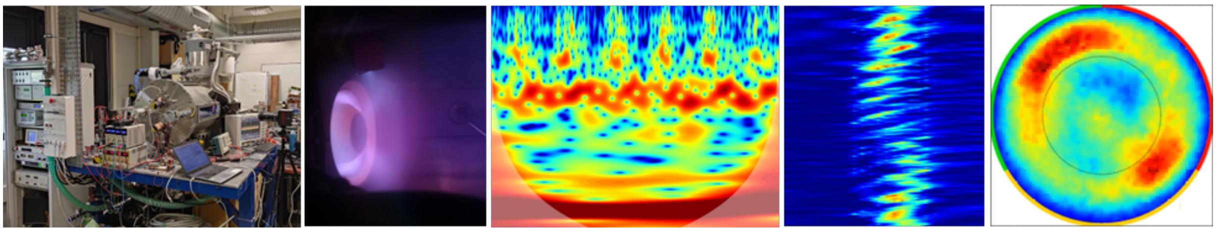
LABORATOIRE PLASMA ET CONVERSION D'ENERGIE
UMR 5213

Toward a better description of low frequency instabilities in Hall thrusters

Postdoctoral position (12 months)

LAPLACE – Université de Toulouse – CNRS

Context - Hall thrusters are devices where a static magnetic field $\boldsymbol{B}$ is applied inside the plasma volume. The magnetic field is radial and perpendicular to the direction of the electron current inducing a drop in electric conductivity and hence the formation of an axial electric field $\boldsymbol{E}$ which both accelerates and extracts the positively charged ions. The axial electric and radial magnetic fields induce a so-called Hall current in the azimuthal $\boldsymbol{E} \times \boldsymbol{B}$ direction. The electron drift is hence closed which results in an efficient confinement of the electrons. As the ions are weakly magnetized, the difference between electron and ion drift velocities can lead to charge separation and to the development of plasma instabilities (waves or spokes propagating in the drift direction and axial instabilities, from kHz to MHz, even up to GHz, and wavelengths ranging from a few mm to several cm) which significantly increase the transport across the magnetic field barrier due to particle-wave interactions (dubbed as "anomalous current"). As these instabilities may control electron transport across the magnetic barrier, numerous experimental and theoretical studies have been devoted to characterizing them. However, the physics of these instabilities is complex and their consequences on anomalous transport are still difficult to quantify, leading to a largely empirical design of Hall thrusters. Recent theoretical work has shown the role of gradients (of density, temperature and magnetic field) in the appearance of these instabilities. However, due to the difficulty of controlling these gradients, experimental work on the subject is rare and very partial. The PPS Flex thruster developed at Laplace is an original and unique tool allowing the magnetic configuration to be varied continuously. It offers a real opportunity to improve the description of these instabilities and consequently the possibility of controlling them as well as helping to give an assessment of the anomalous current.



Objectives and work program - This study is part of a project funded by the French Space Agency CNES. The main objectives are 1- to identify the type of low-frequency instabilities present in the PPS Flex thruster at the nominal operating point, 2- to improve the physical description and understanding of low-frequency instabilities by experimentally characterizing the effect of the magnetic field on the appearance/disappearance of instabilities and on their characteristics (frequency, amplitude, location, etc.). For now, dedicated diagnostics for characterizing instabilities and the thruster have been set up and are now operational. Signal analysis tools (wavelet decomposition)

[1] [2] and a time readjustment technique based on signal similarity have been developed [3] and tested for PPS-1350-type magnetic configurations. In this context, the post-doctoral researcher will rely on:

- the development of these tools to study experimentally the effect of magnetic field gradients on the characteristics of low-frequency instabilities (breathing mode oscillations, Ion Transit Time Instabilities and Rotating Spokes) in PPS-Flex thruster;
- the LAPLACE lab's expertise in theoretical instability analysis and Hall thruster simulation to complement experimental observations and analysis.

Candidate education - PhD in plasma physics
Candidate profile and skills required - the ideal candidate will have an excellent knowledge of physics with strong experimental and communication skills. Knowledge with Hall thruster and programming will be helpful.
Final application date - April 2025
Start date - September 2025
Contact – Express your interest by emailing Freddy Gaboriau – gaboriau@laplace.univ-tlse.fr and Laurent Garrigues – garrigues@laplace.univ-tlse.fr . To apply please send CV and a cover letter that highlights your research experience.

[1] Q. Delavière-Delion, F. Gaboriau, G. Fubiani, and L. Garrigues, Physics of Plasmas 31, 072110 (2024)
[1] Q. Delavière-Delion, F. Gaboriau, G. Fubiani, and L. Garrigues, Physics of Plasmas 31, 122115 (2024)
[3] Q. Delavière-Delion, F. Gaboriau, G. Fubiani, and L. Garrigues, IEPC-2024-290 paper, IEPC, Toulouse (2024)