SPACE PROPULSION SYMPOSIUM (C4)
Electric Propulsion (4)

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HIGH THRUST-OVER-POWER ELECTRIC PROPULSION

Abstract

A major figure of merit in propulsion in general and in electric propulsion in particular is the thrust per unit of deposited power, the ratio of thrust over power. We have recently demonstrated experimentally and theoretically [1-5] that for a fixed deposited power in the ions, the momentum delivered by the electric force is larger if the accelerated ions collide with neutrals during the acceleration. The higher thrust for given power is achieved for a collisional plasma at the expense of a lower thrust per unit mass flow rate, reflecting what is true in general, that the lower the flow velocity (and the specific impulse) is, the higher the thrust for a given power. This is the usual trade-off between having a large specific impulse and a large thrust. Broadening the range of jet velocities and thrust levels is desirable since there are different propulsion requirements for different space missions. Operation in the collisional regime can be advantageous for certain space missions. In particular, a high thrust over power should be considered for air-breathing electric propulsion at altitudes of less than 200 km.

The mechanism of thrust enhancement by ion-neutral collisions has been investigated in the past in the case of electric pressure, what is called ionic wind [6]. However, electric pressure is limited by space-charge. In our experiments, the enhanced thrust due to ion-neutral collisions is a result of magnetic pressure in quasi-neutral plasma [1, 2, 4]. The plasma is accelerated by J*B force, in a configuration similar to that of Hall thrusters. Scaling laws for acceleration under magnetic field pressure will be presented. Our measurements for three different gases and for various gas flow rates and magnetic field intensities, confirmed that the thrust increase is proportional to the square-root of the number of ion-neutral collisions [4]. Additional measurements of local discharge parameters will be shown to be consistent with the force measurements.

1. G. Makrinich and A. Fruchtman, Phys. Plasmas 16, 043507 (2009). 2. G. Makrinich and A. Fruchtman, Appl. Phys. Lett. 95, 181504 (2009). 3. A. Fruchtman, IEEE Trans. Plasma Sci. 39, 530 (2011). 4. G. Makrinich and A. Fruchtman, Phys. Plasmas 20, 043509 (2013). 5. A. Fruchtman, Plasma Chem. Plasma Process. 34, 647 (2014). 6. R. S. Sigmond, J. Appl. Phys. 53, 891 (1982).