USING GEOTAIL, WIND, AND POLAR OBSERVATIONS OF PLASMA WAVE AND RADIO EMISSIONS TO FURTHER OUR UNDERSTANDING OF DYNAMIC HELIOSPHERIC AND MAGNETOSPHERIC PHENOMENA

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ABSTRACT

Wave data from GEOTAIL, WIND, and POLAR are used to investigate plasma dynamics and instabilities. Type III radio bursts are detected shortly after the onset of solar flares and their generation at the fundamental and harmonics of the electron plasma frequency (Fpe) yield details of density and structure in the solar wind from within a few solar radii to many AU beyond the Earth's orbit. Type II radio bursts are generated ahead of ejecta from coronal mass ejections and at interplanetary shocks and allow the remote tracking of both phenomena. Fpe emissions in the upstream solar wind allow detection of abrupt density changes. Escaping terrestrial continuum radiation provides remote observations of magnetospheric structures.

INTRODUCTION

The GEOTAIL Plasma Wave Instrument (PWI), launched in July 1992, continues to provide fascinating electric field data from 5 Hz to 800 kHz and magnetic field data from 5 Hz to 12.5 kHz. The WIND Radio Science Experiment (WAVES), launched in November 1994, continues to provide spectacular electric field data from 4 kHz to 14 MHz. The POLAR PWI operated from launch in February 1996 to mid-September 1997 and provided excellent electric and magnetic field data from 5 Hz to 800 kHz. Data from these three spacecraft are extremely important for investigating and understanding heliospheric and magnetospheric plasma dynamics, instabilities, and wave-particle interactions.

OBSERVATIONS

Type III solar radio bursts are detected shortly after the onset of solar flares. Observations of their generation at the fundamental and harmonics of the electron plasma frequency (Fpe) yield details of density and structure in the solar wind from within a few solar radii to many AU beyond the Earth's orbit. Type II solar radio bursts are generated ahead of ejecta from coronal mass ejections (CMEs) and at interplanetary shocks and allow the remote tracking of both phenomena. When the simultaneous observations of these radio bursts from two or more spacecraft are not similar, one can often deduce the presence of high density regions blocking portions of the emissions. Fpe emissions in the upstream solar wind allow detection of abrupt density changes including those from solar flare and CME driven interplanetary shocks. Comparisons of the remote 2Fpe emissions generated in the electron foreshock with the in situ emissions as well as the comparison of the in situ Fpe emissions between the two widely separated spacecraft identify temporal and spatial changes in the solar wind density structure.

Numerous terrestrial plasma wave phenomena often begin or increase in intensity following the solar radio bursts or abrupt solar wind density, pressure, or magnetic field changes at time intervals from instantaneous to many hours. These include auroral kilometric radiation (AKR), continuum storms, escaping terrestrial continuum radiation, kilometric continuum, electron plasma oscillations (Langmuir waves), whistler-mode emissions (such as chorus and hiss), and electron cyclotron harmonic (ECH) waves.

Enhanced escaping terrestrial continuum radiation is believed to be due to injected electrons from the plasmasheet drifting around the earth eastward and impinging on portions of the plasmasphere and magnetosphere where steep density gradients occur. Electrostatic emissions at the local electron plasma frequency are mode converted to electromagnetic radiation that propagates out unless or until it encounters a region more dense than where it was generated. Kilometric continuum radiation in the 100 kHz to 800 kHz frequency range (first found in the GEOTAIL PWI data [1]) is believed to be due to a similar source mechanism but from much deeper within the plasmasphere. The GEOTAIL and POLAR Plasma PWIs and the WIND WAVES primarily when near the Earth have frequently detected these emissions that contain much narrowband filamentary and fine structure. Occasionally narrowband filaments lasting many hours have been observed. By comparing the appearance of these emissions from two or more spacecraft we are able to deduce remotely the structure of the plasmasphere and magnetosphere. Some of the structure observed in both these emissions can be explained by the bulges, ducts, and irregularities found in the plasmasphere. Comparisons of wave data from GEOTAIL and wave and imaging data from IMAGE indicated that some kilometric continuum events have their source in density bite-outs deep within the plasmasphere. Some of these bite-outs appear to last for several days as has previously been deduced from ISEE and CRRES number density measurements. We are comparing our deduced structures with those previously detected on CRRES and those now detected by IMAGE.

Density measurements determined from the lower cutoff of the continuum radiation in the tail and from Langmuir waves detected in the plasma sheet help identify in situ the dynamics of the tail region simultaneously with the remote observation of AKR from the auroral region during substorms. Increased AKR intensity and bandwidth are known to be related to increased geomagnetic activity and indicate enhanced energetic electron precipitation and expanding source regions. Comparison of AKR and kilometric continuum observations from multiple spacecraft appropriately located (for example, from POLAR in the auroral region, GEOTAIL in the tail or solar wind, and WIND in the solar wind) can help distinguish whether spectral and bandwidth differences are due to the sources or are due to propagation effects. Similarly, enhanced AKR and kilometric continuum can be distinguished from Type II solar bursts when WIND is sufficiently far from GEOTAIL.

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