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Influence of the electron description on the modelling of scenarios with interest for plasma-based applications

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The adequate description of the electron kinetics is paramount to capture the behaviour of low-temperature plasmas, becoming a critical aspect of modelling in scenarios with interest for applications. In this talk, we present two examples where modelling results can be severely affected by the formulation adopted to describe the plasma electrons.

The first example focuses on the temporal evolution of the electron kinetics in dry-air plasmas (80%N2:20%O2), excited by electric-field pulses with rise-times 10-9 and 10-6s, applied to a stationary neutral gaseous background at pressures 105 and 133Pa [2]. The study solves the electron Boltzmann equation (EBE) using the LisbOn KInetics Boltzmann solver (LoKI-B) [1] and adopts either (i) a time-dependent formulation that considers an intrinsic time evolution for the electron energy distribution function (EEDF); or (ii) a quasi-stationary approach, where the time-independent form of the EBE is solved for different values of the reduced electric-field during the pulse. The simulations show that (i) gives solutions similar to (ii) for rise-times longer than the characteristic evolution time of the EEDF, i.e. 20ns at 105Pa and 20ms at 133Pa, meaning that a quasi-stationary description is possible in microsecond pulses at atmospheric pressure, failing for nanosecond pulses at both pressures considered here.

The second example addresses capacitively coupled radio-frequency discharges in N2–H2 at low pressure (0.3–0.9mbar), low power (5–20W), and H2 concentrations up to 5% [3]. Simulations use a hybrid code that couples a two-dimensional time-dependent charged-particle fluid module to a zero-dimensional kinetic module, that solves the EBE and includes a detailed surface chemistry for NHx. The code includes a dedicated module for fast electrons generated by secondary emission. The inclusion of these fast electrons results in an exponential growth of the electron density at higher powers, which is not captured by the fluid code for slow electrons and allows fitting the measurements by tuning the secondary emission coefficient

(SEC). The results highlight the relevance of plasma-surface interactions, given the role of SEC in the electrical parameters and the critical influence of the surface production of ammonia in the plasma chemistry.

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References

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