Rocket Propulsion Through Multiple-Charged Ions From a Mirror Plasma*

L. Leung[1] and C.C. Petty[2]
[1]*University of California–Berkeley, Berkeley, California USA*
[2]*General Atomics, P.O. Box 85608, San Diego, California USA*

Plasma propulsion is of interest for space exploration because the high exit velocity of the propellant generates a high final spacecraft velocity with reduced propellant mass. This project evaluates a new type of ambipolar thruster which uses multiply charged ions as propellant. Electron cyclotron heating (ECH) of a mirror plasma produces deeply trapped hot electrons which strip heavy ions of electrons. The positive ambipolar potential of the mirror plasma accelerates the highly charged ions to high velocity as they exit the end of the magnetic mirror open to space, generating thrust. This project self-consistently models the ion charge state distribution and confining electrostatic potentials using the particle, charge, and energy conservation equations. All relevant atomic processes are included with cross-sections taken from the ADAS database. The model is benchmarked against data from low-density ECH mirror plasmas. Extending this ambipolar thruster model to the high-density rocket regime finds: (1) the specific impulse is relatively high (~5000 s) and easily varied by changing the neutral pressure, gas type, and "cold" electron temperature, (2) the thrust efficiency is relatively low, ~25% for double-ended operation and ~45% for single-ended operation. Even with the modest thrust efficiency, this ambipolar thruster is capable of producing high thrust in a compact source because ECH mirror plasmas can operate at high density.

*Work supported by a US DOE National Undergraduate Fusion Fellowship and DE-FC02-04ER54698.