

# Beam stopping and Beam emission spectroscopy

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- 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

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- 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	energy scan	density scan	reference conditions	temperature scan
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						
-----						

# ADAS304 Input

The screenshot displays the 'ADAS 304 INPUT' window. The main area is titled 'Input Stopping Ion File Details:-'. It contains the following fields and controls:

- Data Root:** A text field containing the path `/afs/cell1/u/adas/adas/adf21/`.
- Navigation:** Three buttons: **Central Data** (highlighted with a red box), **User Data**, and **Edit Path Name**.
- Group name for input files:** A text field containing `bms97#h` with a note: `( Usually - bms97#<beam> )`.
- Class prefix for input member:** A text field with a note: `( Up to 3 characters - Blank=none`.
- Stopping Ion List:** A text field containing `Be4 C6 H1` with a note: `(maximum of 10)`.
- Instructions:** A line of text: `Edit the processing options data and press Done to proceed`.
- Buttons:** **Browse Comments**, **Reselect Ion List** (highlighted with a red box), **Cancel**, and **Done**.

A secondary window titled 'Select Stopping Ions' is open in the bottom right. It contains a list of beam species with checkboxes:

- B5
- Be4
- C6
- F9
- H1
- He2
- Li3
- N7
- Ne10
- O8

Below the list, it says: `Make a Maximum of 10 selections`. At the bottom are **Cancel** and **Done** buttons.

Two red circles with arrows provide annotations:

- A circle around the **Central Data** button points to the text: `sub-library of data for beam species`.
- A circle around the **Reselect Ion List** button points to the text: `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 <sup>-3</sup> )	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.)

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- 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

File Name :

Select Device

Post-Script

Post-Script

HP-PCL

HP-GL

Text Output  Replace

File Name :

beam  
energy  
plot  
selected

# ADAS304 graph



Each contribution to stopping and total

specified conditions



# Computing effective beam coefficients

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- 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.)

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- 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.)

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- 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

Central Data User Data  Edit Path Name

Data File

Charge Exchange File Details:-

Data Root

Central Data User Data  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.)

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- 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<sup>-3</sup>)

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

general parameters controlling x-sect. use

specify details of bundle-n model for hydrogen

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.)

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- Output options
  - » There is no graphical display from ADAS310.
  - » Several pass files are created
  - » The fourth passing file is the population structure (ADF26)
  - » Execution time is longer than most interactive codes.



# 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

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- The calculation of local Stark/Zeeman emission feature from H (D/T) beams is accessed via 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_fig

beam   = {mass : 2.0, energy : 40.0e3, te : 10.0, density : 4.27e9, $
          dc_x : 0.0, dc_y : 0.0, dc_z : 1.0}
plasma = {mass : 2.0, te : 8e3, density : 5.0e13, 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 : 0.00, pi : 1.0}

wave_min = 6510
wave_max = 6550
npix     = 500

adas305_get_stark, beam           = beam,           $
                    plasma        = plasma,        $$$
                    bfield         = bfield,        $$$
                    efield         = efield,        $$$
                    obs             = obs,           $$$
                    n_lower        = 2,             $$$
                    n_upper        = 3,             $$$
                    wave_comp       = wave_comp,     $$$
                    emiss_comp     = emiss_comp,     $$$
                    wave_min        = wave_min,     $$$
                    wave_max        = wave_max,     $$$
                    npix            = npix,         $$$
                    emiss_doppler  = demiss , /doppler ; , /nocheck

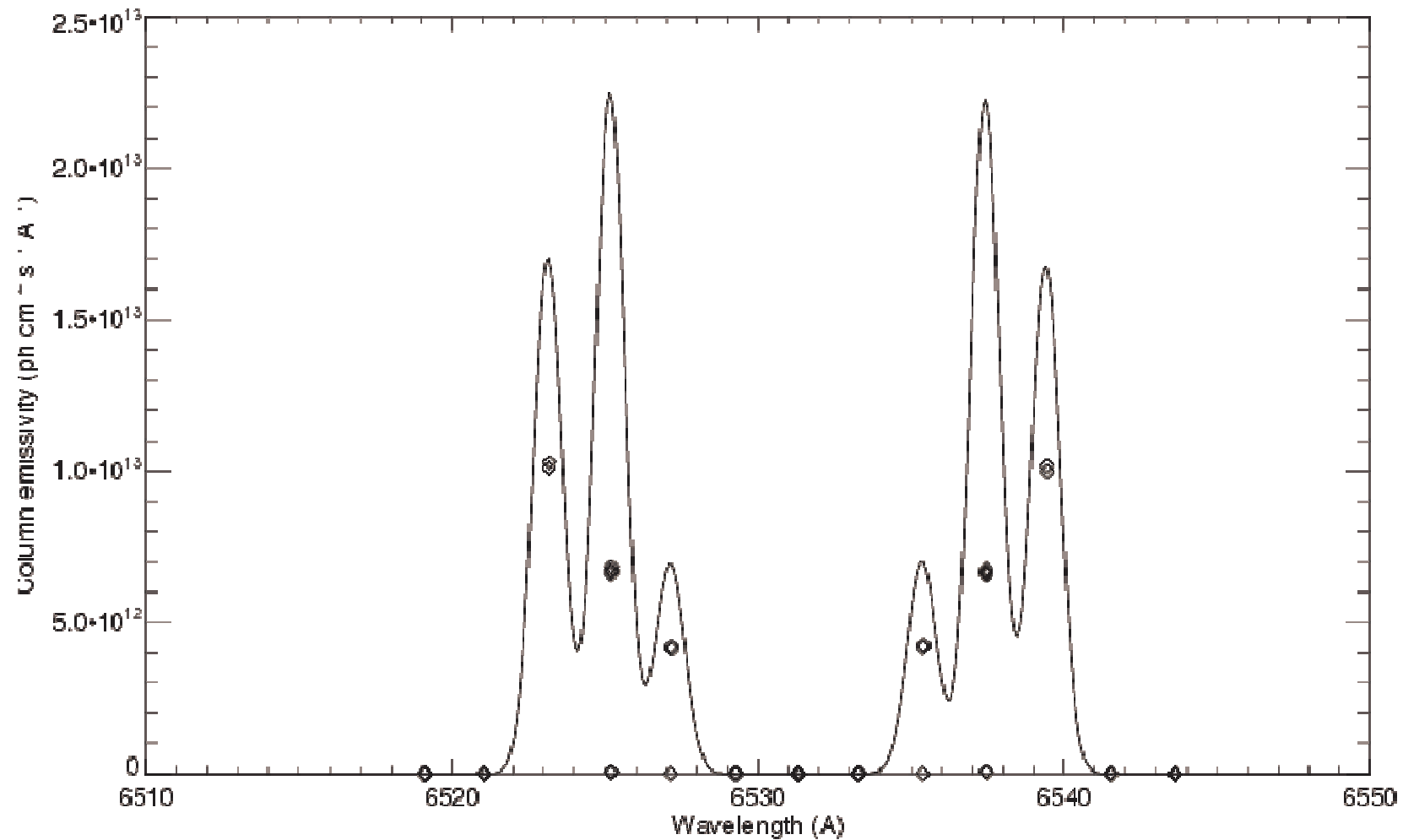
wave = adas_vector(low=wave_min,high=wave_max,num=npix, /linear)
dwave = wave[1]-wave[0]

plot, wave, demiss/dwave, $
      xtitle = 'Wavelength (A)', $
      ytitle = 'Column emissivity (ph cm!u-2!n s!u-1!n A!u-1!n)'

plots, wave_comp, emiss_comp, psym=4[

END
```

# Balmer alpha Stark multiplet



# Feature variation

B: 1.4T – 50 T

E: 0.5Mev/amu – 100eV/amu

