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Research Activities: 1 October 1994 through 30 September 1995

Introduction

The first phase of the Geotail mission, an exploration of the distant magnetotail, was successfully concluded in October 1994. Geotail is currently engaged in a survey of plasmas at distances from Earth approximately 10 to 30 R_E. Throughout the mission the Comprehensive Plasma Instrumentation has functioned well with successful return of data. The analysis of the CPI measurements has resulted in a series of publications, and research efforts are ongoing.

Data Processing

Telemetry from the instrumentation is received at the University of Iowa on compact disks provided by the Central Data Handling Facility (CDHF) at Goddard Space Flight Center. Routine processing at the University of Iowa includes the production of color spectrograms that display the directional intensities of the plasmas. Operation of the plasma instrumentation is continuous, and spectrogram production is an ongoing effort. The measurements are also used to compute basic quantitative plasma parameters, e.g., the plasma number density, bulk flow velocity, temperature, and pressure.

CPI data are available in graphical formats on the World Wide Web. The Web plots were initiated in January 1995 to facilitate access to the measurements and to promote collaborative studies. The graphics files can be viewed using Web-browser software such as Mosaic or Netscape. Access is unrestricted. The Uniform Resource Locator (URL) is http://www-pi.physics.uiowa.edu/www/cpi/. Survey spectrograms and a preliminary set of plasma parameters are given in 5-day and 30-day plots. These plots are designed to give an overview of the plasma measurements. A set of software that computes CPI plasma parameters has also been provided to the CDHF for the production of Key Parameter files that are made available to the ISTP research community.

Research Summary

The analysis of CPI observations is provided by the Principal Investigator L. A. Frank, a Co-Investigator, K. L. Ackerson, and Associate Research Scientist W. R. Paterson. A graduate student, J. Seon, is also involved in the research effort. Theoretical interpretation is supported by Professor M. Ashour-Abdalla and by Co-Investigators G. L. Siscoe and F. V. Coroniti. Measurements from CPI are also provided to other investigators in support of varied research projects. A list of presentations and publications is appended to this report. A summary of some of the research now in progress using CPI plasma measurements is given below.

The topology of the magnetotail with its various regions and boundaries is determined in large part by the interaction with the fields and plasmas of the solar wind. In a recent manuscript Frank et al., [1995] report on a series of magnetotail observations from Geotail and simultaneous solar wind observations from IMP 8. These observations are presented in comparison with the results of a global time-dependent MHD simulation. From the observations it is found that a rotation of the magnetic field in the solar wind is well correlated with repeated transitions at Geotail from the magnetotail lobe to a magnetosheath-like boundary layer. Using the solar wind magnetic field as input the MHD simulation accurately predicts these transitions. This work is remarkable because it provides the first substantial evidence that a global MHD model is capable of correctly predicting important aspects of the large-scale topology and dynamics of the magnetotail. If the MHD model can be fully validated it will serve as a valuable tool. Testing of the model is to be extended by examination of additional cases when Geotail is at both significantly greater and smaller radial distances. Two candidate cases have been identified that will utilize IMP 8 as a solar wind monitor. At the Geotail-Wind Science Meeting in May 1995 an additional 10 cases were identified that will utilize measurements from the Wind spacecraft for the required input of solar-wind conditions.

It has long been surmised that steady-state magnetic reconnection proceeds in the distant magnetotail at a neutral line bounded by a pair of slow-mode magnetohydrodynamic shocks. Verification of this process has been difficult. Fully three-dimensional observations of both electrons and positive ions are required to verify the nature of the boundaries. In a recent paper submitted for publication in Geophysical Research Letters Seon et al., [1995] uses measurements from CPI and from the Geotail Magnetic Field Experiment (MGF) to demonstrate with a high degree of certainty that Geotail did encounter a slow-mode shock for one crossing of the boundary between lobe and plasma sheet at a distance from Earth of 135 R_E. The observations are compared with theoretical predictions for a steady-state, one-dimensional shock. The observed plasma moments and magnetic field upstream from the shock are successfully used to predict these parameters in the downstream region. The measured parameters are in sufficient agreement with the theoretical predictions to provide considerable confidence that this boundary is a slow-mode shock.

The development and evolution of plasmoids is a topic of considerable interest in studies of the magnetotail and magnetospheric substorms. The standard model of a plasmoid pictures a disconnected magnetic island filled with hot plasmas that is expelled from the magnetotail as one part of the process of magnetic substorms. However, the plasma and the magnetic field measurements from Geotail suggest that many of the cases identified as plasmoids are more akin to magnetic flux ropes with axial magnetic fields aligned along the dawn-dusk axis [Lepping et al., 1995] For one case an axial current is measured with the CPI Hot Plasma analyzer [Frank et al., 1995]. The observation of this current greatly strengthens the identification in favor of flux ropes.

A remarkable result from Geotail is the observation of cold ion beams coexisting as distinct components in the presence of hot plasma-sheet plasmas. Cold ions that encounter the distant X line or the neutral sheet at the center of the plasma sheet are accelerated and eventually may be heated or isotropized. The cold ions in the distant plasma sheet observed by CPI appear to be cold source plasmas at an early stage of this processing. Interpretation of the Geotail observations in terms of nonadiabatic particle motion is proceeding in collaboration with the theory group at UCLA led by M. Ashour-Abdalla. Current research efforts are directed towards the development of plasma parameters that will provide a quantitative assessment of the degree to which the ion velocity distributions are non-Maxwellian.

Collaborative work with other researchers also is ongoing. Plasma measurements from CPI have been provided for use by scientists associated with the MGF, EFD, EPIC, and PWI instrument groups. Plasma measurements from the CPI Solar Wind and Hot Plasma analyzers are currently used by members of the Geotail MGF team led by S. Kokubun in their investigation of unusually large magnetotail magnetic fields and in a separate study of substorm timing that utilizes ground-based magnetic observations. G. Siscoe and colleagues at Boston University are using measurements from CPI to investigate the evolution of cold streaming plasmas in the magnetotail subsequent to magnetotail entry at the nose or along the flanks. Plasma measurements from CPI are used by H. Matsumoto and coworkers in comparison with PWI plasma wave measurements in their investigations of broadband electrostatic noise (BEN), narrowband electrostatic noise (NEN), Langmuir waves in the magnetotail, and "barber-pole" emissions in the dayside magnetosphere. I. Nagano of Kanazawa University is using velocity distributions acquired with CPI in an investigation of Chorus emissions in the dayside magnetosphere. In March 1995 members of the CPI research group and the Geotail Plasma Wave Investigation (PWI) met at Kyoto

University to discuss collaborative research. At this meeting five separate topics were identified as candidates for timely publication.

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