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Session 6B Paper 3

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Resonance of electromagnetic ion cyclotron waves in diverging magnetic field

We investigate the propagation of electromagnetic ion cyclotron (EMIC) waves as they move towards cyclotron resonances in an inhomogeneous plasma with a spatially decreasing magnetic field. In fact, we consider the case of multiple ion species, which introduce resonances at locations where the local ion cyclotron frequency of each of the respective ion species equals the transmitted wave frequency. The results have relevance for the Earth's magnetosphere where heavier ions are more abundant at lower altitudes and lighter ions at higher altitudes, and where the EMIC waves can pitch angle scatter relativistic electrons trapped in the radiation belts.

The model results are guided by the laboratory experiments which study the propagation of a shear Alfvén wave in a diverging magnetic field (Vincena et al., 2001). The waves were excited by modulating a field-aligned electron current drawn to a disk antenna with a size comparable to the electron skin depth. The modulated pulse, consisting of about 10 wave periods, propagated as a kinetic Alfvén wave (with the phase speed comparable to the electron thermal speed) from a region where Landau damping due to electrons plays an important role to where ion cyclotron damping dominated.

We use the Hall-MHD code by Eliasson et al. (2012) and Sharma et al. (2016) to carry out simulations relevant to the laboratory case. We use parameters relevant for the LArge Plasma Device (LAPD) at UCLA, employing a Neon plasma with a homogeneous plasma density of 10^12 1/cm^3 and with a decreasing (dipole) magnetic field along the plasma slab. The model results are in agreement with the laboratory observations.

We also consider the ionospheric case in which circularly polarized EMIC wave is transmitted along the straight magnetic field lines in the magnetic polar region. We choose this case for numerical efficiency, but the results would apply qualitatively also for oblique propagation. We use the ionospheric parameters of Sharma et al. (2016). The model allows us to estimate the required parameters of the ground based radio facility which could be used for the remediation of the perturbed radiation belts.

References:

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