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UNIVERSITA' DEGLI STUDI DI PADOVA

Corso di Dottorato in Scienze, Tecnologie e Misure Spaziali

Study and Development of a Fluidic System for Iodine-fed Magnetically Enhanced Plasma Thruster (MEPT)

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Table of Contents:

Framework and Statement of the Problem

MEPT

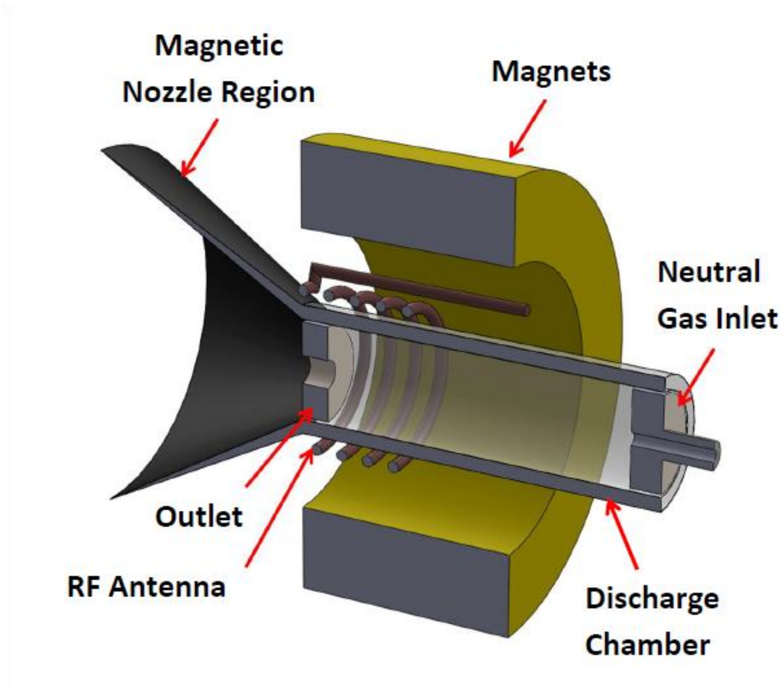
The **Magnetically Enhanced Plasma Thruster** (**MEPT**) is an **innovative low-cost electric propulsion system** able to increase small spacecrafts mobility, opening new unconventional mission scenarios.

THRUSTING A DIFFERENT FUTURE

T4i is engaged in the design and development of a complete propulsion module based on the MEPT. The module is intended for CubeSat platforms ranging in size from **6 U** to **24 U**, providing:

- 0.25-0.65 mN of Thrust
- Isp up to 650 s
- input power lower than 60 W

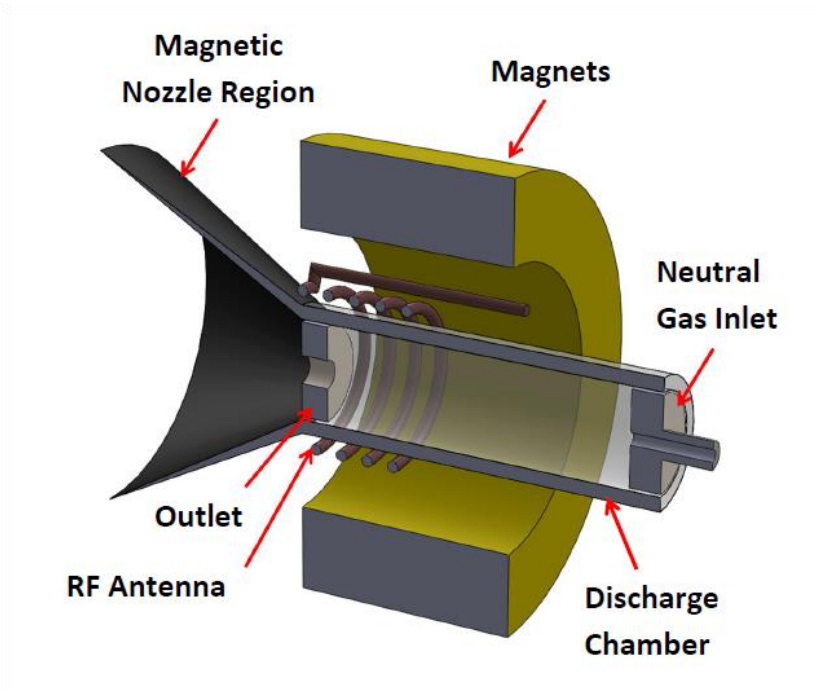
MEPT



The main components of MEPT are:

- A **fluidic line** which transfers the neutral gas propellant from a storage tank to the **discharge chamber**.
- A **discharge chamber** inside which the neutral gas is ionized
- A **RF antenna**, in the MHz frequency range, which generates the electromagnetic (EM) fields for gas ionization
- **Magnets** producing a magnetostatic field to enhance the plasma confinement and provide the magnetic nozzle effect.

MEPT



Advantages:

- Absence of electrodes immersed in the plasma
- Good power scalability
- Adaptability to different propellants
- No need for a neutralizer

Disadvantage:

- High thermal load

MEPT: Iodine Propellant

MEPT can work with different propellants (such as Ar, Kr, Xe, Air, CO2). Because of this last feature it seems extremely promising to investigate the employment of **Iodine as a propellant**, which is particularly appealing for space applications.

Why Iodine Propellant?

- It costs only 1/5 compared to Xenon
- It can be stored as solid
- High density
- No pressurized tank

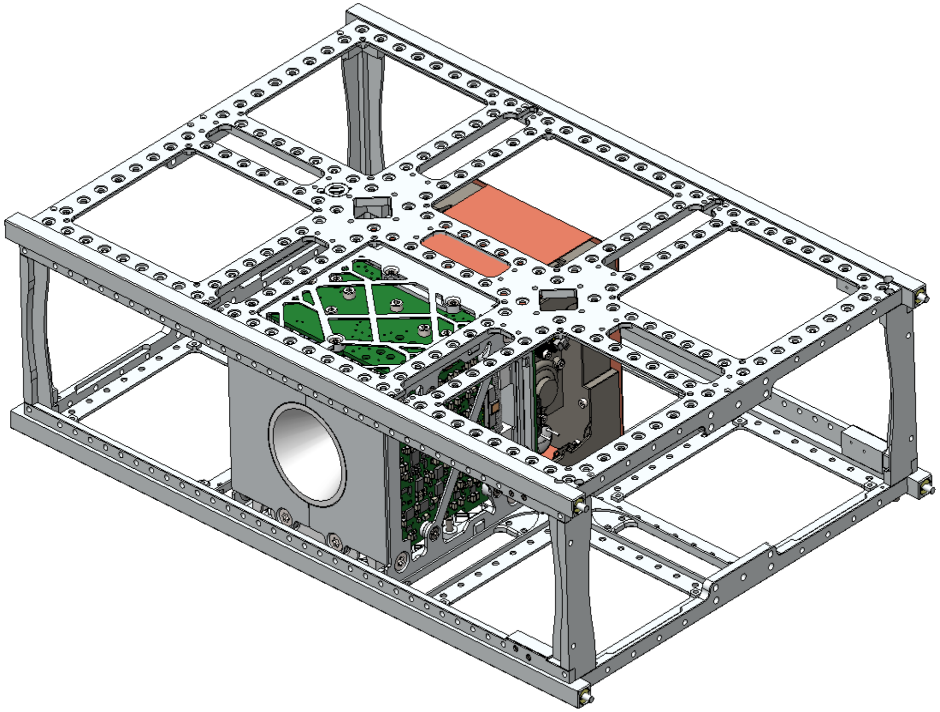
Disadvantages:

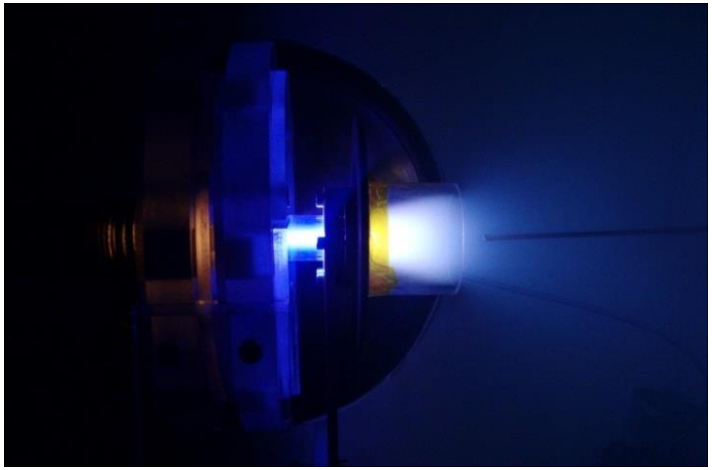
- Chemically reactive
- Never flown before

Research Project

Aim of the Project

The research program will be focused mainly on the design of an innovative **low cost fluidic system for Iodine fed Magnetically Enhanced Plasma Thruster**, in order to use it on a Cubesat platform.





The fluidic subsystem must provide a **fixed mass flow rate of 0.1 mg/s ±10%** to the thruster.

Research Activity

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1. Study and optimization of the **mass flow control system** by means of thermal management strategy, in order to grant the proper **sublimation rate** and to avoid **the re-condensation**.

2. Development of a proper **software tool** to design and optimize the system from a thermal and fluidic point of view.

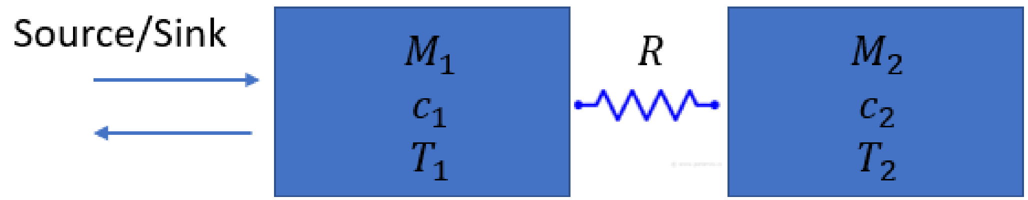
3. Testing of **the mass flow control system with Iodine propellant**.

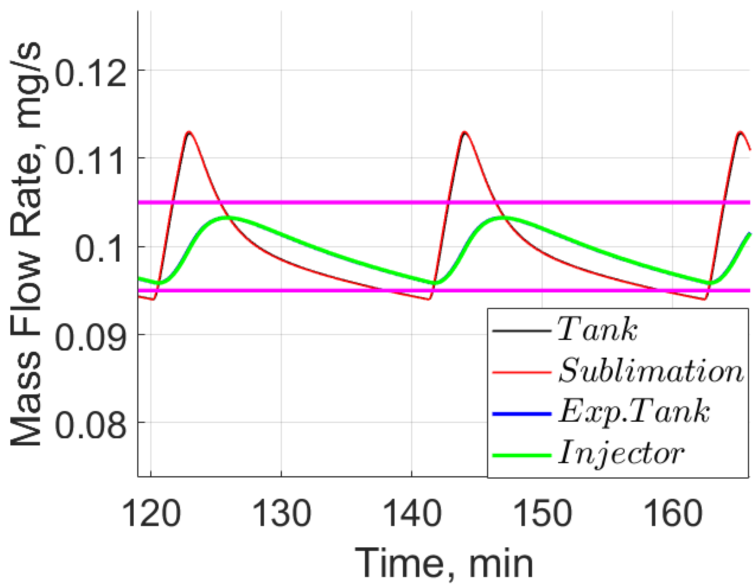
Activities up to now

Numerical Approach

A Thermal Lumped Parameter Model was developed in order to simulate the thermal behaviour of the system.

$$M = mass$$
$$c = specific\ heat$$
$$T = Temperature$$
$$R = radiative/conductive\ resistance$$



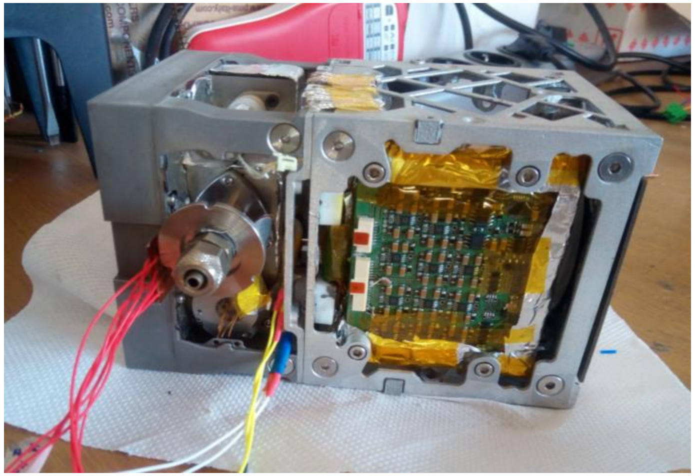


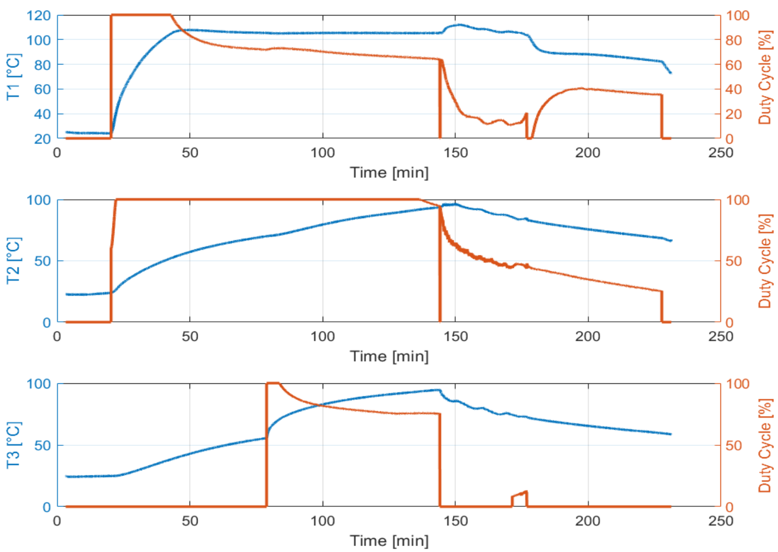
A Fluidic Model, coupled with the thermal one, was developed and was used to study the mass flow control system.

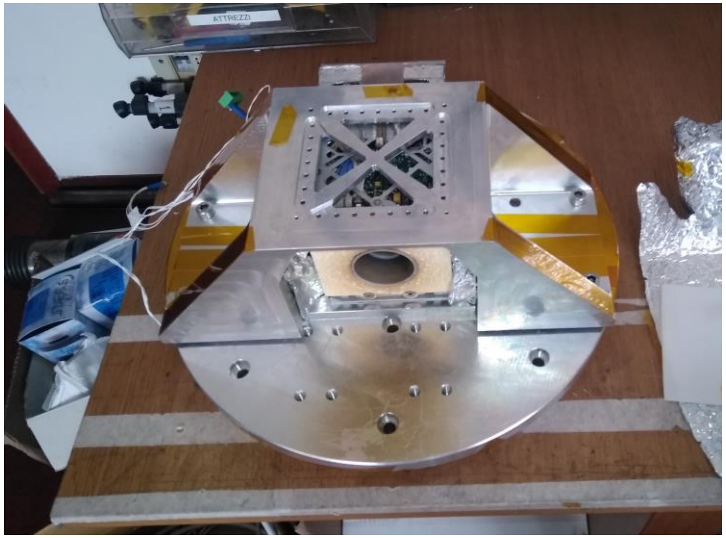
Tests

The following tests have been performed:

- Tuning of the thermal control loop
- Calibration of the sensors
- Functional tests in vacuum with the thruster module (heating, ignition, thrusting and cooling)
- TVAC





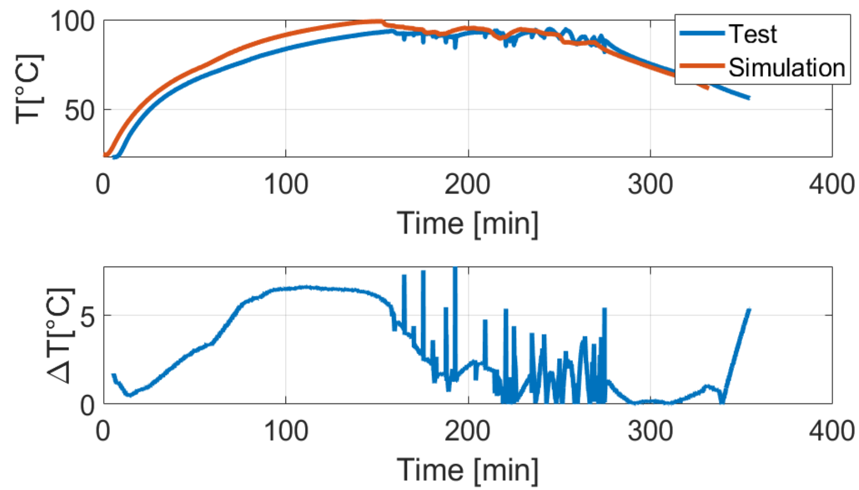


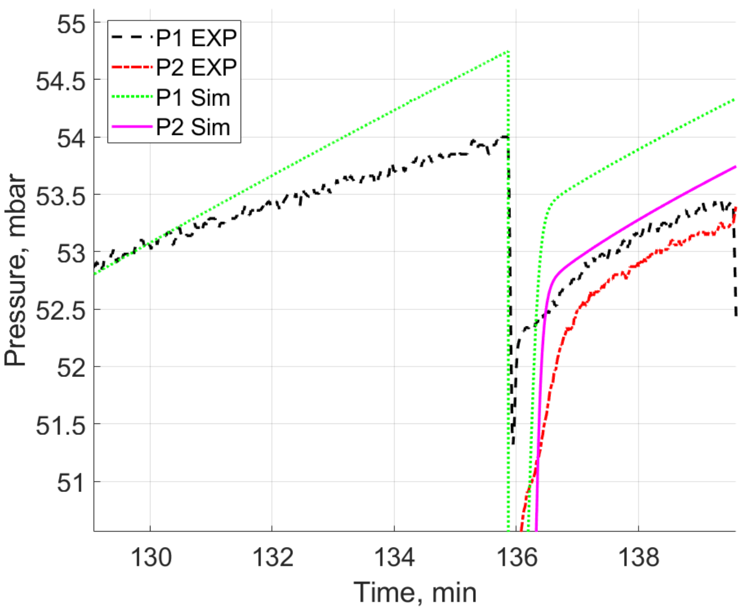
Validation of the Numerical Model

The following steps were followed:

1. Calibration of the thermal resistances

2. Validation of the temperature profile vs time





3. Calibration of the fluidic parameters

4. Validation of the pressure profile vs time

Future Work

Future Work

1. To finish the fluidic tests;
2. To conclude the optimization of the fluidic module.
3. To write the thesis

Summary of Activities

Legend

- ✓ Finished
- ▪ In progress
- ❑ To start

- ✓ **Bibliography Research**
  - ✓ **International Papers**
- ✓ **Numerical Models**
  - ✓ **Thermal Model**
  - ✓ **Fluidic Model**
  - ✓ **Coupling**
  - ▪ **Validation**
- ▪ **Design and Development**
  - ▪ **Mass Flow Control System**
  - ▪ **Optimization**
- ▪ **Calibration and Test**
  - ▪ **Thermal Control**
  - ▪ **Mass Flow Control**

Thanks for your attention…

… any questions?