NASA SBIR/STTR Technologies

X2.03-8323. – Multiscale Modeling of Hall Thrusters

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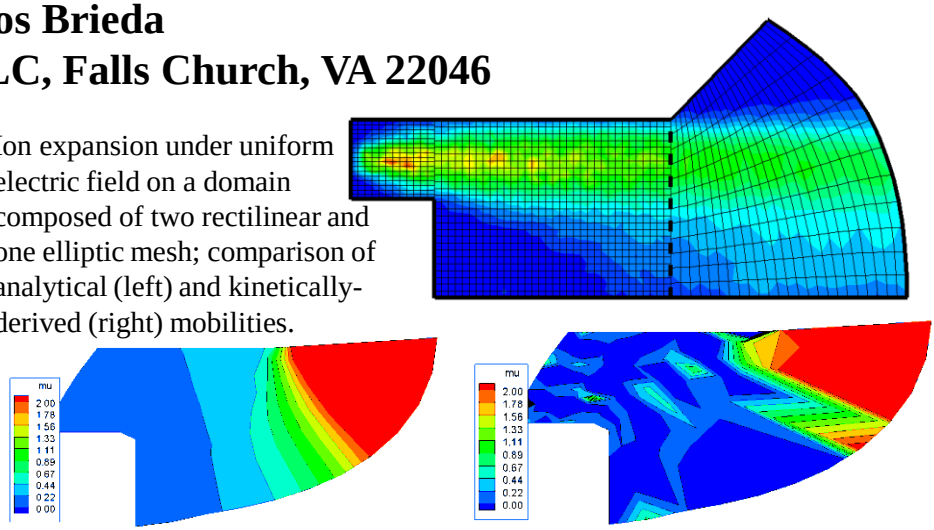
Identification and Significance of Innovation

Despite over 40 years of flight heritage, no software tool exists for predictive modeling of Hall thrusters. Contributing to this shortcoming is the presence of multiple spatial and temporal scales on which physics of interest happens. SOA codes are optimized to treat just a single physical realm. As an example, existing codes utilize analytical expressions for electron cross-field transport. Furthermore, they assume quasi-neutrality and do not resolve wall flux self-consistently. We propose a novel approach to study Hall thrusters based on a multiscale formulation in which we compute different spatial scales self-consistently.

Expected TRL Range at the end of Contract (1-9): 5



Ion expansion under uniform electric field on a domain composed of two rectilinear and one elliptic mesh; comparison of analytical (left) and kinetically-derived (right) mobilities.

Technical Objectives

The primary technical objective of this Phase I effort was to determine the feasibility of modeling Hall thrusters using a multiscale approach. This effort encompassed the self-consistent calculation of mobility and the use of a non-neutral 2D code to obtain wall ion fluxes and erosion rates.

Work Plan

1) Development of 2D plasma solver Starfish.
   A general 2D plasma code Starfish was designed and developed
2) Coupling of Starfish with 1D kinetic code Lynx
   Starfish was successfully coupled with Lynx
3) Analysis of near-wall interactions with 2D sheath code
   Study of magnetic lens influence on wall erosion was conducted
4) Incorporation of material interaction models
   Models for secondary electron yields and wall potentials were derived
5) Model validation by comparison with experimental data
   Preliminary validation was conducted

NASA and Non-NASA Applications

This effort directly benefits the NASA high power Hall thruster program by providing it with a computational tool capable of analysis beyond what is possible using existing SOA tools. The need to analyze Hall thrusters is however not limited to NASA. The Air Force and industry also have need for such codes. In addition, the general nature of Starfish makes it applicable to other plasma/rarefied gas technologies, such as medical plasmas, contamination modeling, and plasma processing.

Contacts

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