Self–consistent modeling of Discharge: the role of superelastic collisions

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To determine the rate coefficients of electron-induced processes the Boltzmann equation for free electrons must be solved to calculate the electron energy distribution function (eedf). Integrating the cross sections over the eedf, the rates of electron induced processes are calculated. The most advanced approach consists in coupling self–consistently the Boltzmann equation, with the state-to-state kinetics, determining at the same time the eedf and the level distribution, accounting for their mutual interaction. To simplify the calculation, under the assumption that eedf relaxes much faster than the gas composition, the rate coefficients can be related only to the local electric field (local field approximation, LFA). However, LFA cannot consider the contribution of the superelastic collisions in the electron kinetics. In participating to the Round Robin [1] activity for the verification of different plasma kinetic codes, strong effects of superelastic collisions on the plasma properties have been observed, when a self–consistent coupling of free electron and level kinetics has been considered. It is well known that superelastic collisions are very important in the post-discharge. In the present work we have observed that they are effective also in the presence of high electric field, as shown in the figure, where the density of free electrons and argon metastable are reported when superelastic collisions are neglected or included in the Boltzmann equation. When superelastic collisions are considered in the electron kinetics, some plateaux appear in the eedf [2, 3], which completely change the rates of electron induced processes. These rates depends not only on the electric field, but also on the level population and on the plasma composition, affecting the time evolution of species densities.

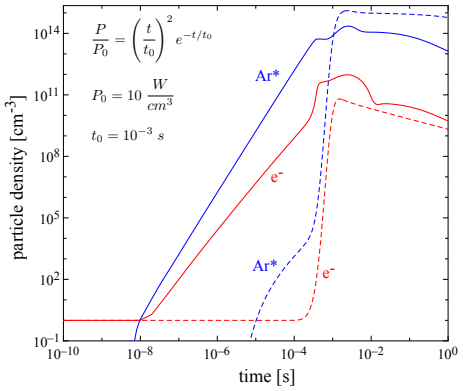

Figure 1: *Electron and argon metastable densities with (continuous lines) and without (dashed lines) superelastic collisions in the Boltzmann equation.*

References

[1] L. Pitchford et al.: Plasma chemistry round robin, GT1.00063, 70th Annual GEC, 2017.

[2] G. Colonna, A. D'Angola (Ed), Plasma Modeling: Methods and Applications, IOP (2017)

[3] M: Capitelli et. al, Fundamental Aspects of Plasma Chemical-Physics: Kinetics (2016)