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Enhanced momentum delivery by electric force to an ion flux due to collisions of ions with neutrals[1]

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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 [1-4] 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 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. 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 [5]. I will describe in the talk experimental results for an enhanced thrust due to ion-neutral collisions in a configuration where the thrust is a result of magnetic pressure [1, 3]. The plasma is accelerated by $\overrightarrow{J} \times \overrightarrow{B}$ force, in a configuration similar to that of Hall thrusters. 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 [3]. Additional measurements of local discharge parameters will be shown to be consistent with the force measurements. Issues that are crucial for the use of this mechanism in an electric thruster will also be discussed. These are the possible increase of the electron transport across magnetic field lines by electron-neutral collisions, and the possible effect on various sources of inefficiency.

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