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On the influence of collisions in the properties of low-temperature plasmas[1]

LL ALVES, IPFN/IST-UL

Research studies on "plasma chemistry" are key when developing plasma-driven applications, as they provide insight on the plasma-enhanced production of reactive species, namely by describing the transfer of energy between species and identifying the most relevant chemical-reaction pathways. The topic is not without challenges, because it requires describing the behavior of various types of particles (charged and neutral, in several excited states), intrinsically in non-equilibrium with each other, undergoing a large number of collisional, radiative and electrostatic interactions. With regard to numerical modeling, the detailed description of the plasma chemistry in complex gas mixtures should involve the coupled solution of a Chemistry module, solving the rate balance equations for the most relevant plasma species (according to a kinetic scheme defining their production / destruction mechanisms), and a Boltzmann module, describing the electron kinetics by solving the corresponding Boltzmann equation. Monitoring the behavior of the electrons is usually at the core of the modelling work-program, particularly at low pressures, since they are the prime responsible for a collisional energy-transfer from the excitation source to the gas/plasma system. In this context, we have recently developed The LisbOn KInetics (LoKI) simulation tool [1,2] using flexible and upgradable object-oriented programming under MATLAB®. The Boltzmann component of this platform (LoKI-B), available as open-source code [3], solves the space-independent form of the two-term electron Boltzmann equation for any atomic / molecular gas mixture, handling first and second-kind electron collisions with any target state (electronic, vibrational and rotational), characterized by any user-prescribed population. This work focuses mostly on electron collisions, leveraging on the LoKI-B simulation tool. We will revisit some aspects of the operators used in the two-term electron Boltzmann equation (e.g. continuous operators for rotational mechanisms [4] and for stochastic heating adopting a Fokker-Planck approach [5]), and analyze the influence of these collisions in the plasma energy transfer (namely in fast-pulsed plasmas).

[1] A. Tejero-del-Caz *et al*, Plasmas Sources Sci. Technol. **28** (2019) 043001
[2] P. Coche *et al*, J. Phys. D **49** (2016) 235207
[3] https://github.com/IST-Lisbon/LoKI
[4] M. A. Ridenti *et al*, Plasma Sources Sci. Technol. **24** (2015) 035002
[5] U. Czarnetzki, Plasma Sources Sci. Technol., submitted (2019)

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