SEMI-ANNUAL PROGRESS REPORT

INVESTIGATION OF PLASMA INSTABILITIES IN THE POLAR CUSP

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ELECTRON CYCLOTRON WAVE GENERATION BY RELATIVISTIC ELECTRONS

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Abstract. We show that an energetic electron distribution which has a temperature anisotropy ($T_{\perp b} > T_{\|b}$), or which is gyrating about a DC magnetic field, can generate electron cyclotron waves with frequencies below the electron cyclotron frequency. Relativistic effects are included in solving the dispersion equation and are shown to be quantitatively important. The basic idea of the mechanism is the coupling of the beam mode to slow waves. The unstable electron cyclotron waves are predominantly electromagnetic and right-hand polarized. For a low density plasma in which the electron plasma frequency is less than the electron cyclotron frequency, the excited waves can have frequencies above or below the electron plasma frequency, depending upon the parameters of the energetic electron distribution. This instability may account for observed Z mode waves in the polar magnetosphere of the Earth and other planets.

INTRODUCTION

The Earth's polar magnetosphere has long been recognized as an active region of wave activities. In the last two decades, numerous spacecraft have sampled this region of space and have identified a large variety of wave modes, most notably, the auroral hiss and the auroral kilometric radiation (AKR). For a review, see *Shawhan* [1979]. These waves are believed to play an important role in various plasma processes in the magnetosphere through wave-particle interactions. Examples of such processes include the diffusion of auroral electrons by electrostatic electron cyclotron waves [*Kennel and Ashour-Abdalla*, 1982], the generation of AKR through relativistic cyclotron resonance [*Gurnett*, 1974; *Wu and Lee*, 1979], the acceleration and heating of ions and electrons by waves in the auroral region leading to the formation of ion and electron conical distributions (see, for example, *Chang et al.* [1986]; *Crew et al.* [1990]; *Lysak* [1986]; *Temerin and Cravens* [1990]; *Wong et al.* [1988], among others).

I. PROGRESS TO DATE

During the last six months, we have concentrated our efforts in studying the excitation of electromagnetic waves in the whistler frequency range by an anisotropic electron beam. A paper entitled "Electron Cyclotron Wave Generation by Relativistic Electrons" was submitted to Journal of Geophysical Research and has been accepted for publication. This paper is in collaboration with Dr. M. L. Goldstein at Goddard Space Flight Center. In this paper, we have shown that an anisotropic electron beam (or gyrating electron beam) is capable of generating electron cyclotron waves with frequency from above to below the electron plasma frequency in a low density plasma. This instability may account for the observed Z mode and the electromagnetic component of auroral hiss in the Earth's polar region. The abstract of this paper is enclosed.

For a high density plasma in which the electron plasma frequency is considerably higher than the electron cyclotron frequency, we have found a new left-hand electromagnetic wave at whistler frequencies, which is also driven unstable by an anisotropic electron beam. The basic notion of this new instability is the significant change of the dispersion equation due to the contribution of the beam component, which can shift the usual right hand whistler waves into left hand waves.

II. CURRENT WORK

We are currently studying the characteristics of the left-hand polarized electromagnetic wave in detail. Our preliminary results indicated that this new instability depends crucially on the beam temperature anisotropy, beam density, and the ratio of the beam temperature to the temperature of the background plasma. A paper entitled "Left-Hand Polarized Magnetic Waves at Whistler Mode Frequencies" is going to submit to Geophysical Research Letters in September, 1993. This paper is in collaboration with Dr. C. W. Smith at Bartol Research Institute. The main results of this paper will be presented in the Fall AGU meeting. We are also in the process of writing a paper to compare the left-hand polarized wave with the usual right-hand polarized whistler wave, and plan to submit the paper for publication in Journal of Geophysical Research in the near future.