Contribution ID: **1101** Type: **Either**

Species Dynamics in Ar/H Plasma Supporting Actinometry Diagnostics Correlation Experiments

Friday 28 June 2019 11:45 (15 minutes)

This analysis doesn't seek to create the most complex and definitive Ar/Hydrogen chemistry and radiation model, but rather to gain enough insight from existing literature to support an easily manageable chemistry set, within a more complex transport code, assessing the plasma species dynamics and radiation rates required to infer line intensities for experimental actinometry.

No matter what details of the chemistry rate scheme, a plasma chemistry model can be represented by a straightforward set of (mostly) binary rate equations combining creation C and destruction D operators for all species.

$\dot{f}_k = f_i f_j (C_{ijk} - D_{ijk}) - A_{\lambda k} f_k$

The mole fractions f_k are dimensionless fractions decomposing unity and the creation or destruction operators are normalized to the (local) heavy particle density, n_h. In the special case of three body destruction or recombination processes, the $D_{ijk} \rightarrow f_h \bullet_h D_{ijk}$ with f_h the vector of heavy particle species. For non-LTE electrons, f_e is further decomposed into a electron energy distribution function (EEDF), viz. $f_e \rightarrow f[e, \varepsilon]$ with the energy grid ε spanning the electron phase space generated by a known value of electric field over total density, viz. E/n_h. Each C or D operator then becomes a convolution of the EEDF with a particular cross section for the process of interest, viz. $C_{ejk}(E/n) = \int \sigma_{jk}(\varepsilon) \bullet f_e[e, \varepsilon]$. Finally, the radiative decay channels, $A_{\lambda k} f_k$, diminish the mole fraction of excited states, providing emission intensities for the observed wavelengths λ.

Generally the Boltzmann modeled EEDF achieves (˜10 ns) a steady state with respect to creation, radiation and recombination in the discharge medium for virtually any specified values $[E/n, f_h, f_e]$ —defining all of the rate coefficients and transport coefficients dependence on f_k. Using the frequency shift in RF cavity modes together with the actinometry data, it is expected that a more precise electron density can be inferred.

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Session Classification: 1.6 Plasma Chemistry

Track Classification: 1.6 Plasma Chemistry