Abstract for an Invited Paper
for the DPP09 Meeting of
The American Physical Society

Experimental and numerical investigation of auroral cyclotron maser processes

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When an electron beam with initial spread in rotational velocity is subject to significant magnetic compression, conservation of magnetic moment results in the formation of a horseshoe shaped velocity distribution. It has been shown that such a distribution is unstable to cyclotron emission [1] and may be responsible for the generation of Auroral Kilometric Radiation (AKR) – an intense RF emission sourced at high altitudes in the terrestrial auroral magnetosphere. In a scaled laboratory reproduction of this process, a 75-85keV electron beam of 5-40A was magnetically compressed by a system of solenoids and electromagnetic emissions observed for cyclotron frequencies of 4.42GHz and 11.7GHz [2]. A comparison of these experimental measurements with the results of 2D and 3D numerical simulations will be presented, showing the effect of cyclotron-wave detuning on the efficiency of forward and backward wave coupling. The experiment presently differs from the astrophysical case in that it has a well defined radiation boundary. PiC code calculations have been undertaken to investigate the dynamics of the cyclotron emission process in the absence of such metallic boundaries and incorporating a background plasma of variable density. Computations reveal that the cyclotron emission process persists although its spatial growth is reduced. A quenching of the instability is also apparent as the ratio ω_{ce} / ω_p is reduced to be < 1. This is consistent with the predictions of theory [3] and satellite observations that suggest AKR emission is localized within a region of plasma depletion where $\omega_{ce} / \omega_p > 1$.

[1] D. Gurnett, "Waves in Space Plasmas", 50th Annual meeting of the APS Division of Plasma Physics, 2008.
[2] K. Ronald et al, Physics of Plasmas, 15, 056503, 2008.
[3] R. Bingham and R. A. Cairns, Physics of Plasmas, 7, 3089, 2000.