An Inner Channel Simulation of the X2 Nested Channel Hall Effect Thruster

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Introduction

Hall Effect Thrusters (HETs) are electromagnetic in-space propulsion devices with low thrust but high specific impulse. They have a rich history of over 60 years [1].

- Current use: stationkeeping and attitude control
- Future use: main propulsion

Nested channel HETs were first developed at the University of Michigan in the Plasmadynamics and Electric Propulsion Laboratory (PEPL) to enable device scaling to higher power:

- 2 channel, 10kW class X2 by Liang [1]
- 3 channel, 100kW class X3 by Florenz [2]

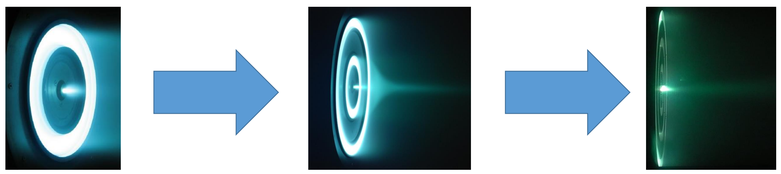


Figure 1: The evolution of Hall thrusters. From left to right: the H6 (6kW), X2 and X3 HETs.

Motivation

Performance gains were observed in multiple channel operation [1].

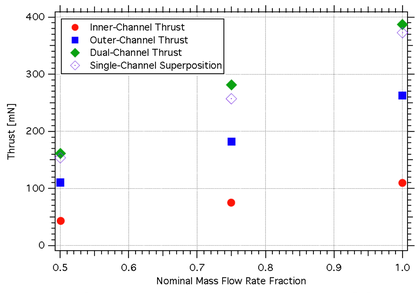


Figure 2: X2 thrust measurements [1]

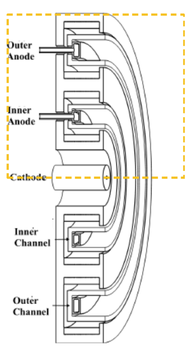
Simulation incentives:

- Investigation of channel interaction
- Full characterization of the thruster channels
- Difficulties in measuring quantities inside channel
- Future input for a plume simulation
- Design feedback

Objectives

1. Validate the inner channel simulation
2. Investigate the effects of facility backpressure

Simulation Setup



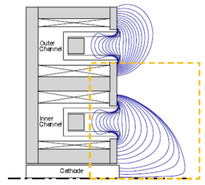
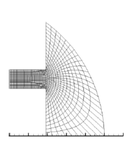


Figure 3: 2D axisymmetric computational domain.



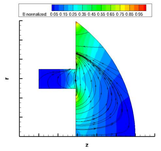


Figure 4: Magnetic field lines.

The 2D axisymmetric hybrid-PIC code HPHall [3] is used in the current study. Parameters:

- Xe propellant: 7 mg/s
- number of neutrals: 133,000
- number of ions: 600,000
- simulation time: 4 ms
- discharge voltage: 200 V
- computation time: 20 hrs

Results

Table 1:Thrust comparison

Thrust Values (mN)		
Measured	Simulation in vacuum	Simulation at 1.5 $* 10^{-5}$ $Torr$
92.0 ± 3.00	92.5 ± 0.365	92.4 ± 0.289

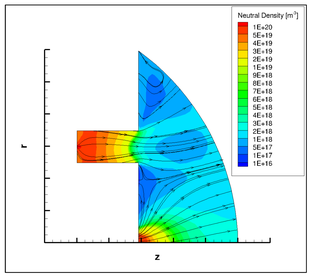


Figure 5: Xe number density.

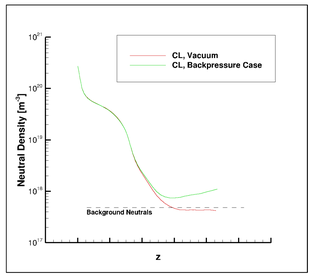


Figure 6: Centerline densities.

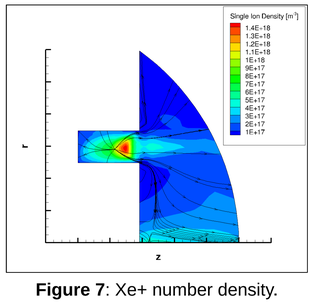


Figure 7: Xe+ number density.

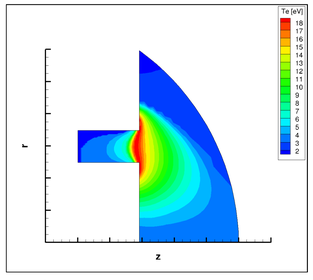


Figure 8: Electron temperature.

Conclusions and Future Work

- Facility backpressure does not influence the inner channel
- Thrust values are in good agreement with measurement
- Electron temperature values confirm ionization assumption (no triples)

- Future work:
  - X2 outer channel simulation
  - Code updates: mesh reading and electron model
  - X2 dual channel simulation
  - X3 single, dual and triple channel simulations

Acknowledgements

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References

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