Simulation of ion cyclotron heating in the auroral current region in the VASIMR

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Plasma physics has found an increasing range of practical industrial applications, including the development of electric spacecraft propulsion systems. One of these systems, the Variable Specific Impulse Magnetoplasma Rocket (VASIMR) engine, both applies and can be used to simulate several important physical processes occurring in the magnetosphere. These processes include the mechanisms involved in the ion acceleration and heating that occur in the Birkeland currents of an auroral arc system. Auroral current region processes that are simulated in VASIMR include lower hybrid heating, parallel electric field acceleration and ion cyclotron acceleration. This paper will focus on using a physics demonstration model VASIMR to study ion cyclotron heating (ICRH) similar to auroral zone processes. The production of upward moving 'ion conics' and ion heating are significant features in auroral processes. It is believed that ion cyclotron heating plays a role in these processes, but laboratory simulation of these auroral effects is difficult owing to the fact that the ions involved only pass through the acceleration region once. In the Variable Specific Impulse Magnetoplasma Rocket (VASIMR) we have successfully simulated these effects. The current configuration of the VASIMR uses a helicon antenna with up to 20 kW of power to generate plasma then uses an RF booster stage that uses left hand polarized slow mode waves launched from the high field side of the resonance. The current setup for the booster uses 2 to 4 MHz waves with up to 20 kW of power. This is similar to the ion cyclotron heating in tokamaks, but in the VASIMR the ions only pass through the resonance region once. The rapid absorption of ion cyclotron waves has been predicted in recent theoretical studies. These theoretical predictions have been confirmed with several independent measurements. The ion cyclotron resonance heating (ICRH) show an substantial increase in ion velocity. Pitch angle distribution studies show that this increase takes place in the resonance region where the ion cyclotron frequency is equal to the frequency on the injected RF waves. Downstream of the resonance region the perpendicular velocity boost should be converted to axial flow velocity through the conservation of the first adiabatic invariant as the magnetic field decreases in the exhaust region of the VASIMR.