Electron kinetics description with combined stochastic and Ohmic Fokker-Planck heating operator

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The electron kinetics in low-temperature plasmas is commonly described by the electron Boltzmann equation (EBE), incorporating either Ohmic (collisional) or non-local (stochastic/collisionless) heating terms, depending on whether the plasma operates at high or low pressure, respectively.
At low pressures (~Pa), typical of ICPs, the electron energy relaxation length exceeds the characteristic system size. In such regimes, the electron population can be described by a non-local (global) distribution function that depends solely on the total energy. Furthermore, when energy transfer from the external field is confined to a small portion of the plasma volume, variations in the electron distribution function due to the plasma potential can be neglected, as the latter primarily affects the electron density. Under these conditions, the electron kinetics can be modeled by an isotropic, non-local electron energy distribution function (EEDF), obtained by solving the EBE with: (i) an energy gain term due to the action of an external electric field, and (ii) energy loss terms due to collisions and transport to the reactor walls. The energy gain term is described by a Fokker-Planck-type heating operator [1], which unifies the treatment of non-local stochastic heating, resulting from the spatial distribution of the electric field, and local Ohmic heating in the presence of electron-neutral collisions.
In this work, we present initial results from the numerical implementation of this approach in the LisbOn Kinetics Boltzmann and Chemistry solver (LoKI-B+C) [2]. We apply the description to a low-pressure argon ICP (p=0.2-1.5 Pa, n_e~10^{16} m^{-3}), assuming an exponential decay of the electric field away from the antenna (13.56 MHz). The self-consistent solution provides the EEDF, the densities of the main argon species, the reduced electric-field intensity, the sheath potential, the skin depth, and the power coupled to the plasma. Simulation results are compared with experimental measurements of the EEDF obtained using electrostatic probes.

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