Development of a Multiscale Ionized Gas (MIG) Flow Code for Plasma Applications

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Accurate modeling of the physics is central to the effective design of ionized flow in several aerospace applications including space propulsion thrusters and high-speed air vehicles. These are of considerable interest to the NASA Earth Science, Space Science, and Human Exploration and Development of Space Strategic Enterprises for developing high-power in-space electric propulsion systems; to the Air Force of Office of Scientific Research, Department of Defense, and DARPA for flow control and stability about an air vehicle; to the Department of Energy, National Science Foundation and industry for understanding fluid-thermal systems at micro and nanoscales. Present status of the space propulsion and hypersonic flow research reflects a need for consistent numerical models to understand the wall loss mechanism for bounded plasma in the presence and absence of a magnetic field. The anomalies are primarily due to an inconsistency in capturing the physics using incorrect resistivity and wall loss models [1]. The task is quite taxing as it involves several temporal and spatial scales and requires integration of several disciplines including fluid dynamics, electromagnetics, chemical kinetics and molecular physics amongst others.

A finite element based module driven multiscale ionized gas (MIG) flow code has been developed to address this challenge [2,3]. The working code has been implemented to a few test problems, specifically to modeling RF induced dielectric barrier discharges, and to designing electromagnetic propulsion thrusters. Both macro and micro flow passages [4] are considered for modeling a range of hydrodynamic problems that operate under the influence of electric and magnetic field. Computed solutions show details of the distribution of charged and neutral particles and their effects on flow dynamics for above applications.

References

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