Investigation of channel interactions in a nested Hall thruster

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Introduction: Electric Propulsion

1. Electric propulsion devices use electric and magnetic fields to generate and propel plasma as a high velocity exhaust.
2. Hall thrusters are a type of electric propulsion being considered for deep space NASA missions because of their **high efficiency**.
3. Nested Hall thrusters are an innovative way to extend the technology to higher power.
4. This series of experiments studies the interaction of the channels in a two-channel nested Hall thruster, the X2.

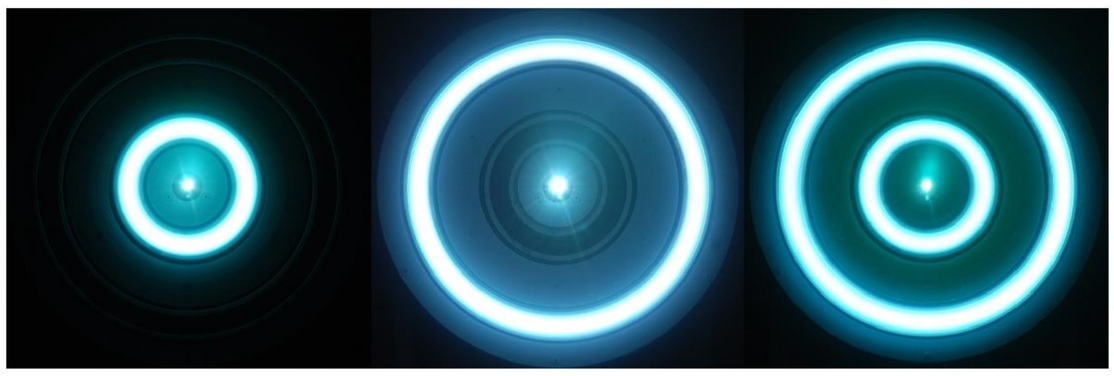


Figure 1: Left: Inner channel, Middle: Outer Channel. Right: Dual Channel

Initial Observations

Initial thrust measurements showed that the thrust in dual channel mode exceeds the sum of the thrust produced by each channel individually, even when the **background pressure was held constant**.

Objectives: Identifying Interactions

1. **Cross flow of propellant** between channels may also result in increased thrust.
2. **Reduced divergence angle** of the exhaust plume could be resulting in increased thrust.

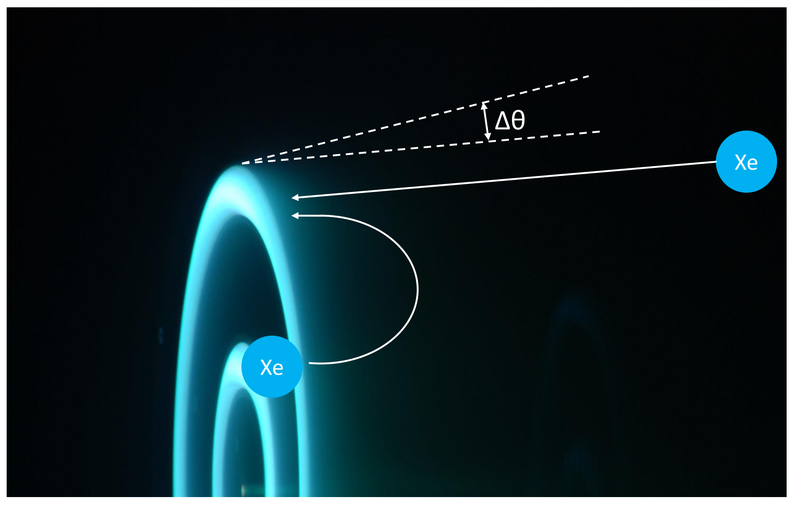


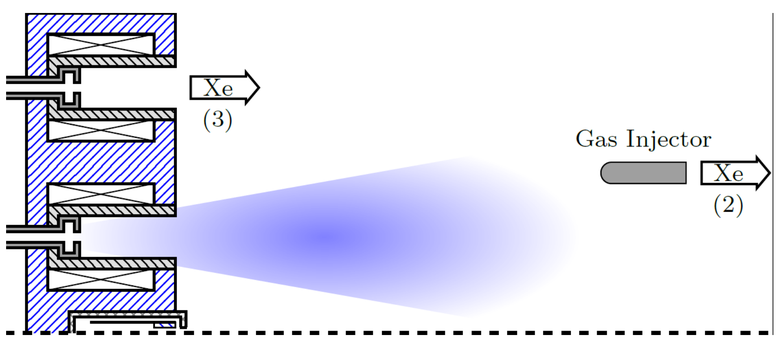
Figure 2: Propellant cross flow and change in divergence angle.

Influence of Local Pressure

1. Improved performance in dual channel mode was observed when the background pressure was held constant.
2. In dual channel mode, the pressure near the thruster is higher than in single channel mode.
3. Cross flow and a reduced divergence angle can both be influenced by local pressure effects.

Controlling Local Pressure

2. Downstream gas injection to control background pressure.
3. Channel injection to control local pressure

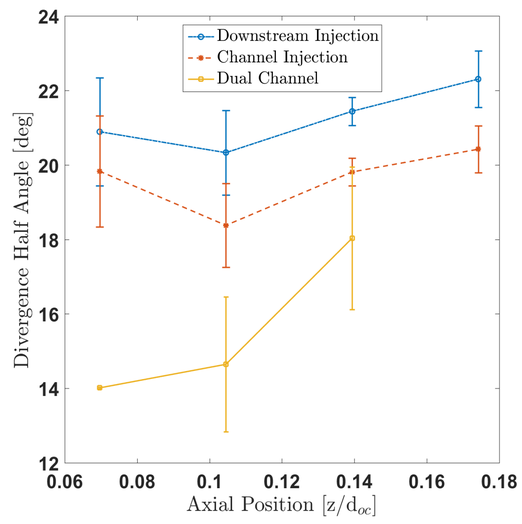


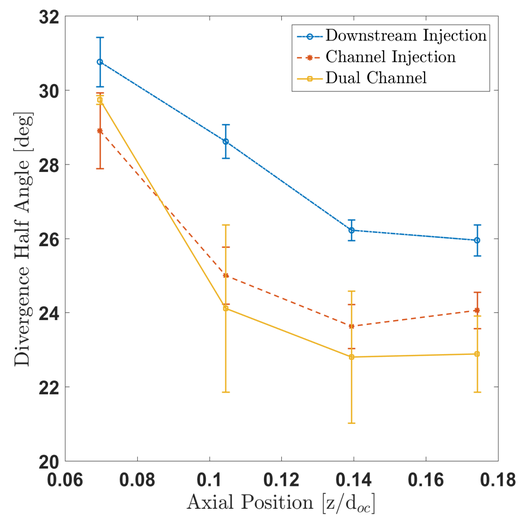
Cross-flow Measurements

Larger beam current for dual and channel injection conditions indicates that **cross flow between channels is a significant effect in dual channel mode.**

Condition	Beam Current [A]
Dual Channel	28.34±0.35
Downstream Injection	27.78±0.10
Channel Injection	28.51±0.05

Divergence Angle Measurements

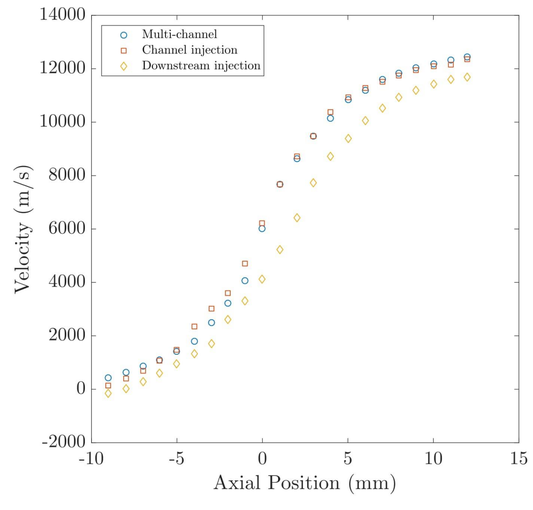




1. Measurements of the ion beam show that the **divergence angle decreases** in the channel injection and dual channel conditions.
2. This means that at higher local pressure the beam becomes more collimated and should result in more thrust.

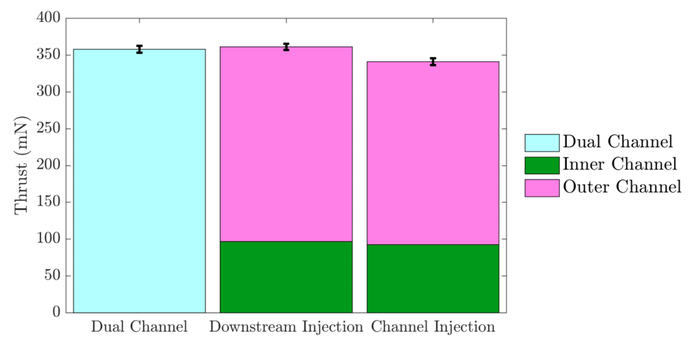
Ion Velocity Measurements

1. Measurements of the ion velocity show that the ion beam exits at the approximately the same velocity, **confirming that the change in the beam current is a result of cross flow**.
2. The change in the divergence angle is a result of the accelerating electric field moving into further into the thruster.



Performance and Conclusions

1. Measurements of the X2's thrust show that the dual and channel injection are in agreement.
2. This suggests that cross-flow and beam divergence are improving thrust.



Acknowledgements

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References

1. Liang, R., "The Combination of Two Concentric Discharge Channels into a Nested Hall-Effect Thruster," Ph.D. Dissertation, University of Michigan, 2013.

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