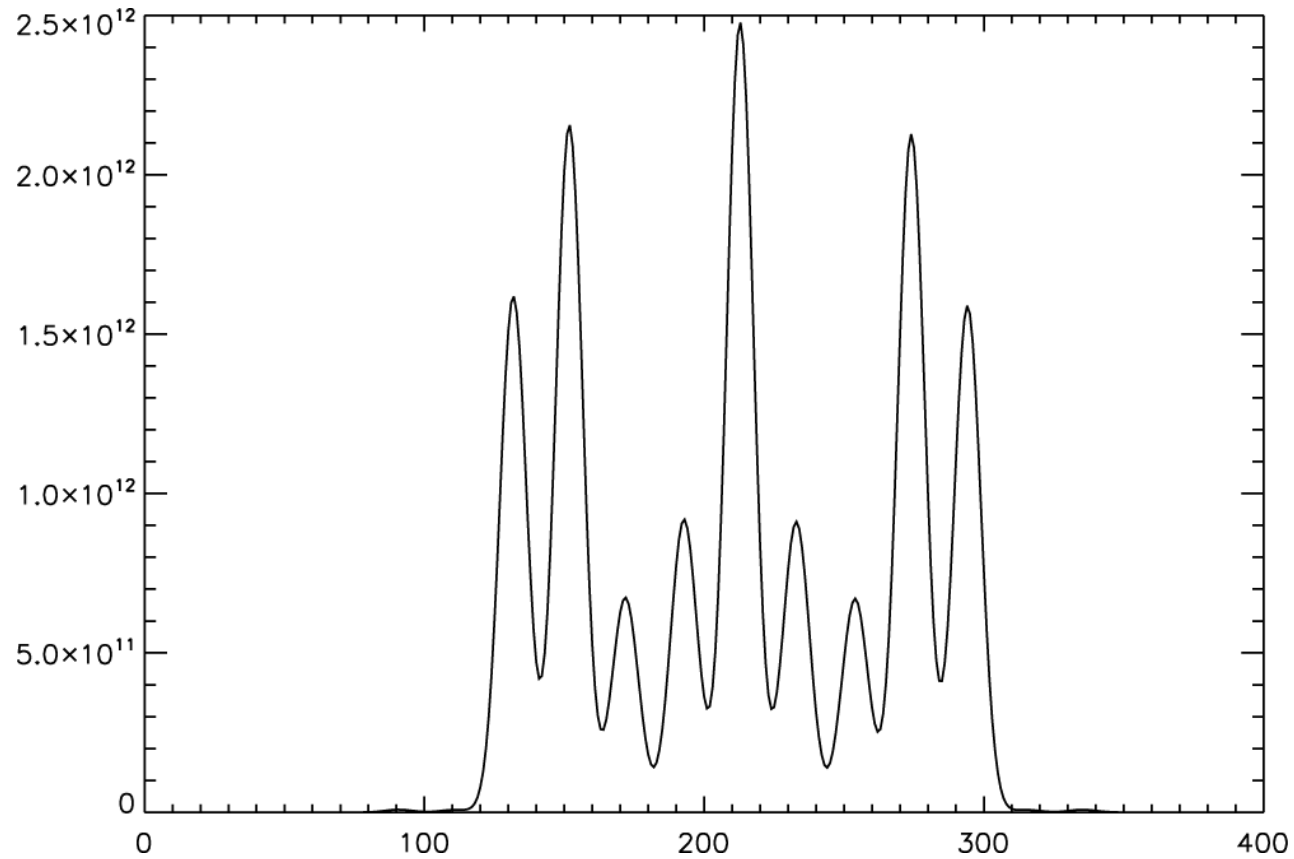
```
beam = {mass : 2.0, energy : 40.0e3, te : 10.0, density : 4.27e9}  
plasma = {mass : 2.0, te : 4.44e3, density : 2.49e13, zeff : 2.0}  
bfield = {value : 3.3915, dc_x : 0.788, dc_y : 0.0053, dc_z : 0.6152}  
efield = {value : 0.0000, dc_x : 1.000, dc_y : 0.0000, dc_z : 0.0000}  
obs = {dc_x : 0.8701, dc_y : -0.047, dc_z : 0.4905, sigma : 0.51, pi : 1.0}
```

```
adas305_get_stark,beam=beam,plasma=plasma,bfield=bfield,efield=efield, $  
obs=obs,n_lower=2,n_upper=3,wave_min=6510,wave_max=6550,npix=400, $  
emiss_doppler=emiss_doppler,/doppler
```

```
!p.thick=1  
!x.thick=1  
!y.thick=1  
!p.charthick=1  
;set_plot, 'PS'  
;device, filename=strcompress('fig_stark_cpts.ps',/remove_all)  
window,1  
plot,emiss_doppler
```

end

Balmer alpha Stark multiplet



Feature variation

B: 1.4T - 50 T

E: 0.5Mev/amu - 100eV/amu

