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Investigation of the plasma flow in arcjet using continuum and dicrete approaches

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Arc-heated thrusters (or arcjets) offer a significant advantage in specific impulse and cost over conventional satellite propulsion system. However, as a complex physicochemical process coupling fluid mechanics, heat transfer, chemical kinetics, plasma physics, and electromagnetic theory, researches on arcjet flow require more multidisciplinary knowledge. Furthermore, the increasing rarefield gas effect in the downstream region of nozzle make the problem more complicated. Despite of these difficulties, a relatively accurate numerical model has been established to facilitate the development of this technique. In the present study, a loose coupled approach combining fluid model and direct simulation Monte Carlo (DSMC) method has been developed for Argon (Ar) arcjet thruster. Specifically, a two-temperature chemical non-equilibrium fluid model has been employed in constrictor and parts of expansion region where gas flow is continuous. Difference between gas and electron temperature has been considered. Electrons, ions, ground-state atoms are represented as separate chemical species in the plasma mixture. To capture the plasma flow characteristics close to thruster exit more precisely and investigate the influence of plume on spacecraft, DSMC method has been applied. Near the exit of thruster, the computation region of computational fluid dynamics (CFD) model and DSMC model is overlapped. These two approaches are coupled by sharing numerical information between each other. Specific impulses, thrust efficiencies, thrust-force, arc voltage, gas velocity and temperature distributions are key problems of arcjet thrusters. In order to make a quantitative analysis on the influence of all these factors, our modeling studies will be performed by arranging different electric currents, mass flow rates for the same thruster.