Exercises, Week 2 PIC/MC

Radial diffusion

The model of the discharge is one dimensional, with the only dimension represented being the axial direction. The discharge is essentially axisymmetric. In reducing the model to a single dimension radial processes have been neglected. In particular radial losses, through diffusion, are not accounted for. One solution, that keeps the PIC code one dimensional, is to add a term that simulates radial losses by having electrons and ions "magically" disappear from the bulk of the discharge at a rate given by the characteristic radius of the discharge Λ and the ambipolar diffusion coefficient D_α. The frequency of this loss term is then given by D_α/Λ^2. Note that in effect this makes the code a hybrid fluid-Monte Carlo code.

Remember that the diffusion coefficient is given by

$$D_i = \int_0^\infty \frac{v^2}{\nu_m(v)} f_0 4\pi v^2 dv,$$

with ν_m the collision frequency for momentum transfer. The average energy $\int_0^\infty \frac{1}{2}mv^2 f_0 4\pi v^2 dv$, is returned by the `MC::Swarm::MeanEnergy()` member.

Exercise 1 *Add some code to calculate the ambipolar diffusion coefficient as a function of the (average) ion and electron temperature. Using an estimate for the radial extend of the discharge estimate the average loss time, that is the average time it takes a particle to diffuse out of the discharge.*

Exercise 2 *Using the expression for the loss time from the previous exercise, add some code to randomly deactivate particles to simulate radial losses.*

Hint for the previous exercise: in the loop that iterates over all particles add some code of the type:

```
double tloss =  .....
if (rnd() > dt/tloss) ions[p].Active() = false;
```

and similar code for the electrons.

Exercise 3 *What are the problems and inconsistensies with this approach to radial diffusion?*

A drift-diffusion experiment

The code can also be used to conduct a drift-diffusion experiment. If the code is stripped of its Poisson solver and the ion swarm a drift-diffusion experiment results. The code can then be used to investigate the influence of the various cross sections or the background gas density on the electron energy distribution function.

Exercise 4 *Remove (or comment out) the Poisson solver and the ion swarms everywhere in the code. Also remove the process lists and related cross sections for the ions. Change the position to the modulus of the grid-size. Make the electric field constant. Recompile the code.*

Exercise 5 *Run the code for different values of the electric field, while keeping the ratio of the electric field to the background gas density (E/n) constant. What is the effect on the electron energy distribution function (eedf)?*

Exercise 6 *Calculate the average drift velocity and the mobility of the electrons. What is the effect of the* E/n *ratio?*

Exercise 7 *Write two new collisional cross section functions for elastical collisions, one returning a constant, and one which keeps the product* σv *constant. Comment on the effects on the eedf. The functions should have a single double argument (representing the energy) and return a double.*