Kinetic mechanisms in air plasmas

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This work presents a comprehensive modelling study on the most important kinetic mechanisms that take place in air plasmas at low pressures (p ~1 Torr). Within this purpose we adopt three different experimental situations in synthetic dry air (N_2-20%O_2): (i) single DC pulsed plasmas; (ii) their afterglows and (iii) repetitively DC pulsed discharges, each of them produced in a cylindrical tube with inner radius of 1 cm, considering pulse durations of the order of a few milliseconds, as reported in [1, 2].

Our simulations for the pulsed discharge are based on the numerical solutions of the electron Boltzmann equation coupled to the system of time-dependent rate-balance equations which incorporates the kinetics of the most populated heavy (neutral and ionic) species produced in an air mixture including the vibrationally excited states of ground state molecular nitrogen of molecular nitrogen $N_2(X\ ^1\Sigma_g^+,v)$ [3]. The afterglow regime is described by the temporal relaxation of all heavy species, discarding the role of electron impact collisions [4].

Modelling simulations show that the production of $N(^4S)$ and $O(^3P)$ atoms, as well as NO(X) molecules is governed by an important interplay between mechanisms $N_2(X, v \geq 13) + O \rightarrow NO(X) + N(^4S)$ and $NO(X) + N(^4S) \rightarrow N_2(X, v\sim3) + O$ for pulse durations longer than 1 ms, with an important contribution from $N(^2D) + O_2 \rightarrow NO(X) + O$ and $N_2(A) + O \rightarrow NO(X) + N(^2D)$ reactions for shorter times. These predictions include the important interdependence between most of the reaction rate coefficients and the gas temperature, namely in what concerns the highly exothermic process $NO(X) + N(^4S) \rightarrow N_2(X, v\sim3) + O$ (~2.45 eV), by solving at the same time the gas thermal balance equation.

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