UNIVERSITÉ DE RENNES 1

Doctorat

Institut de Physique de Rennes UMR CNRS 6251

Optical diagnostic of space propellers for CubeSats.

Start of the PhD: October 1st 2021

Funding: ½ Contract from the Brittany region, ½ ANR Contract (project FULLDIBS)

Key words: Laboratory astrophysics; High resolution molecular spectroscopy; Optical frequency combs; Optical cavities.

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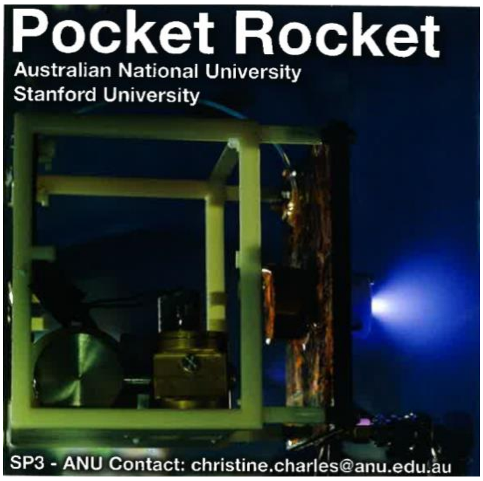
PhD project: CubeSats are satellites characterized by their small dimensions and built of units of 10x10x10 cm^3 with a maximum weight of 1,33 kg each. These standardized specifications have allowed an important reduction of the launching costs, paving the way for multiple applications, commercial or scientific. The development of a new type of satellite missions compatible with such small volumes is a technological challenge which has aroused interest toward miniaturized propeller.



The PhD project aims at modelling in laboratory the performances of small propellers developed in collaboration with the Space Plasma, Power and Propulsion laboratory (SP3) of the Australian National University, led by Prof. Christine Charles. These propellers aim at reaching the best efficiency from solid fuels, such as naphthalene ($C_{10}H_8$), which high densities allow to load a high propelling capacity while avoiding the issues attached to the transportation of highly pressurized gas. A second type of propeller will be studied during this project, involving plasmas. These electrothermic propellers, so-called Pocket Rocket, generate a radiofrequency plasma which rise the thermic energy of a gas to convert it into kinetic energy through a nozzle. The project will aim at finding a method to adapt these different propellers to a solid fuel, in particular to naphthalene.

Our goal is to use cavity-enhanced infrared spectroscopy, such as cavity ring-down spectroscopy [1-2] or frequency comb spectroscopy [3], to study and model at the molecular scale the propellers developed at SP3. The scientific objectives will include the modelling of the structure of the supersonic gas flow produced by a miniaturized nozzle. We will also investigate quantitatively the energy stored in the different internal degrees of freedom of the naphthalene molecules when heated at temperatures < 400 K and expanded through a supersonic nozzle. The distribution of the translational, rotational, and vibrational molecular energies will be measured using the infrared spectrometers developed within the department and already employed to probe supersonic flows. A simulation chamber will be developed to simulate the spatial conditions.

General context: The group of laboratory astrophysics, whithin the department of molecular physics (https://ipr.univ-rennes1.fr/en/molecular-physics-department), employs 24 tenured staff and 20 PhD students and postdoctoral researchers. We are developping among other high-resolution and high-sensitivity spectrosocpic techniques with the purpose of studying molecules of astrophysical interest in extreme conditions of temperature and pressure. These techniques are based on optical cavities, which enhance the interection length between the laser and the gaseous sample, and on infrared high-resolution laser sources as continuous wave diodes or optical frequency combs. Most of our works use hypersonic flows to reach rotational temperatures lower than 50 K.

Qualifications: The applicant should have a master degree in physics or equivalent. The project will require a strong experimental involvement (vacuum techniques, infrared optics, lasers, electronics, compressible flow) but also a real drive in the theoretical understanding of the measured spectra. Qualifications in a CFD simulation program, MATLAB, Python and/or LabVIEW programming, in optics and in laser-based absorption spectroscopy will be highly appreciated.

Bibliography : [1] N. Suas-David et al. Chem. Phys Lett. 659, 209-215 (2016) ; [2] E. Dudás, *et al.* The Journal of Chemical Physics, **152**(13), 134201 (2020); [3] A. C. Johansson, *et al.* Optics Express, 26(16), 20633-20648 (2018).

Application procedure: Please submit your application at your earliest convenience by email to Lucile Rutkowski or Robert Georges, and please include:

- Cover letter
- Detailed CV
- Copy of M.Sc. degree or equivalent
- Grade transcripts
- Contact details of two academic references.

Alternatively, the application can be filled online on the website: https://theses.doctorat-bretagneloire.fr/3m/