Ion Acceleration Modes in a Miniature Helicon Thruster

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CubeSat – Affordable Platform, Limited Capabilities

- Modularized, based on 10 cm cubes
- Limited available propulsion options
- High performance propulsion is mission enabling
CubeSat Ambipolar Thruster (CAT)

- Electrodeless, permanent magnet, helicon
- Volume without propellant tank < 1U
- $\Delta V > 1000$ m/s
Experimental Setup

- 1200 L/s pumping speed on argon
Diagnostics

- RPA measured ion energy distribution
- Emissive probe measured plasma potential
Three Operational Modes – Two with Energetic Ions

**Diffuse mode**
- High plume divergence
- Diffuse, bright plume

**High flow rate, low power mode**
- Some neutral throughput
- Collimated beam

**Low flow rate, high power mode**
- Ultra-bright ionization region
- Saber-like beam

- > 10 sccm, > 20 W
- 3 - 15 sccm, < 15 W
- < 0.3 sccm, > 50 W
Operational Mode – High Flow Rate, Low Power Mode

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< 0.3 sccm, > 50 W
High Flow Rate, Low Power Mode – Vary Input Power, $P \approx 1 \times 10^{-4}$ Torr, Ar
High Flow Rate, Low Power Mode – Vary RPA Position, $P \approx 1 \times 10^{-4}$ Torr, Ar
Operational Mode – Low Flow Rate, High Power Mode

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Low Flow Rate, High Power Mode – Vary Input Power, $P \approx 1 \times 10^{-6}$ Torr, Xe

Ion Beam

Energy Distribution, $-\frac{dI}{dV}$ (arb.)

Voltage (V)

$P < 78.9$ W
$P < 86.0$ W
Low Flow Rate, High Power Mode – Vary RPA Position, $P \approx 1 \times 10^{-6}$ Torr, Xe
Conclusions

• Multiple significantly different modes observed
  – Different operational parameters
  – Different plume structures
  – Different ion energies

• Two of three modes show promising characteristics
  – Possible high specific impulse modes
Future Work

• 2D plume mapping
  – Plasma potential
  – Density
  – Electron temperature

• Determination of plume composition

• Direct thrust and specific impulse measurement

• Measurement of efficiency
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Thank you for your time!

Questions?

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