Volume production of negative ions and atomic hydrogen in low-pressure inductively coupled hydrogen plasmas: resolving spatial gradients in the gas temperature and vibrational kinetics

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Non-equilibrium, low-pressure hydrogen plasmas are of significant interest for fundamental plasma science and technological applications including materials surface processing and negative ion sources.

In planar-geometry inductively coupled plasmas, significant spatial gradients can form in the temperature of the neutral gas [1]. For operation in hydrogen, it is therefore important to understand the plasma response to these gradients, and in particular that of negative ions and atomic hydrogen.

In this study, we undertake 2D fluid-kinetic simulations of low-pressure inductively coupled hydrogen plasmas with the Hybrid Plasma Equipment Model [2]. The plasma chemistry is based upon that established in Ref. [3], and is developed further to account for gas-temperature dependencies in determining heavy particle reaction rates with all of the vibrational levels of the ground electronic state.

The results demonstrate that the incorporation of spatially resolved gas temperatures has a significant impact on the distribution of atomic hydrogen and the vibrational states, but has a relatively smaller impact on the negative ions. The impact of spatial gas-temperature gradients on the macroscopic plasma structure and chemistry is expected to be of significant interest for the basic understanding of electronegative plasmas and the future development of non-equilibrium plasma applications.

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