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Scaled experimental investigation of the moderation of auroral cyclotron emissions by background plasma

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Scaled laboratory experiments have been conducted at Strathclyde University [1,2] to further the understanding of the naturally occurring generation of Auroral Kilometric Radiation (AKR) in the Earth's polar magnetosphere. At an altitude of around 3200km there exists a region of partial plasma depletion (the auroral density cavity), through which electrons descend towards the Earth's atmosphere and are subject to magnetic compression. Due to conservation of the magnetic moment these electrons sacrifice parallel velocity for perpendicular velocity resulting in a horseshoe shaped distribution in velocity space which is unstable to the cyclotron maser instability [3,4]. The radiation is emitted at frequencies extending down to the local electron cyclotron frequency with a peak in emission at ∼300kHz. The wave propagation is in the X-mode with powers $\sim 10^9$W corresponding to radiation efficiencies of 1% of the precipitated electron kinetic energy [5]. The background plasma frequency within the auroral density cavity is approximately 9kHz corresponding to an electron plasma density $\sim 10^6 \mathrm{m}^{-3}$.

Previous laboratory experiments at Strathclyde have studied cyclotron radiation emission from electron beams which have horseshoe shaped velocity distributions. Radiation measurements showed emissions in X-like modes with powers ∼20kW and efficiencies ∼1-2%, coinciding with both theoretical and numerical predictions [6-9] and magnetospheric studies.

To enhance the experimental reproduction of the magnetospheric environment a Penning trap was designed and incorporated into the existing apparatus [10]. The trap was placed in the wave generation region where the magnetic field would be maintained at ∼0.21T. The trap allowed a background plasma to be generated and its characteristics were studied using a plasma probe. The plasma had a significant impact on the radiation generated, introducing increasingly sporadic behaviour with increasing density. The power and efficiency of the radiation generated was lower than with no plasma present. Plasma diagnostics established the plasma frequency on the order of 150-300MHz and electron density ranging from $\sim 10^{14}$-$10^{15}\mathrm{m}^{-3}$, whilst the cyclotron frequency of the electrons within the Penning trap was 5.87GHz giving f_{ce}/f_{pe} ∼19-40, comparable to the auroral density cavity. Numerical simulations coinciding with this part of the experimental research program are currently being carried out using the VORPAL code. Details of these simulations will be presented in a separate paper [Speirs et al] at this meeting.

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