PROPOSITION DE SUJET DE THESE

Numerical modeling of electric field and mutual impedance probes onboard interplanetary missions

Référence : **PHY-DPHY-2025-13**
(à rappeler dans toute correspondance)

Début de la thèse : octobre 2025	**Date limite de candidature : juin 2025**

Mots clés

Physique des plasmas, Environnement spatial, simulation numérique, instrumentation

Profil et compétences recherchées

Compétences : Physique générale, Méthode numérique, Physique des plasmas.

Master 2 Physique fondamentale ou appliquée, Physique générale, Physique des plasmas

Présentation du projet doctoral, contexte et objectif

Space missions that explore our solar system carry out a variety of scientific instruments. Among them, electric instruments enable us to directly explore the structure and dynamics of interplanetary and planetary plasmas. In particular, electric antennas perform passive and active measurements of the plasma to diagnose different physical quantities, such as the electric field, the plasma density and temperature. The CNRS laboratory LPC2E (Orléans) is responsible for electric and mutual impedance instruments onboard many planetary exploratory space missions. However, the spacecraft carrying those instruments directly influences and modifies the plasma flow that surrounds the instruments. This means that the plasma to be diagnosed is influenced by the presence of the instrument itself. In order to consider such crucial spacecraft-plasma interactions, a Spacecraft-Plasma Interaction Software (SPIS) has been developed by ONERA (Toulouse).

In this context, the main goal of this PhD research project is to model the behavior of electric instruments onboard space missions within the SPIS model itself, in order to consider the influence of the spacecraft as well as its interaction with the plasma surrounding the spacecraft.

First, the PhD student develop numerical methods and models to simulate the different instruments targeted in this thesis. These different electric instruments models are based on the same measurement concepts, so that the associated numerical models are expected to share a significant part of their developments. The new models will consider the plasma inhomogeneities generated by the spacecraft, as well as the non-linearities that might be injected into the plasma by active instruments, in order to assess their impact measurement performances.

Second, the PhD student will validate the implementation of these new models using both laboratory and space measurements. (i) He/she will use a plasma chamber, where such electric instruments already exist and are ready to use. Plasma chamber already exist both at ONERA and at LPC2E. (ii) He/she will then validate the models with the flight data acquired by the JUICE space mission during 2024, as well as the future 2026, Earth flybys.

Third, the PhD student will use these new validated instrument models to perform in-depth analysis of the near-Earth environment as a proof of concept for future JUICE operations around Jupiter and its icy moons. Subsequently, he/she will model the JUICE measurements planned at Jupiter in the 2030s.

Last, the PhD student will prepare the observations of the BepiColombo mission at Mercury, and subsequently contribute to the analysis of the exciting new data that will be acquired at Mercury from 2027.

Collaborations envisagées

The instrumental modeling is developed in collaboration between the LPC2E, LAGRANGE and LAPLACE laboratories with the involvement of ESA ESOC (mission) and ESTEC (technology) centers.

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