Call for applications for PhD student position in the laboratory of excellence, labex Plas@Par

Title: Dynamics of pulsed radiofrequency plasmas in simple halogen gases

Project description

Radiofrequency-excited inductively-coupled plasmas in low-pressure (0.2-10 Pa) halogen-containing diatomic molecules (for example Cl_2 and HBr) are an archetype for the study of the dynamics of plasmas in simple molecular electronegative gases, and are amenable because we possess techniques to measure the densities of all of the major species occurring in them. The kinetics of creation and destruction of transitory species can be probed by time-resolved measurements in pulse-modulated plasmas. In terms of applications, plasmas in these gases are widely used in industry and research for plasma etching of nanostructures, an essential step in the fabrication of nano-devices such as integrated circuits and photonic devices. Electronegative plasmas are equally of current interest for the development of ion-ion plasma thrusters.

Understanding these systems involves not only treating the charged particle dynamics but also the collisional processes of the atoms and free radicals created by electron-molecule collisions. For instance, the Hybrid Plasma Equipment Model (HPEM[1]) developed over many years by Prof Kushner of Michigan (with whom we are collaborating) treats the motion of electrons and ions under the influence of applied electromagnetic fields using a hybrid fluid/Monte-Carlo approach, and couples this to a fluid chemical kinetics model. While the validity of the HPEM approach is well established, a recent study at LPP of Cl_2 plasmas[2], using state-of-the-art laser and microwave diagnostic measurements, showed that the physico-chemical model of Cl_2 used in HPEM is naive, leading to wildly inaccurate predictions (for instance, underestimation of such basic parameters as the electron density by a factor of 3 under some circumstances). Inclusion of processes such as electron collisional vibrational excitation[3] of Cl_2 (followed by v-T transfer), and spin-orbit excitation[4] and quenching was found to radically improve the model agreement.

The aim of this PhD project is to complete our study of Cl_2 plasmas and extend it to the study of HBr. This molecule is interesting for several reasons: the large dipole moment leads to huge electron collision cross-sections; the dynamics of Br atoms has never been studied, and this gas is widely used in industrial processes but its role is poorly understood.

[1] http://uigelz.eecs.umich.edu/Projects/HPEM-ICP/index.html

[2] Booth J P, Azamoum Y, Sirse N and Chabert P *Journal of Physics D: Applied Physics* 2012 45 195201

[3] Gregorio J and Pitchford L C *Plasma Sources Science & Technology* 2012 21 032002

[4] Wang Y, Zatsarinny O, Bartschat K and Booth J P *Phys.Rev. A.* 2013 accepted

Requirements for the candidate:
This project is essentially experimental. The candidate should have a background in low-temperature plasmas, and ideally knowledge of molecular physics and laser spectroscopy

Location and starting date: LPP, Ecole Polytechnique, Palaiseau, October1, 2013

Application with detailed CV, copies of degree diplomas and grades, two reference letters, copies of any previous research-related work and personal statement explaining your motivation. Application deadline is *May 15, 2013*. The application should be sent preferably by e-mail to the following address: jean-paul.booth@lpp.polytechnique.fr