Quasi 2D PIC Model of a Magnetically Enhanced Plasma Thruster

M.Minute[1], M. Magarotto[1], F. Trezzolani[2], M. Manente[2],
I. Bevilacqua[3] and D. Pavarin[3]
[1]*UNIPD-CISAS, Padova, Italy*
[2]*T4i S.r.l, Padova, Italy*
[3]*UNIPD-DII, Padova, Italy*
(mail: marcominute@gmail.com,magamir91@gmail.com)
36th International Electric Propulsion Conference (IEPC), Vienna (Austria), 2019

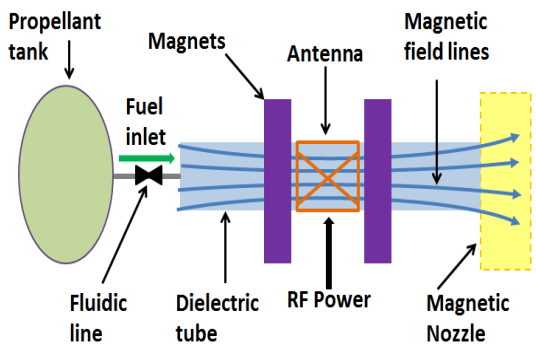
Magnetically Enhanced Plasma Thruster

Main Components

- RF antenna for heating and ionizing plasma
- Magnets for confining magneto-static field
- Dielectric tube inside which the neutral gas is ionized

Main Advantages

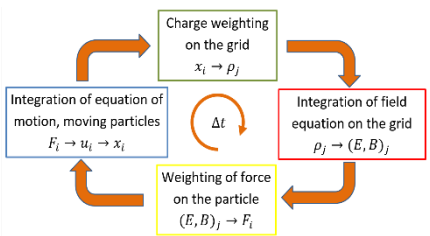
- No grids or neutralizers
- Low cost, simple geometry



Numerical Model

Main Features

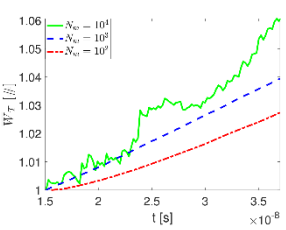
- Electrostatic-magnetostatic PIC
- Axial symmetrical geometry
- Axial symmetrical magneto-static field
- Magnetic cusps can be handled
- 1D PIC model along the axial direction
- Analytical relations along the radial direction

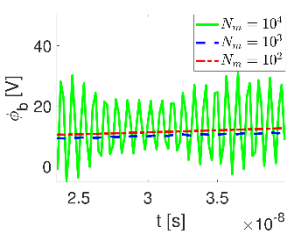


Numerical Validation

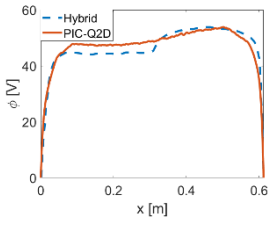
- Validation against theoretical results: Bohm sheath criterion
- Validation against the results of a 1D hybrid code

Theoretical: monitored the potential and the total energy by varying the mesh size, the time step and the super particle's dimension.





Well established code: results benchmarked against an hybrid code in a configuration with non-uniform magneto-static field

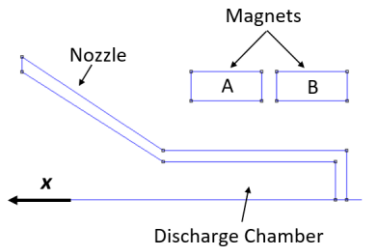


Comparison against experimental Measurements

Geometry

The shape is axisymmetric and consisting of three parts:

- the discharge chamber where the particles are created;
- the nozzle where the particles are accelerated;
- the magnets that provide the magneto-static field.



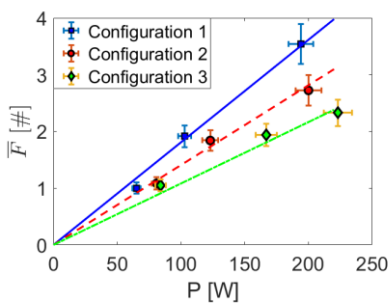
Configuration	Δd [mm]
1	0
2	12,5
3	25

Three different configurations have been studied moving the magnet A along the positive x direction by an amount Δx with respect to the configuration 1.

Experimental Results

Experimental characterization of non-optimized MEPT:

- The system is operated with Xenon gas,
- the propellant mass flow rate is 0.3 mg/s
- the working frequency is 2 MHz



Comparison between Numerical and Experimental results

We have compared the three magnetic configurations with respect to the normalized thrust.

- The normalized experimental thrust $\bar{F}_{exp}$ was computed from the angular coefficient of the respective experimental interpolation line
- $\bar{F}_{num}$ represents the normalized numerical thrust.

Configuration	Δd [mm]	$\bar{F}_{num}$ [#]	$\bar{F}_{exp}$ [#]
1	0	1	1
2	12,5	0.80	0.77
3	25	0.73	0.61

Conclusions & Future Works

Conclusions: magnetic cusp regions and two dimensional effects simulated successfully; the code can be employed for the preliminary design of MEPT.

Future works: we manage to introduce the ion-neutral collision mechanism and the power source for the heating region, in order to extend the relevant physics captured by the simulation.