AN OVERVIEW OF RADIO PLASMA IMAGER ACCOMPLISHMENTS

James L. Green[(1)] and Bodo W. Reinisch[(2)]

[(1)]NASA/Goddard Space Flight Center, Space Science Data Operations Office,
Greenbelt, MD 20771, USA;
E-mail green@mail630.gsfc.nasa.gov

[(2)]Center for Atmospheric Research, University of Massachusetts Lowell,
Lowell, MA 01854, USA;
E-mail bodo_reinisch@uml.edu

ABSTRACT

The Radio Plasma Imager (RPI) on the Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) spacecraft was designed as a long-range magnetospheric radio sounder, relaxation sounder, and a passive plasma wave instrument. The RPI is a highly flexible instrument that can be programmed to perform these types of measurements at times when IMAGE is located in key regions of the magnetosphere. An overview of many of the accomplishments of the RPI will be presented.

RADIO SOUNDING

The RPI continues to provide a wealth of observations about the electron density structures and boundary locations of many features in the Earth's magnetosphere [1]. RPI sounding observations of echoes can be observed from the plasmasphere at distances of 3 R_E or greater from the target [2]. These are the first radio soundings at such large radial distances within the magnetosphere. During soundings of the plasmasphere, direct RPI echoes exhibit various amounts of spreading, from ~0.5 R_E to ~2 R_E in virtual range (range assuming speed of light propagation). These observations suggest that the plasmasphere is regularly permeated by field-aligned irregularities with scale sizes ranging from ~100 m to over 10 km and plasma density within of ~10% of background [2].

One of the surprising results from the RPI is that a large number of field guided echoes are observed in the plasmapause region [3,4], plasmaspheric bite-outs [5], in the plasma trough [3], and over the polar cap [6]. A profile inversion technique for RPI echo traces has been developed that provides a method for determining the electron density (N_e) distribution of the plasma from either direct or field-aligned echoes. This technique has enabled the determination of the evolving density structures of the polar cap and the plasmasphere under a variety of geomagnetic conditions. New results from RPI show that the plasmasphere refills significantly faster (by a factor of ~2) than theories have predicted [6]. In the events studied, the density increases at a faster rate toward the ionosphere than the field strength. The index of the power law of the density as a function of field strength increases from a few tenths near the equator to close to unity near 40° and greater than 2 near the ionosphere [7].

In addition to the RPI long range echoes, plasma resonance observations from RPI at large radial distances over the polar cap have been made allowing for the determination of the plasma density to within an accuracy of a few percent [3,8]. The plasma resonances have been used to provide the starting points for the inversion process leading to N_e polar-cap profiles measured by RPI [3].

RPI has also been used to successfully test the feasibility of magnetospheric tomography during several perigee passages of the Wind spacecraft . Many future multi-spacecraft missions propose to use Faraday rotation to obtain global density pictures of the magnetosphere. The RPI radio transmissions at one and two frequencies has been received by the WIND Waves instrument. Faraday rotation was measured and occurred when the received electric field was observed to rotate with time due to the changing column density of plasma along the line of sight between the spacecraft [9].

OBSERVATIONS OF NATURAL EMISSIONS

The RPI also operates in a passive mode in order to receive natural magnetospheric emissions. The passive operations help to eliminate possible confusion about the reception of echoes from active RPI transmissions, and place the sounder echo measurements into a familiar context. RPI's long antennas and its very low noise receivers provide excellent observations in the passive receive-only mode when the instrument measures natural emissions such as the continuum radiation and auroral kilometric radiation (AKR). Recent passive measurements of AKR show a new double peaked AKR emission spectrum that is predominately observed in the northern hemisphere during times of large dipole tilt [10]. At this time it is not known if the doubled spectrum of AKR is coming from the same source region, or from the same auroral field line or from other auroral field lines at other local times. There are currently no theories that can explain the generation of the observed doubled peaked spectrum of AKR from the same source region.

Plasmaspheric measurements from RPI have been compared extensively with the Extreme Ultraviolet Imager on IMAGE and with the Plasma Wave Instrument on GEOTAIL resulting in a number of new discoveries. These combined observations show that the kilometric continuum radiation is frequently generated from sources deep within a bite-out region of the plasmasphere in or very near the magnetic equator at the plasmapause [5,11]. RPI observations also found that KC sources were also associated with intensification of the local upper hybrid resonance band. Statistical analysis of 246 KC events shows that the typical source region is at an equatorial radial distance of ~2.3 earth radii in the magnetic equator and produces an emission cone that is, on the average, ~43^{o} in longitude and ~10-15^{o} in latitude [11].

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