Effect of Electric and Magnetic Field on the Transport Coefficients of a Non-Equilibrium Gas by the Monte Carlo Method

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Introduction

This work is devoted to the calculation of the transport parameters of electrons subjected to the action of an electric field and a uniform magnetic field, in a weakly ionized gas to better understand the kinetics of electronsin an electric discharge. We've chosen the Monte Carlo method, which tracks electrons one by one as they travel through the gas from their emissions to their extinction, atany time and at any point of the discharge. In this workwe are interested to the study and simulation of electronic transport parameters in oxygen O_2 and carbon dioxide CO_2 under the effect of a uniform electric and / or magnetic field and electron-molecular collisions (solving the Boltzmann equation). The calculation procedure takes into account the random walk of the electrons and the influence of the transport parameters expressed as a function of time, as a function of the reduced electric field$E\ N$ (E: applied electric field, N: the density of the gas), and as a function of the magnetic field $E\ N$ (B: the magnetic field applies). Monte Carlo simulation consistsin simulating the movement of a large number of electrons one by one, thus followed from its emissionuntil its disappearance. During the simulation, the flight position and speed are recorded for each flight time and for each electron. The knowledge of these magnitudes allows using the appropriate static averages and using the sampling methods to calculate the electronic transport parameters in the gas under consideration, taking intoconsideration the collision processes involved.

Modelisation Procedure

In this work we are interested in the estimation of transport parameters in a weakly ionized gas, under the action of a uniform electric and / or magnetic field, using the Monte Carlo method. We will present the different results obtained by our Fortran program. We will treat in this program all the real electron-molecule collision processes (elastic, inelastic, excitation, ionization and attachment), and fictitious which occur in a dischargeplasma (or weakly ionized gas), and we will store the speed, and the energy of each electron at a given time, to calculate the electronic transport parameters (average energy E_{moy} , the drift speed $V_{z\ moy}$, the transverse diffusion coefficient ND_T , the longitudinal diffusioncoefficient ND_L, the coefficient of ionization N and the attachment coefficient). We will run the program foran electron beam $n_0 = 15000$ (the number of primary electrons), is free with a maximum energy large enough to deal with all the following situations $\epsilon_{max} = 120$ eV, a gas density N_{gaz} at the temperature being equal to 3.293×10^{22} m^{-3}, and a maximum simulation time $t_{max} = 8$ ns (was chosen always greater than the relaxation time), in what follows all the transport parameters are calculated under the same conditions. Transport parameters were calculated for two gases,

DOI: 10.21467/abstracts.122 ISBN: 978-81-954993-3-5

oxygen, and carbon dioxide, in the following three cases:

- Under the unique action of an electric field anti-parallelto the axis *Oz*
- Case of a magnetic field parallel to the electric field, *i.e.* $B \parallel (Oz)$
- Case of a magnetic field perpendicular to the electric field, *i.e.* $B \perp (Oz)$

Results and Discussion

Under the effect of a uniform electric and / or magnetic field, electrons are animated between two collisions, with a uniformly accelerated movement following the directionof the fields. In general, all the transport parameters (average energy, drift speed, transverse diffusion coefficient, longitudinal diffusion coefficient, ionization coefficient, attachment coefficient, etc.) increase with the field (electric and / or magnetic), and the nature of the gas.

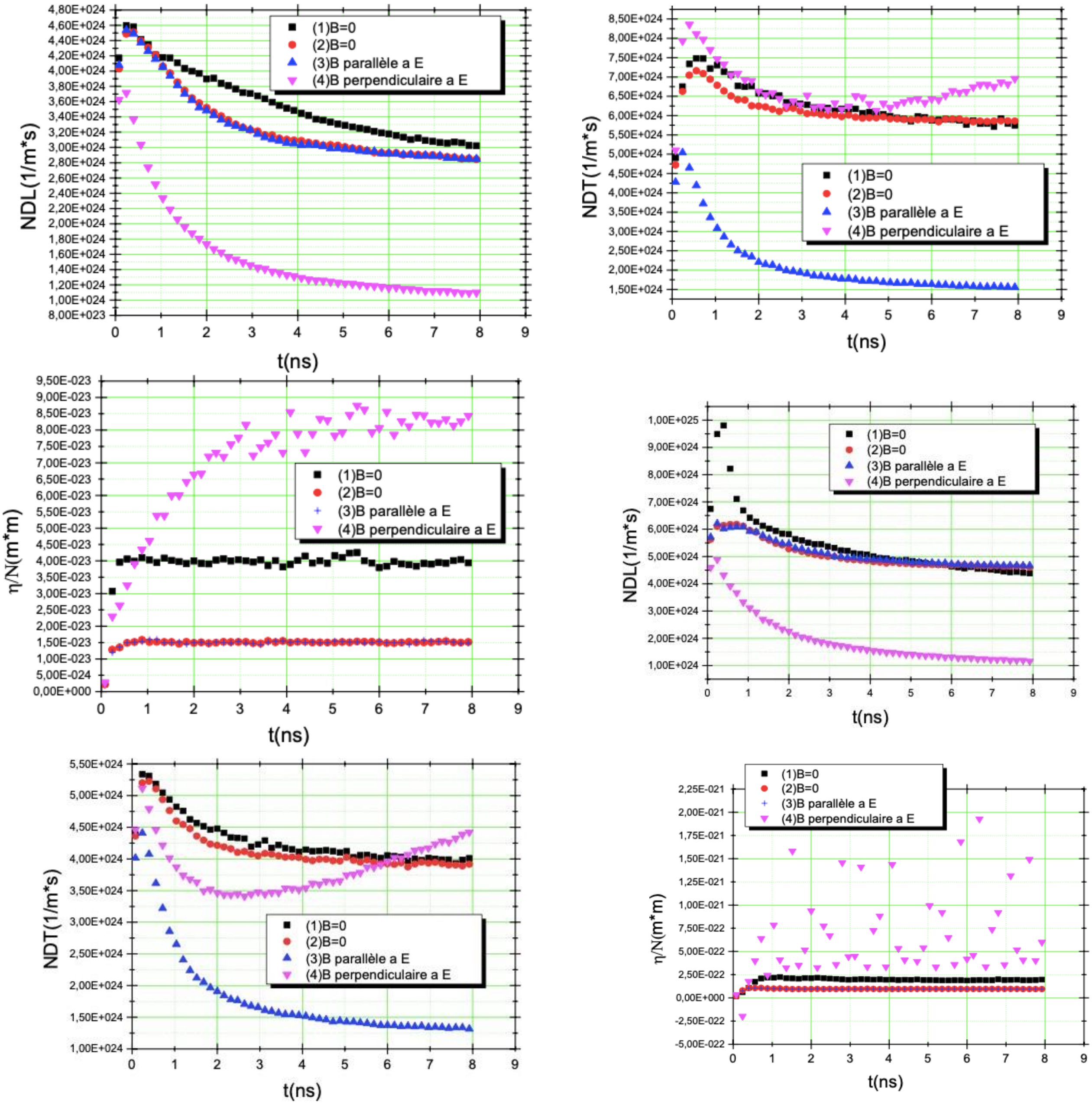

Fig1: longitudinal diffusion coefficient, transverse diffusion coefficient and attachment coefficient Vs time. First row for O_2 and the second row for CO_2

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Conclusion

In this work we were interested in determining the variousparameters that can displace or modify the state of equilibrium (the evolution time, the electric field and the longitudinal and transverse magnetic field). We can say that the Boltzmann equation can only be solved if andonly if the transport parameters are in a state ofequilibrium.

References

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ISBN: 978-81-954993-3-5

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