Description of the input file for BIT1

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(part of the input is similar to XPDP1 code input)

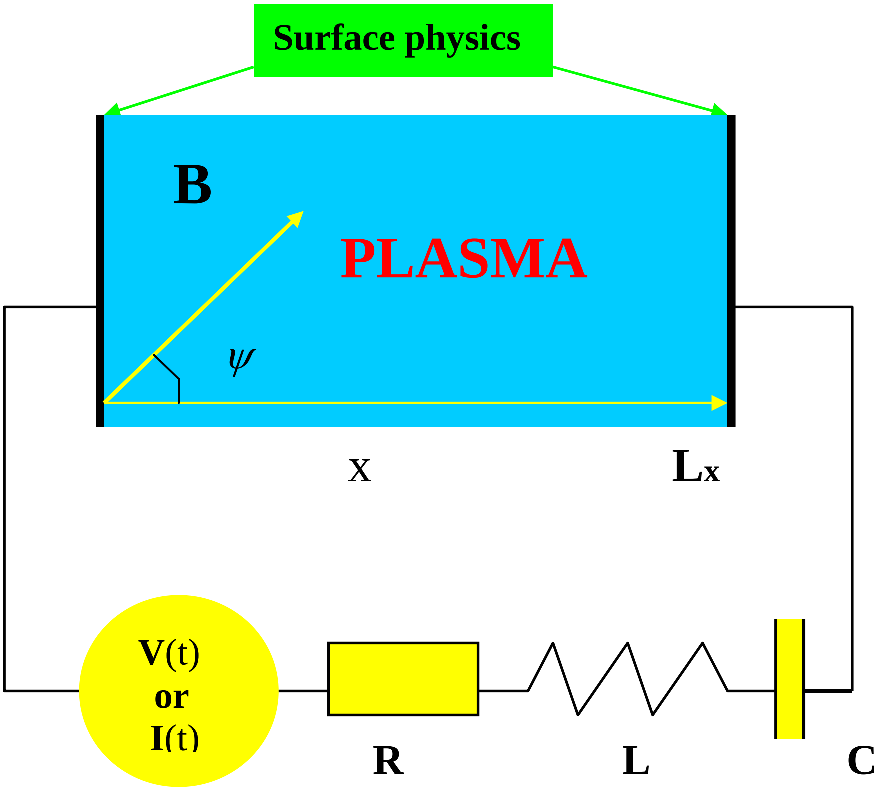

Figure 1. Simulation geometry

1. First part of the input (general parameters)

```
-nsp---nc---nc2p---dt[s]---length[m]--area[m^2]--epsilonr--B[Tesla]---PSI[D]--
  2    2500  8.e8    7.e-13   5.e-2         1.e-4             1.0           2.4          84

-rhoback[C/m^3]---backj[Amp/m^2]---nfft---nsmooth---MAXpart---short--reflux--
     0.0                          0.0                   512    10           1000000      150      0

-nfft1---
   512
```

nsp

The number of particle species to simulate (1= one species in the whole system, etc.). If modifying an input file that has, say, 2 species, to add more species, just copy one of the blocks of parameters corresponding to species 1, and change the parameters to the desired values. Note that each species added seeks an additional memory.

Maximum number of the particle species is 4 (but can be changed by modifying “NSMAX” in the **bit1.h** file).

nc

The number of spatial cells.

nc2p

The number of physical particles per computer particle (uper-articles). The number of super-articles in the simulation is found using $N = initn \times area \times L_x / nc2p$, where ***initn*** is the physical particle density, and *area* and L_x are the simulated system area and length (Fig.1).

dt

The time step [sec].

length

The length of the system (distance between electrodes) [m].

area

The area of the system (Electrode) [m^2]. Allows application of currents and external circuit parameters.

epsilonr

Background relative (to the vacuum) dielectric constant of system.

B

Applied homogeneous magnetic field [Tesla].

PSI

Angle the magnetic field makes with the normal from the electrode, *x*-axis (B-field is in the *x*-*z* plane) [deg] (Fig.1).

rhoback

Fixed background charge density [C/m^3].

backj

Fixed background current density [Amps/m2].

nfft

Number of samples for the Fast Fourier Transform analyser (must be a power of 2). When this parameter is set to zero, no FFT analysis is done, and the diagnostics in the frequency-domain are NOT shown.

nsmoothing

Number of time that a (1, 2, 1) digital smoothing filter is applied to the plasma parameter profiles (from my experience 8-16 is OK).

MAXpart

Maximum number of super-articles (per particle species). Maximum number of the super-particles per spatial grid is 1000 (but can be changed by modifying “MAXD” in the **bit1.h** file).

short

The shorting factor (L_{real}/L_x). If it is different from zero, all collision strengths parameters are multiplied by **short**. This is done to have similarity between the real and the simulated systems.

reflux

The flag for specifying particle behaviour when it crosses the wall.

1. If 0, then it flag is neglected (and particle is absorbed at the wall);

2. if 1, then at the LHS wall (x=0) particle is reflected (x, V_x → $-x$, $-V_x$), and at the RHS wall it is absorbed;
3. if 2, then particles are reflected at both boundaries (walls);
4. if 3, , then particle crossing one boundary are reinjected from the other one with the same velocity.

Important: if **reflux** > 0 then the external circuit is neglected!

nfft1

Number of time steps over which are averaged the following values (given in diagnostics):

1. the particle and energy fluxes at the wall;
2. time histories of (i) potential, (ii) electron-neutral excitation collision rate and (iii) temperature. These histories are calculated at the points (**potpos 1 and 2**) specified in the input.

nfft1 can be any integer number. This averaging is activated only if **slow**>0, or **Ef_flag**>0.

2. External circuit parameters

(For theory see J.P. Verboncoeur, et. al., J. Comput. Phys., **104** (2), 321 (1993))

```
-dde---extR[Ohm]---extL[H]---extC[F]---q0[C]---dcramped---source--
 0.0     0.              0.0     1.e6     0.0        0          v

-dc[V|Amp]--ramp[(V|Amp)/s]---ac[V|Amp]---f0[Hz]--theta0[D]--
   0.0              0.0               0.0        1e7     0.0
```

dde

Sinusoidal perturbation of the initial particle density: $\delta x(x) = L_x dde \sin(2\pi x / L_x)$.

extR

External circuit resistance [Ohms] (Fig.1).

extL

External circuit inductance [Henries].

extC

External circuit capacitance [Farads].

q0

Initial capacitor charge [C].

dcramped

The flag for ramping external voltage/current source to a final DC value.

1. If 1, yes, then signal is ramped to its final DC value sinusoidally (rise time equal to 1/2**f0**), or with a constant slope (Fig. 2); if 0, no. The AC part is ignored.
2. if 0, then the general form of the applied source is:

$$V, I(t) = DC + ramp \times t + AC \times \sin\left(2\pi f_0 t + \vartheta_0\right).$$

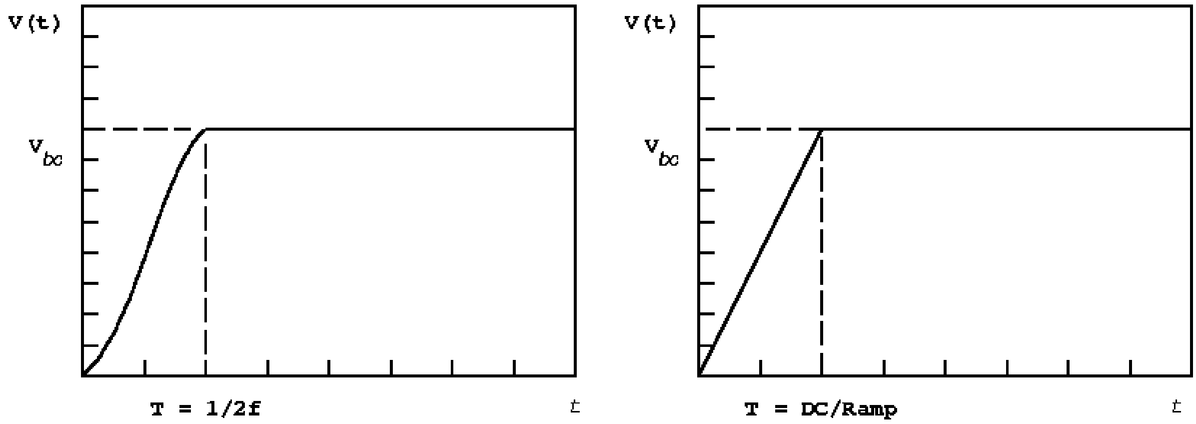

Figure 2. When the flag **dcramped** is set, then a) if **ramp**=0, the signal is ramped to its final DC value sinusoidally (left), b) else it is ramped with a constant slope (right).

source

Voltage or current source indicator (v=voltage, i=current).

DC

DC voltage, or current source [V, or Amps]. Zero value indicates zero DC voltage.

ramp

Rate of ramping for voltage, or current source [V/sec, or Amps/sec]. Zero value indicates zero ramping.

AC

AC voltage, or current source [V, or Amps]. Zero value indicates zero AC voltage and the values of **f0** and **theta0** are ignored.

f0

AC source driving frequency [Hz].

theta0

Initial phase angle of AC source [deg].

3. Field parameters

```
-field---E_y[v/m]---x_E[m]--
  1        0.          0.
```

field

The Flag for the self-consistent electric field (E_x). If 0, then Poisson solver is not used and E_x =0.

E_y

The prescribed (parallel to the wall) component of the electric field (E_y).

x_E

Describes the shape of E_y (Fig. 3):

1. if $x <$ **x_E**, then $E_y(x)=$ **E_y** *x/ **x_E**;
2. if $x > L_x$ - **E_y**, then $E_y(x)=$ **E_y** *($L_x - x$)/ **x_E**;
3. else $E_y(x)=$ *const*.

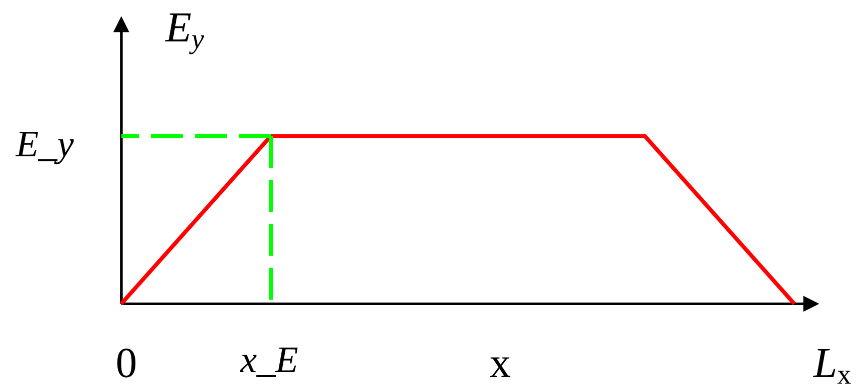

Figure 3. Profile of E_y.

4. Run type

```
-slow-Xwindows---datfile--dmpstep---Last_step--origdmp--origres-
  1        1            100       1000       10000000      1           1

-Ef_flag--T_diag---pot.pos.1---pot.pos2--
   1          0              0            0
```

slow

The flag for diagnostics (indirectly defines speed of simulations).

1. If 0, then only N(t), n(x), pot(x), E(x), LHSpot(t), LHS Flux(t), RHS Flux(t), LHS Potential(t) and MID Potential(t) diagnostics are calculated (see "BIT1 diagnostics"). If **Ef_flag** is set, then also LHS Energy Flux(t) and RHS Energy Flux(t) are calculated. **nfft** and **T_diagn** are automatically set to 0;
2. else (if > 0), all of the diagnostics are calculated.

Xwindow

The flag for X windows. If 0, no windows are displayed and code runs in a noniterative mode.

datfile

Time average profiles (if **slow** >0) and time histories are saved in ASCII format (the file name is "<inputfile>.dat") after **datfile** time steps. If 0, then **datfile** =**nfft**, and if also **nfft**=0, then **datfile** =1000.

dmpstep

If >0 then every **dmpstep** time steps the given state of the simulated system is saved. Corresponding file is called "<inputfile>.dmp".

Last_step

If code is running in the noniterative mode (**Xwindow**=0), then after **Last_step** time steps code will save the present state and will terminate.

origdmp

The flag for the format of the saved (dumped) file with a system state description.

1. If 1, then it saves the run in the “original” format, used in XPDP1 (which is compact, but machine dependent);
2. if 0, then file is saved in the ASCII format (about 3 times larger than the original one).

origres

The flag for the format of the saved file from which starts the new run.

1. if 1, then run starts from the file, which is in the original format;
2. if 0, then run starts from the file, which is in the ASCII format.

Ef_flag

The flag for history diagnostics, if **slow** =0 and **Ef_flag** >0, then history diagnostics are activated for the following quantities: the energy flux at the wall, the potential, the temperature and the electron-neutral excitation collision rate (at positions **pospot 1, 2). Important (!!!)**: These values are averaged over **nfft1** time steps.

T_diag

The flag for additional temperature diagnostics. If **T_diag** > 0 then the Tx(t), (T_par-T_perp)(x) and (T_par-T_perp)(t) diagnostics are switched on. If there are Coulomb collisions between two species, then in addition to the given above diagnostics also Teq is activated. In the case of **slow**=1 these data are printed in the output file ("<inputfile>.dat").

pot.pos 1 and 2

Positions where potential and temperature history diagnostics are calculated.

5. Source in the middle of the system

```
-Source---Dn/Dt[1/sm3]---L_s[m]--Src_pos[m]--heat---T_asym.---T_asym.r[%]--
  2         1.65e26         8. e-3      0.       1      1             10.
```

Source

The flag for source type.

1. If 0, no particle source;
2. If 1, then the spatially uniform particle source is on;
3. If 2, then the particle source of the following shape is on:

$$\cos\left(\pi\left(\frac{x - Src\_pos}{2L\_s} - \frac{1}{2}\right)\right), \text{ if } \; Src\_pos - L\_s < x < Src\_pos + L\_s,$$

else = 0.

Dn/Dt

The particle source intensity (in the source region). Number of the injected super-particles per time step (δt) is $N = Dn / Dt \times area \times 2L\_s \times \delta t / nc2p$.

L_s

The particle source half-length [m].

Src_pos

The position of the middle of the source. If 0, then it is in the middle of the system.

heat

For "heating" of particles in the source region. This is done to keep particle distributions on the source region close to Maxwellian. During their stay inside the source region the particle velocities artificially change in average **heat** times. The newly attributed velocities are Maxwell-distributed. This artificial mechanism is equivalent to simplified Coulomb collisions. Probability for the particles to be heated up during the time step (δt) is calculated as follows:

$$P = \left(1 - \exp\left(-V_T \times heat \times \cos\psi \times \delta t / 2L\_s\right)\right),$$

where, V_T is the thermal velocity (in the source region specified in the input file) of the given particle species, and $\cos\psi = 1$ if there is no magnetic field. As we see, **heat** defines the effective mean free path for this heating, $l_{mfp} = 2L\_s / heat / \cos\psi$.

T_asym

The flag for temperature profile of the particles injected and “heated” in the source region.

1. If 0, it is symmetric;
2. Else, the temperature profile in the source is asymmetric (LHS RHS asymmetry).

T_asym.r

Rate of the temperature asymmetry [%]: $T(x) = T_0 \left(1 - \frac{T\_asym.r}{100} \frac{x - Src\_pos}{L\_s} \right)$.

Here, T_0 is the temperature in the middle of the source region.

6. Coulomb collision parameters

(The binary collision model is used; see T. Takizuka and H. Abe, J. Comput. Phys. **25**, 205 (1977))

```
-Coul_coll---Av.den[m-3]---cc_coeff---cc_step--
  2              2.e19             0                100
```

Coul_coll

The flag for Coulomb collisions (maximum two particle species can be collided).

1. If 0, no collisions;
2. If 1, only particles of the first species are colliding;
3. If 2, then particles of the 1st and 2nd species are colliding (there are collisions between particles of the same type, as well as between particles of different species).

Av.den

Density used for calculation of the Landau logarithm [m^{-3}].

cc_coeff

Coefficient for the strength of the Coulomb collisions (ignored if =0). It is used to increase artificially the plasma collisionality.

cc_step

Relative time step for Coulomb collisions.

Important to note, that

a) For the temperature for the Landau logarithm code uses temperatures specified in the input **TparS** (and not obtained during the simulation!). So even there is no particle injection in the source region, this temperature have to be specified for the (Coulomb) collided species (see the species parameters);

b) If there are two collided species then the first species must be the lighter one (this sequence is used for calculation of the Landau logarithm). If both collided species have the same weight, then for the correct Landau logarithm we have to use

$$\textbf{Av.den} = n_1 + n_2 \frac{T_1}{T_2}\left(\frac{q_2}{q_1}\right)^2 \quad . \qquad \text{(cc1)}$$

Here $n_{1,2}$, $T_{1,2}$ and $q_{1,2}$ are the estimated densities, charges and input temperatures (**TparS**) of the collided species, respectively.

c) Landau logarithm is calculated from the following equation $\lambda = \ln \lambda_D / r_{\min}$, where $r_{\min} = \max\left(Z_a Z_b / 4\pi\varepsilon_0 \mu u_{ab}^2, h/2\pi\mu u_{ab}\right)$, $\mu = m_a m_b /(m_a + m_b)$. Here $Z_{a,b}$ and $m_{a,b}$ are the charge [C] and mass [kg] of the collided particles *a* and *b*, respectively. u_{ab} is the average relative velocity of the collided species. λ_D, $\varepsilon_0 = 8.854\times10^{-12} F/m$ and $h/2\pi = 1.0546\times10^{-34}\ J$ are the Debye length, the vacuum permittivity and the Planck constant, respectively (see **NRL plasma formulary**, ed. D. L. Book, (1978); **remark:** in this formulary there is $r_{\min} = \max(..., h/4\pi\mu u)$).

d) For the self collisions the Landau logarithm is calculated according to the following expression:

$$\lambda = 29.7 - \ln\left(Z^2 Z_1 \sqrt{n_1/T_1}/T\right), \text{ if } V_T = \sqrt{T/m} < Z^2 1.3\times10^6\ m/s\ ;$$
$$\lambda = 30.8 - \ln\left(Z_1 \sqrt{n_1 m_e / mTT_1}\right), \text{ if } V_T = \sqrt{T/m} > Z^2 1.3\times10^6\ m/s\ .$$

Where, $Z_{(1)}$, $m_{(1)}$ and $T_{(1)}$ are the charge (in proton charge units), the mass and the temperature (**TparS**) of the colliding and the first (lightest) species, respectively. m_e is the electron mass.

e) For the collisions between the particles of *a* and *b* species code uses the following Landau logarithm:

$$\lambda = -9.4 - \ln\left(Z_a Z_b Z_1 m_e \sqrt{n_1/T_1}/\mu\left(V_{Ta}^2 + V_{Tb}^2\right)\right), \text{ if } \sqrt{V_{Ta}^2 + V_{Tb}^2} < Z_a Z_b 1.3\times10^6\ m/s\ ;$$
$$\lambda = 5.6 - \ln\left(Z_1 m_e \sqrt{n_1 m_e /\left(V_{Ta}^2 + V_{Tb}^2\right)T_1}/\mu\right), \text{ if } \sqrt{V_{Ta}^2 + V_{Tb}^2} > Z_a Z_b 1.3\times10^6\ m/s\ .$$

f) The following assumptions have been used:

1. $T_1 > \frac{m_1}{m_i} T_i$, if $m_i > m_1$; else (if $m_i = m_1$) one has to use the Eq. (cc1);

2. For collisions between different species it is assumed that (at least for one collided species) the following condition is satisfied $V_T \geq u_{ab}$.

7. Charged-neutral particle collisions

(See V. Vahedi, M. Surendra, Comput. Phys. Com., **87** 179 (1995))

```
-e_coll---i_coll---ion_sp.---ef.ion----NN[m-3]---NT[eV]---NL---labda--
   1          2          2              0         1.e19         0.1           3     0.0005
```

e_coll

The flag for ionization, elastic, and excitation electron-neutral collisions (if 0, off, if 1, species 1 is the colliding electron species, etc.). Note: Only ONE species can be the colliding electron species.

i_coll

The flag for scattering and charge exchange ion-neutral collisions (if 0, off, if 2, species 2 is the colliding ion species, etc.). Note: Only ONE species can be the colliding ion species.

ion_sp

Indicates the ion species created by electron-neutral ionization collisions (if 2, the created ions are of type species 2, etc.). Note: this also specifies the type of the background neutral gas particles colliding with electrons.

Ef.ion.

The flag for effective ionization for hydrogen isotopes [Popova L., Tskhakaya D., Kuhn S., Nikolov T., et al., Contrib. Plasma Phys.,]. If 0, then effective ionization is off, else it is on and ef.ion will be the relative time step for calculation of the temperature (needed for calculation of corresponding cross-sections). This is necessary if code runs in the fast mode, when temperature is not calculated. Normally ef.ion=100 is used, then there is no significant decrease of the run speed and there is no reduction of the accuracy of simulations.

NN

The neutral density [m^{-3}]. Ignored if **NL**=3.

NT

The neutral temperature [eV]. Ignored if **NL**=3.

NL

The flag for neutral particle density and temperature profiles.

1. If 0, then neutral density and temperature are is constant;
2. If 1, then the temperature is constant and the density is linearly decreasing from the walls to the source region. At the wall density=**NN** and at the source region edge it is zero. It is activated only if **source** > 0;
3. if 2, then the temperature is constant and the density is exponentially decreasing from walls to the source region (see **labda**). It is activated only if **source** > 0;
4. if 3, then code uses the txt file: "<input>.txt" for loading neutral density and temperature profiles. In the first line of this file should be given the number of lines with data, then each line should contain the position (x [m]), the density (n [m^{-3}]) and the temperature (T [eV]) at this position:

   x n T

labda

The density gradient scale length for neutrals (switched on only for **NL**=2, **source** > 0):

$N = NN \exp\left(-x / labda\right)$, at the LHS wall;

$N = NN \exp\left(-\left(L_x - x\right) / labda\right)$, at the RHS wall;

$N = 0$, in the source region.

8. Electron-neutral collision parameters

```
-Hydrogen---selsmax[m^2]---elsengy0[eV]---elsengy1[eV]---elsengy2[eV]--
    2            .0              0.0             0.0          10.0

-Hydrogen---sextmax[m^2]---extengy0[eV]---extengy1[eV]---extengy2[eV]--
  2              .0             12.0            50.0          100.0

-Hydrogen---sionmax[m^2]---ionengy0[eV]---ionengy1[eV]---ionengy2[eV]--
   2          1.0e-20           13.6            60.0           100.0
```

Hydrogen

The flag for electron-neutral collision cross-sections.

1. If 1, 2, or 3, e+H, e+D, or e+T collisions are considered. The corresponding cross-sections are saved in the code and all other electron-neutral collision parameters are ignored. For details see D. Tskhakaya and S. Kuhn, Europhys. Conf. Abstr. **26B**, P-2.094 (2002);
2. If 0, then the original input (for XPDP1) is activated (see the Fig. 4):

$$\begin{aligned} &\sigma(E) = 0, \quad E < E_0, \\ &\sigma(E) \propto E, \quad E_0 \le E \le E_1, \\ &\sigma(E) = \sigma_{\max}, \quad E_1 \le E \le E_2, \\ &\sigma(E) \propto \ln(E)/E, \quad E_2 \le E. \end{aligned} \qquad (1)$$

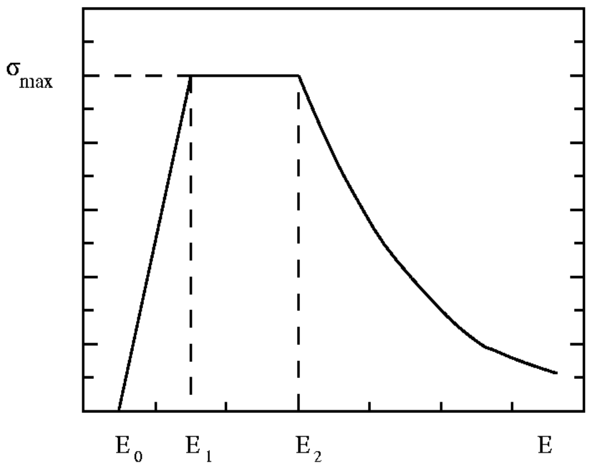

Figure 4. Profile for electron-neutral collision cross-section versus incident particle energy E.

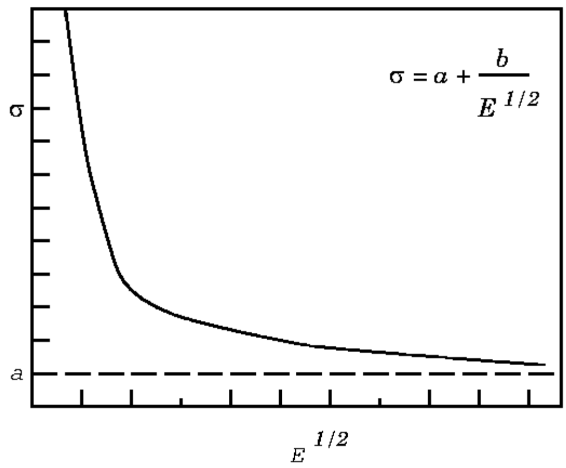

Figure 5. Profile for ion-neutral collision cross-section versus incident particle energy E.

selsmax

Maximum electron-neutral elastic cross section [m^2], σ_{max}.

elsengy0

Elastic collision threshold energy [eV], E_0.

elsengy1

Low energy of plateau for elastic collisions [eV], E_1.

elsengy2

High energy of plateau for elastic collisions [eV], E_2.

sextmax

Maximum excitation cross section [m^2].

extengy0

Excitation threshold energy [eV].

extengy1

Low energy of plateau for excitation [eV].

extengy2

High energy of plateau for excitation [eV].

sionmax

Maximum ionization cross section [m^2].

ionengy0

Ionization threshold energy [eV].

ionengy1

Low energy of plateau for ionization [eV].

ionengy2

High energy of plateau for ionization [eV].

9. Ion-neutral collision parameters

```
--HH--achrgx[m^2]--bchrgx[m^2/V^1/2]-------ascat[m^2]--bscat[m^2/V^1/2]--
   2      4.e-19         0.0                          1.0e-18          0.0
```

HH

The flag for ion-neutral collision cross-sections.

1. If 1, 2, or 3, $H+H_+$, $D+D_+$, or $T+T_+$ collisions are considered. The corresponding cross-sections are saved in the code and all other ion-neutral collision parameters are ignored. For details see D. Tskhakaya and S. Kuhn, Europhys. Conf. Abstr. **26B**, P-2.094 (2002);
2. If 0, then the original input (for XPDP1) is activated: $\sigma(E) = a + b/\sqrt{E}$ (see the Fig. 5).

achrgx

Charge exchange cross section [m^2], a .

bchrgx

Charge exchange cross section [$m^2/\sqrt{eV}$], b.

ascat

Scattering cross section [m^2].

bscat

Scattering cross section [$m^2/\sqrt{eV}$].

10. Species parameters

```
--Type: ------q[C]---------m[Kg]--------rel_t--
          -1.6022e-19    9.1094e-31       1

-Initial:--initn[m^-3]--initTpar[eV]--initTperp[eV]--initVx0[m/s]--initVz0[m/s]-
           0.              10.              10.            0.            0.

-Injection L:--F0L[1/sm^2]--TparL[eV]--TperpL[eV]--Vx0L[m/s]--Vz0L[m/s]--
                  0.            0.           0.          0.          0.

-Injection R:--F0R[1/sm^2]--TparR[eV]--TperpR[eV]--Vx0R[m/s]--Vz0R[m/s]--i_type-
                  0.             0.          0.             0.           0.        0

-Source:-----Con_s----TparS[eV]----TperpS[eV]----Vx0S[m/s]----Vz0S[m/s]--
                 1         80.            80.              0.             0.

-For-wall-Diagnostic:---nbin----Emin[eV]----Emax[eV]--
                         200         0.           800.

-For-Mid-Diagnostic:---nbin----Emin[eV]---Emax[eV]----XStart--XFinish--
                         200       0.0           800.0      .009        .01

-For-Fv-Diagnostic:---nvxbin----vxmin[m/s]---vxmax[m/s]----XStart--XFinish--
                         200           -4.e7        4.e7            0.009     0.01
```

```
-Surface-Phys:--N_sec--Sec_sp--Sec_type--seecl---seecr--workfl[eV]--workfr[V]--
                        2       1          0          1.       0.     4.5          4.5

--------------E0l[eV]---E0r[eV]--inj_typel--inj_typer--Tseecl[eV]--Tseecr[eV]--
                   300.    300.          0            0         4.5            4.5

---------------------------Sec_sp--Sec_type--seecl---seecr--workfl[eV]--workfr[V]--
                               2           0          1.       0.     4.5          4.5

--------------E0l[eV]---E0r[eV]--inj_typel--inj_typer--Tseecl[eV]--Tseecr[eV]--
                   300.    300.          0            0         4.5            4.5
```

q

Charge per physical particle [C].

m

Mass per physical particle [kg].

rel_t

Relative (to the one specified in the general parameters) time step.

initn

Given species initial density in the system [m^{-3}]. In general, particles can have the shifted Maxwellian velocity distribution.

initTpar

Parallel (to the magnetic field) temperature of the given particles species initially loaded in the system [eV]. If **B**=0, then the *x* component of the temperature.

initTperp

Perpendicular (to the magnetic field) temperature of the given particles species initially loaded in the system [eV]. If **B**=0, then the *yz* component of the temperature.

initVx0

The *x* component of the shift velocity of the particles initially loaded in the system [m/s].

initVz0

The *z* component of the shift velocity of the particles initially loaded in the system [m/s].

F0L

The flux of the particles (of the given species) injected from the LHS wall [$1/sm^2$].

TparL

The parallel temperature of the particles (of the given species) injected from the LHS wall [eV]. If **B**=0, then the *x* component of the temperature.

TperpL

The perpendicular temperature of the particles (of the given species) injected from the LHS wall [eV], if **B**!=0 must be **TparL** = **TperpL**. If **B**=0, then the *xy* component of the temperature.

Vx0L

The *x* component of the shift velocity of the particles (of the given species) injected from the LHS wall [m/s].

Vz0L

The z component of the shift velocity of the particles (of the given species) injected from the LHS wall [m/s].

F0R, TparR, TperpR, Vx0L, Vz0L

Same as above, but at the RHS wall.

i_type

The flag for the type of injection of particles at the RHS wall (can be used for half-bounded plasma simulations). This flag is **activated only** for magnetized plasmas (**B** > 0) with no reflection, or reinjection at the RHS wall (**reflux** < 2).

1. If 0, the flag is ignored;
2. If 1, then the particles with the parallel (to the magnetic field) velocity directed towards the RHS wall are not injected from this wall.
3. If 2, then same as 1, but in addition, the particles from the bulk plasma moving towards the RHS wall with positive parallel velocity (directed towards this wall) are not removed from the simulation if they cross the wall. They move in additional space where E_x=0. Due to the gyro motion they can re-enter the “normal” simulation domain. If they do not enter normal simulation domain during the cyclotron period, then these paricles are removed from the simulation.

Important NOTE: if **i_type** > 0, there is no surface physics at the RHS wall.

Con_s

The relative intensity of partzicle injection in the source region. So, the number of the injected super-particles of this species per time step (δt) is $N = C\_con \times N_0$, where $N_0 = Dn / Dt \times area \times 2L\_s \times \delta t / nc2p$ is the source total intensity.

Tpars

The parallel temperature of the particles (of the given species) injected in the source region [eV]. If **B**=0, then the *x* component of the temperature.

Tperps

The perpendicular temperature of the particles (of the given species) injected in the source region [eV].]. If **B**=0, then the *xy* component of the temperature.

Vx0S

The *x* component of the shift velocity of the particles (of the given species) injected in the source region [m/s].

Vz0S

The z component of the shift velocity of the particles (of the given species) injected in the source region [m/s].

nbin

Number of bins for the energy distribution diagnostic of the species at the wall and (separately) inside the system.

Emin

The minimum energy seen in the energy distribution diagnostic of the species at the wall and (separately) inside the system [eV].

Emax

The maximum energy seen in the energy distribution diagnostic of the species at the wall and (separately) inside the system [eV].

Xstart and XFinish

Parameters for the energy and (separately) the velocity distribution function in the system. These parameters designate a region (a window) in the space over which these distributions are calculated. Xstart corresponds to the lower (left) boundary of the diagnostic region, and Xfinish corresponds to the upper (right) one.

Surface physics part (in species parameters)

N_sec

The number of secondary particle species injected due to the impact of particles of the given species. If 0, no secondaries. Important NOTE: if **N_sec** < 2, then there should be only two lines for the surface physics part; otherwise (if **N_sec** ≥ 2) this two lines of the parameters should be copied for each additional secondary particle species (i. e. should be copied **N_sec –** 1 times). The **N_sec** is given only in the parameter set of the first secondary species.

Maximum number of the secondary species is 3 (but can be changed by modifying "MAXSRF" in the **bit1.h** file)

Sec_sp

Specifies the secondary particle species. If 1, then species 1 is the secondary particle species, etc.

Sec_type

Type of the secondary particle injection.

1. If 0, then the emission coefficient (γ) is similar to the electron impact induced secondary electron emission coefficient (see Nucl. Fusion, Data Compendium for Plasma-Surface Interactions, Special Issue (1984)):

$$\gamma = \gamma_0 \frac{1}{\cos\alpha} \frac{E_p}{E_0} \exp\left(2\left(1 - \sqrt{\frac{E_p}{E_0}}\right)\right), \text{ if } \frac{1}{\cos\alpha} > 2, \ \frac{1}{\cos\alpha} \Rightarrow 2. \qquad (2)$$

   Here, E_p is the primary particle energy, α is the angle of the particle incidence on the wall, and E_0 and γ_0 are constants (specified in the input file).

2. If 1, then the emission coefficient is similar to the ion impact induced secondary electron emission coefficient (see A.Qayyum, et. al., J. Nucl. Mat., **313-316,** 674 (2003)):

$$\gamma = \gamma_0 \frac{1}{\cos\alpha} (V_p - V_0), \text{ if } \frac{1}{\cos\alpha} > 2, \ \frac{1}{\cos\alpha} \Rightarrow 2. \qquad (3)$$

   Here, V_p is the primary particle velocity, and V_0 and γ_0 are constants (specified in the input file).

3. If 2, then $\gamma = \gamma_0$ (γ_0 specified in the input file).

Seecl

The secondary particle emission coefficient at the LHS wall (γ_0 , see the Eq.s 2 and 3).

Seecr

The secondary particle emission coefficient at the RHS wall (γ_0).

workfl

The work function for the given emission: the minimum energy needed to inject a particle of the given species from the given LHS wall surface material (and possibly, for the given primary particle impact) [eV]. Typically it is *4-5 eV*.

workfr

Same as above, but for the RHS wall.

E0l

The parameter for calculation of the secondary particle emission coefficient at the LHS wall.

1. If **Sec_type**=0, then **E0l** =E_0 [eV]**,** see the Eq. (2). Important NOTE: in this case **E0l** > 1 eV ;
2. If **Sec_type**=1, then **E0l** =V_0 [m/s]**,** see the Eq. (3);
3. If **Sec_type**=2, then this parameter is ignored.

E0r

Same as above, but for the RHS wall.

inj_typel

The flag for the velocity distribution of the given secondaries emitted at the LHS wall.

1. If =0, then the secondaries are Maxwell-distributed (injection distribution is $f(\vec{V}) \propto V_x \exp\left(-V^2 / 2V_T^2\right)$.
2. If =1, then the velocity distribution can be any function. The corresponding distribution should be written and activated in **sphys.c** file (in the routine called **dist1**()).

inj_typer

Same as above, but for the RHS wall.

Tseecl

Temperature of the secondary particles of the given species emitted at the LHS wall.

Tseecr

Same as above, but for the RHS wall.