DEPARTURES FROM LOCAL THERMODYNAMIC EQUILIBRIUM IN HID LAMPS

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It is generally accepted that high-pressure plasmas with high electron densities are close to equilibrium. This implies that for these plasmas the temperatures of the electrons and heavy particles are (almost) the same ($T_e = T_h$) and that the ionization degree follows from Saha’s law ($n_e = n_e^S$).

We investigated plasmas in High Intensity Discharge (HID) lamps with the aim to find whether deviations from LTE could be found. This information is of crucial importance to validate our grand models that solve the competition between the transport modes of convection, diffusion and radiation together with Ohm’s law in a self-consistent way [1].

HID lamps have a small volume, high pressure and high luminance. This makes them very useful for the illumination of large surface areas such as streets and stadiums. These lamps are mainly divided in high-pressure mercury, high-pressure sodium and metal-halide lamps.

The presence of LTE was experimentally investigated for a model HID mercury lamp and related to the results found for lamp based on a mixture of mercury and dysprosium. The mercury lamp has a length of 39 mm and an arc length of 18 mm. It contains pure mercury and has no outer jacket. The validation of the LTE assumption requires the measurements of different temperatures. This was done using three different techniques. X-ray Absorption (XRA) [2] measures the heavy-particle temperature, Thomson Scattering (TS) [3] the electron temperature, Absolute Line Intensity (ALI) [4] measurements determine the excitation temperature. By comparing the different temperatures the LTE assumption can be validated.

All temperature profiles are radially resolved. The TS temperature profile shows a relatively constant radial profile, whereas the XRA profile is parabolic. This is a clear indication of the departure from LTE in the outer regions of the discharge.

Moreover, strong deviations form Saha’s law were found, especially in the outer part of the plasma.

In this contribution we will present the various experimental methods and their results, while possible reasons for the LTE-departures will be discussed. Results of modeling will be presented as well.

Reference

