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Experimental Study of an Advanced Plasma Thruster using ICRF Heating and Magnetic Nozzle Acceleration.[1]

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Electric propulsion (EP) systems utilize plasma technologies and have been developed for years as one of the most promising space propulsion approaches. It is urgently required to develop high-power plasma thrusters for human expeditions to Mars and future space exploration missions. The advanced thruster is demanded to control thrust and specific impulse by adjusting the exhaust plasma density and velocity. In the VASIMR project, a combined system of efficient ion cyclotron heating and optimized magnetic nozzle design is proposed to control the ratio of specific impulse to thrust at constant power[1]. In this system a flowing plasma is heated by ICRF (ion cyclotron range of frequency) waves and the plasma thermal energy is converted to flow energy in a diverging magnetic field nozzle. We have recently performed the first demonstration of ion cyclotron resonance heating and acceleration in a magnetic nozzle by using a fast-flowing plasma with Mach number of nearly unity. Highly ionized plasma is produced by Magneto-Plasma-Dynamic thruster (MPDT). When RF power is launched by a helically-wound antenna, electromagnetic ion cyclotron waves are excited, and plasma thermal energy and ion temperature drastically increase (nearly ten-fold rise) during the RF pulse. The value of resonance magnetic field is affected by the Doppler shift due to the fast-flowing plasma. Dependences of heating efficiency on both plasma density and input RF power will be presented. Ion acceleration along the field line is also observed in a diverging magnetic field nozzle. Perpendicular component (to the magnetic field) of ion energy decreases, whereas parallel component increases along the diverging magnetic field.

[1] F.R. Chang Diaz, "The VASIMR Engine," AIAA 2004-0149. AIAA conf. (Reno,2004); Bulletin of APS (46th APS-DPP), NM2A-3, 2004.

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