Comparation of different particle injection models on the results of plasma sheath PIC simulation

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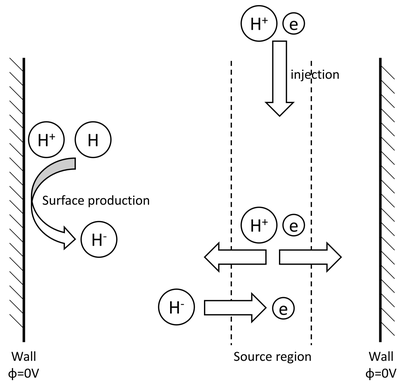
Introduction

- Particle-In-Cell (PIC) is an important method in of PG is not self sustaining, particle injection is needed to sustain the plasma density in simulation region.
- What's the difference among different particle plasma simulation.
- There are different particle injection methods used in PIC simulation.
- An injection method is needed. Because the PIC simulation in front injection methods in PIC simulation.
- What are the advantages and disadvantages of different particle injection methods.

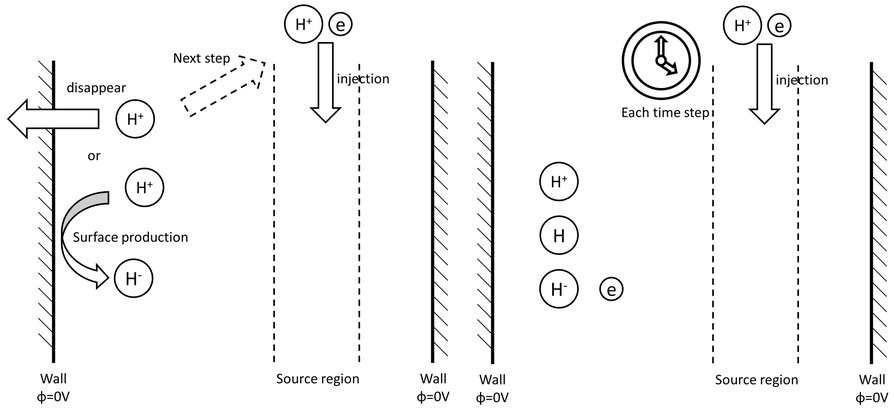
Simulation Model



Some Details

- 1D3V model is used in this PIC simulation.
- There are left and right walls in this simulation.
- The walls have zero potential .
- Surface production is considered.
- A source region is set.
- An injection method is chosen.
- When a hydrogen negative ion enters the source region, it will turn into a electron.

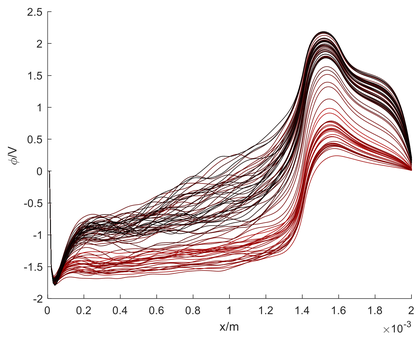
Injection Method



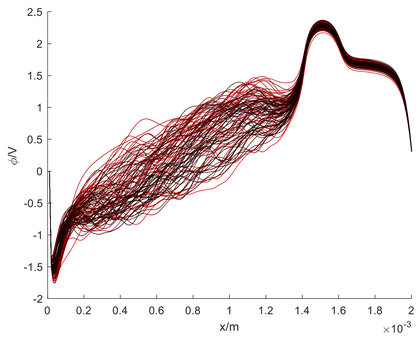
pair re-injection
the number of ion-electron pairs injected is according to the number of positive ions removed

constant flux injection
a fixed number of ion-electron pairs are injected each time step

Simulation Proceeding



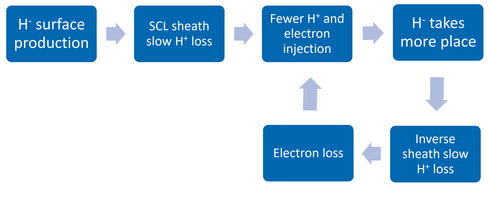
pair re-injection



constant flux injection

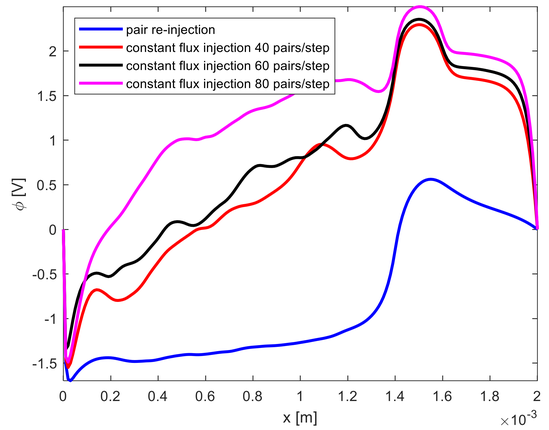
- These figures show the potential of the sheath.
- Different lines in a figure stand for the average potential of different time steps.
- The lines with color closed to black show the potential at an earlier time step, while the lines with color closed to red show the potential at a later time step.
- About 20 pairs H^+ and electron are injected each time step in the simulation with pairs re-injection in the beginning.

- The sheath in simulation with pairs re-injection becomes inverse sheath regularly.
- Potential in simulation with constant flux injection has a bigger fluctuation.

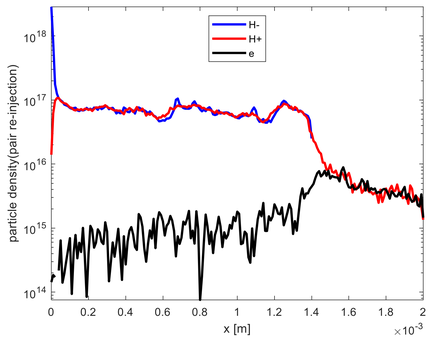


Feedback problem of pairs re-injection

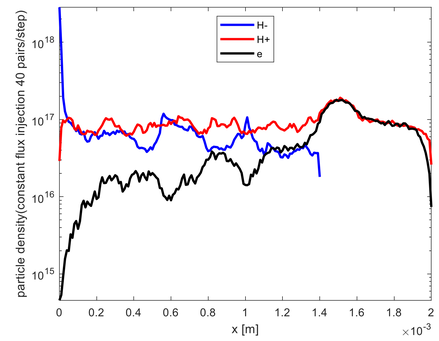
Simulation Results



- The potential is the average of 10000 time steps, or there may be potential fluctuation appearing.
- There is a potential well in the simulation with constant flux injection method, and the width of the potential well depends on the number of hydrogen positive ion and electron pairs injected into source region each time step. While an inverse sheath will appear in simulation with pair re-injection method



pair re-injection



constant flux injection

- These figures show the density of particles.
- The density is the value of a certain time step.

- The density of particle in source region in simulation with pair re-injection method is lower than other region, while the other method is higher.

Conclusion

- From the comparation, the sheath in simulation with pairs re-injection becomes an inverse sheath with an irreversible trend.
- There is an inverse sheath in simulation with pair re-injection method, which doesn't match experiment without magnetic field.
- From this comparation, it's hard to maintain the particle density in source region at a certain value with pair re-injection method.
- Potential in simulation with constant flux injection is more stable on a time scale, while has a bigger fluctuation on a space scale.

Reference:

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[2] MONTELLANO, I. M., WUENDERLICH, D., MOCHALSKYY, S., et al. 3D-PIC modelling of a low temperature plasma sheath with wall emission of negative particles and its application to NBI sources[J]. Journal of Physics, D. Applied Physics: A Europhysics Journal,2019,52(23).