EVIDENCE FOR ION ACCELERATION BY OSCILLATIONS IN THE DISCHARGE PLASMA OF ION ENGINES

J. N. Przybylowski
California Institute of Technology
Pasadena, CA 91125, USA

J. E. Polk
Jet Propulsion Laboratory, Pasadena, CA 91109, USA

J. E. Shepherd
California Institute of Technology, Pasadena, CA 91125, USA

The hollow cathode discharge plasma in ion engines is highly non-uniform, geometrically complex, and confined by a magnetic field; elucidating the mechanisms responsible for producing ions with anomalously high energies observed in the downstream regions of hollow cathodes will contribute to understanding the behavior of complex plasmas. Ions with energies in excess of ten times greater than the energy associated with electrostatic acceleration from the largest steady-state potential difference in the plasma discharge of ion engines have been detected.

Several ion acceleration mechanisms have been proposed. By process of elimination, experimental evidence appears to support wave-based acceleration; however, the details of the wave and of the acceleration process are unknown. Ion energy distributions collected with an electrostatic energy analyzer reveal multiple ion populations when the analyzer is aligned along the cathode axis, including a high-energy tail. The high-energy population and tail are present in the distributions when the detector is rotated off of the cathode axis up to 90^{o}, thereby eliminating the primarily axial acceleration mechanisms.

A newly designed instrument that consists of a velocity filter and an energy-per-charge filter in series allows determination of the charge-state of the high-energy ions, thus revealing the importance of multiple charge-exchange collisions. In addition, this instrument is used to examine whether ions of different masses are preferentially accelerated.

Recent experiments demonstrate a relationship between ion energies and fluctuations in the discharge plasma. Preliminary investigations that recorded fluctuations in the applied voltage difference between the cathode and anode reveal that when the average energy of ions which have an energy-to-charge ratio greater than the steady-state discharge voltage is high, the power of oscillations with frequencies up to 2MHz increases. In addition, the average energy of ions is a shifted-exponential function of the peak-to-peak fluctuations in the discharge voltage. High sample-rate measurements of ion energies correlated with measurements of plasma potential recorded with a Langmuir probe provide further insight into the relationship between ion energies and oscillations in the plasma.

978-1-4244-2636-2/09/$25.00 ©2009 IEEE