SPREAD ECHOES FROM THE PLASMAPAUSE REGION AND MAIN PLASMASPHERE RECEIVED DURING HIGH ALTITUDE RADIO SOUNDING BY THE RPI INSTRUMENT ON THE IMAGE SPACECRAFT

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ABSTRACT

Since April, 2000, the Radio Plasma Imager (RPI) instrument on the IMAGE satellite has been sounding the Earth's plasma environment from a 1200 km – 8R_E polar orbit. Repeated observations of echo range spreading suggest that electron density irregularities are commonly "embedded" in the plasmasphere "surface," and that the middle and outer plasmasphere are regularly permeated by geomagnetic-field aligned irregularities with cross **B** scale sizes ranging from 200 m to > 10 km and electron density within < 10 % of background. Antecedents for this work exist in reports from topside sounders and whistler receivers, and in theory of plasmaspheric instabilities.

SPREAD ECHOES FROM THE PLASMASPHERE DETECTED BY RPI

Since May, 2000, the Radio Plasma Imager (RPI) on IMAGE has been sounding the Earth's plasmasphere from various points along the satellite's polar orbit, with apogee ≈ 8 R_E geocentric distance and perigee near 1200 km altitude [1]. RPI also measures local plasma parameters along the IMAGE orbit through passive measurements of natural wave activity. A principal new result is that both the plasmapause region and the main plasmasphere tend to be "rough" targets at sounding frequencies ranging from about 50 kHz to 1 MHz [2]. Echoes that return from directions generally Earthward or transverse to the geomagnetic field are usually not the discrete traces on range-versus-frequency records (plasmagrams) that ray tracing simulations in smooth magnetospheric density models predict. Instead, they exhibit various amounts of spreading, from ≈ 0.5 to 2 R_E in virtual range (range assuming free-space speed of light propagation). For echo turning points within the main plasmasphere, the range spreading is attributed to scattering from, partial reflection from, and partial-path propagation along geomagnetic-field-aligned electron density irregularities with cross-field scale sizes ranging from ≈ 200 m to > 10 km and electron density within < 10 % of background. For echo turning points within the plasmapause region, the spreading appears to be partially attributable to a longitudinal distribution of irregularities along the plasmapause "surface." That the irregularities are field-aligned is suggested by the efficiency with which RPI, in addition to the spread "direct" echoes noted, excites other echoes that are guided, sometimes into both hemispheres, along the geomagnetic field, and which commonly return with minimal range spreading [3]. Although the occasional existence of the irregularities in question is supported by evidence from other radio experiments such as topside sounders [4,5] and whistler-mode instruments [6,7], and is also supported (somewhat less directly) by in situ measurements on satellites such as CRRES [8], ISEE, synchronous satellites [9], and CLUSTER [10], the apparently new aspect of the RPI data is the regularity with which the spreading is observed, even during periods of deep magnetic quieting. Z mode echoes are frequently well defined in RPI plasmagrams, and may contain both discrete and widely spread components. Their potential as diagnostic tools complementary to the free space modes is being explored. In future studies that may involve full wave treatments and ray tracing in density models that include field aligned irregularities, it is hoped to learn about the specific ways in which irregularities act to produce the observed range spreading effects. Once progress is made in that area, high altitude radio sounding may provide a means of studying the scale sizes and occurrence properties of plasmasphere structures that are otherwise not easily susceptible to measurement. The RPI data should add impetus to an already existing body of theoretical work on mechanisms that may naturally give rise to irregular structures within the plasmasphere and plasmapause regions [11,12,13], such as interchange and quasi-interchange instabilities, shear flow instabilities, and the perturbing action of electric fields with various spatial scales.

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