Indirect Azimuthal Current Measurement in an RMF Thruster

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Motivation

- Rotating Magnetic Field (RMF) thrusters could fill the role of high-power (>100 kW), propellant-agnostic thruster
- However, direct thrust data shows significantly lower performance (≈1%) than anticipated
- Understanding the processes behind plasma acceleration requires knowledge of time- and spatially-resolved current density in the thruster
- **To address the question of what acceleration mechanisms are dominant in the RMF thruster, there is a need for a time- and spatially-resolved current density measurement scheme**

Bayesian Approach

$$Posterior(I|B_{CL}) = \frac{Prior(I)Likelihood(B_{CL}|I)}{Evidence(B_{CL})}$$

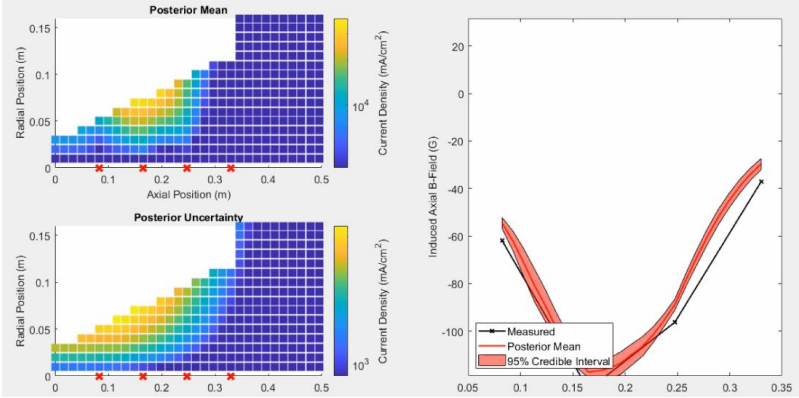
- A prior distribution for the spatially-resolved current I can be updated by comparing modelled centerline induced B-field to measurements B_{CL}
- Linear Gaussian Likelihood and Prior allow for analytic form of Posterior – much faster than using Monte Carlo methods

$$\mu_{post} = m_0 + \Sigma_0 A^T (A\Sigma_0 A^T + \Gamma)^{-1}(y - Am_0)$$

Prior mean

Update Term depends on:
- Prior variance Σ_0
- Current-to-Bfield Matrix A
- Data noise Γ
- Data y

Results



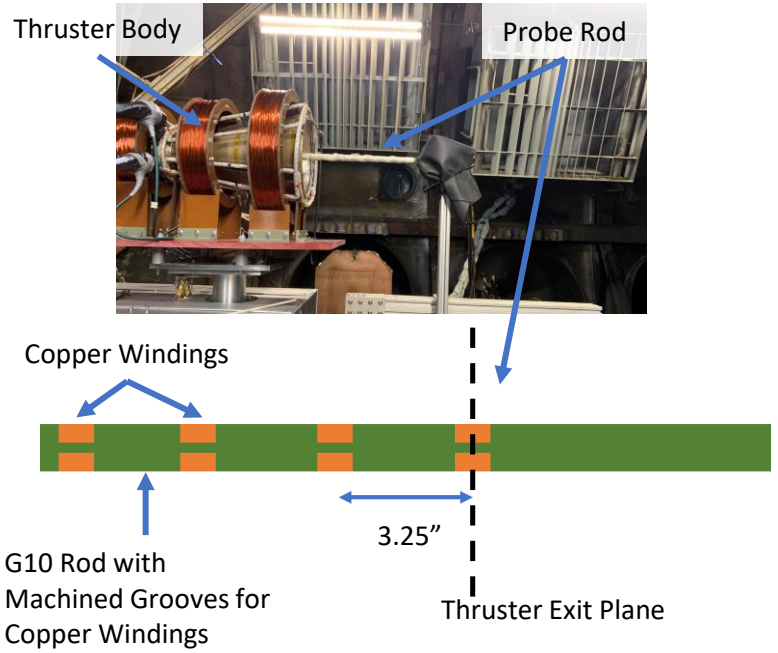
Thruster Setpoint: 45 sccm Xe steady flow rate, 2.5 kA pk-to-pk RMF antenna current. Frame captured at 125 μs into 200 μs pulse

Left: Mean and Uncertainty for Posterior current density.
Right: Measured centerline B-field, plotted with field associated with Posterior current densities

Conclusions

- We can successfully reproduce centerline magnetic field using Bayesian regression
- Plasmoid formation and translation is observed, along with magnetic field-reversal (FRC is formed)
- Self-induced magnetic field dominates applied bias field, necessitating a stronger bias field
- Very little current appears close to centerline, meaning mass flow along center of cone is not accelerated. A coaxial design could improve this

Experimental Setup



Four inductive probes are situated at different positions along thuster centerline to measure induced axial B-field

References

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