Spécialité de Master « Optique, Matière, Plasmas »

Stage de recherche (4 mois minimum, à partir de début mars 2010)

Proposition de stage pour l'année 2009-2010 (ne pas dépasser 1 page)

Date de la proposition :

Responsable du stage / *internship supervisor*:

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Nom du Laboratoire / *laboratory name*:

Code d'identification : ICARE, UPR 3021 Organisme : CNRS

Site Internet / *web site*: www.cnrs-orleans.fr/icare/

Adresse / *address:* 1c, Avenue de la Recherche Scientifique, 45071 Orléans

Lieu du stage / *internship place*: ICARE

Titre du stage / *internship title*: Optimization of an ion-ion plasma source for an innovative electric thruster

Résumé / *summary*

Electric propulsion is currently used onboard geosynchronous communication platforms and interplanetary robotic probes. A set of new missions is foreseen for the near future: drag reduction for low Earth orbit satellites with low-power thrusters and orbit topping and orbit transfer maneuvers of large satellites with high-power thrusters. Two thrusters technologies clearly monopolize the market, namely, the gridded ion engines and the Hall effect thrusters. They both offer a high level of performances in terms of specific impulse, hence in propellant consumption, and thrust efficiency. However, the two concepts, even though relying on unalike architectures and distinct physical mechanisms for ions acceleration and extraction, suffer from the same two drawbacks:

- the need for an external electron gun (cathode) of which the role is to supply the electron stream necessary for neutralizing the ion beam,
- the fact that the thruster plume is a quasi-neutral plasma that comprises ions and electrons (the recombination length is of several hundreds of meters); ions, especially when their velocity is low owing to scattering and charge exchange collision events, interact with the spacecraft components such as solar arrays and electronic payload. As a consequence, the spacecraft lifetime or mission duration may be drastically shorten.

A new concept of electric thruster, of which the strength is to get rid of the two aforementioned weakpoints, was proposed in 2005 and patented by P. Chabert from the Ecole Polytechnique in Paris. The concept – named PEGASES for Plasma Propulsion with electronegative GASES – takes advantage of an ion-ion plasma that means an electron-free plasma that solely contents positive and negative ions. The basic idea is to create a stratified plasma with an electron free (ion-ion plasma) region at the periphery of a highly ionized plasma core such that both positive and negative ions can be extracted and accelerated together to provide thrust and specific impulse. The recombination of positive and negative ions to form neutral molecules is very efficient and it takes place over a short distance. Hence, the classical plasma plume of available electric thrusters is attractively replaced by a beam mostly composed of neutral gas, that means a drastic reduction in the degree of plume-spacecraft interactions.

The ICARE team and the LPP team are currently working together on the proof of concept as well as on the development of a high-efficiency ion-ion thruster prototype in the frame of a research project financially supported by Astrium.

The research topic can be divided into two main activities. The first activity concerns the production of a Radio-Frequency ion-ion plasma starting from an O_2-SF_6 gas mixture by way of magnetic filtering. The second activity is connected with the recombination process and extraction (free flow) of both positive and negative ions. The most relevant question to answer being how to obtain a stable high-density ion-ion plasma suitable for a first stage of a PEGASES-type thruster?

Studies will be carry out in the NExET test-bench of the ICARE laboratory. The facility consists in a 1.8 m in length by 0.8 m in diameter vacuum vessel equipped with a specific cryogenic pumping system able to maintain a background pressure below 5×10^{-5} mbar with 1 mg/s gas mass flow rate and up to 200 W input power.

Ce stage pourra-t-il se prolonger en thèse ? *Possibility of a PhD* **? : Eventuellement**

Si oui, financement de thèse envisagé/ *financial support for the PhD***: BDI / Astrium**

Lasers et matière		Lumière, Matière : Mesures Extrêmes	
Optique de la science à la technologie		Physique des plasmas	**X**

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