NASA-CR-196274

SEMIANNUAL STATUS REPORT

for

ANALYSIS OF PLASMA MEASUREMENTS FOR THE GEOTAIL MISSION

NAG5-2371

Period Covered: 1 October 1993 - 31 March 1994

Submitted by:

Louis A. Frank, Principal Investigator

Department of Physics and Astronomy
The University of Iowa
Iowa City, Iowa 52242 - 1479

ANALYSIS OF PLASMA MEASUREMENTS FOR THE GEOTAIL MISSION

Research Activities: October 1993 through March 1994

The CPI plasma measurements from the Geotail spacecraft are currently used by a number of scientists in support of varied research projects. During this reporting period results were presented at the 1993 Fall Meeting of the American Geophysical Union and at the International Conference on Substorms-2. In addition, a series of papers has been submitted to Geophysical Research Letters, and abstracts have been submitted for presentations at the 1994 Spring Meeting of the American Geophysical Union and for the Eighth International Symposium on Solar Terrestrial Physics. A list of presentations and publications is appended to this report. This list includes reports on research led by CPI investigators at the University of Iowa, by CPI Co-Investigators at other research centers, and reports produced in collaboration with scientists associated with other Geotail instrument teams. A summary of some of the research now in progress using CPI plasma measurements is given below.

Measurements from the CPI Hot Plasma analyzer have been processed to compute one-minute averages of plasma densities, temperatures, and velocities for the period 1 October 1992 through 31 July 1993. These parameters are used in a preliminary survey of the magnetotail for distances from Earth 10 to 210 Earth radii. Average parameter values and the range of parameter values are given for the center of Earth's magnetotail. The survey characterizes hot plasmas in the plasma sheet and cold plasmas in the vicinity of the plasma sheet. This work includes the thermal ion plasmas for which observations in this range of distances previously had been unavailable. One unanticipated result is the pervasive observation of cold tailward-streaming plasmas within the distant magnetotail. The source of these plasmas appears to be primarily the solar wind. Entry into the

magnetotail occurs either at the nose of the magnetosphere or along the flanks. The evolution of cold streaming plasmas subsequent to magnetotail entry is now being researched by CPI Co-Investigator G. Siscoe and colleagues at Boston University.

The cold plasmas within the magnetotail drift towards the midplane and are thought to be a principal source for the hot plasma sheet. A remarkable result from Geotail is the observation of cold ion beams coexisting as distinct components in the presence of hot plasma-sheet plasmas. Previously, such complex non-Maxwellian distributions with hot and cold components had been observed only during the magnetotail traversal of the Galileo spacecraft. 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. Eventually these ions may become part of the hot isotropic plasma sheet near Earth, or may be ejected as streams into the plasma sheet boundary layer. However, the physical processes that lead to the development of these regions are not well understood. 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. This work is expected to contribute to our understanding of the formation of the plasma sheet and its boundary layer.

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. Previous observations of plasmoids in the distant tail did not include measurements of the thermal ions which are essential for a complete understanding of the plasma dynamics. A number of possible plasmoids have been identified in the Geotail data set by D. Fairfield at GSFC

based upon reversals of the Z component of the magnetic field as observed with the MGF instrumentation. An intensive study of the electron and ion velocity distributions and the plasma parameters for several of these events reveals unexpected features. Within the region of the plasmoid, as identified from the magnetic signature, the electrons are counterstreaming along the magnetic field indicating that these particles are trapped in a closed or bounded magnetic topology. However, the ion distributions are found to be complex with separate hot and cold components. The bulk velocities of the electrons and the hot ions are the same, but the cold ions have lower speeds. Thus the bulk speed of the electrons is different from the bulk speed of the combined cold and hot ions, and an electric current must exist. The current is consistent with the large dawn-dusk component of the magnetic field that is observed in these cases. This transverse field seems to be a common feature of plasmoids, but is not accounted for by the standard model of comoving ions and electrons trapped in a magnetic island. The plasma and the magnetic field measurements from Geotail suggest that many of the cases identified as plasmoids may be more akin to magnetic flux ropes aligned along the dawn-dusk axis. Geotail provides an excellent in-situ laboratory for study of the development and evolution of these objects which also are known to exist in interplanetary space. We are currently working with R. Lepping at GSFC who finds that model flux-rope topologies compare well with the observations. Eventually, this work may modify and improve our understanding of the substorm process.

Collaborative work with several Geotail instrument teams and other researchers also is ongoing. Plasma measurements from CPI are used by H. Matsumoto and coworkers in comparison with PWI plasma wave measurements in their investigation of broadband electrostatic waves in the magnetotail and electron cyclotron harmonic emissions at the magnetopause. An investigation of coronal mass ejections and interplanetary shocks utilizing measurements from the CPI Solar Wind analyzer is in progress at Kyoto

University. Plasma measurements from CPI also have been provided for use by scientists associated with the MGF, EFD, and EP IC instrument groups.

CPI Science - 1 October 1993 through March 1994

Presentations at the 1993 Fall Meeting of the American Geophysical Union, San Francisco:

Ackerson, K. L., L. A. Frank, W. R. Paterson, S. Kokubun, M. Ashour-Abdalla, F. V. Coroniti, G. L. Siscoe, D. H. Fairfield, R. P. Lepping, and A. J. Lazarus, Geotail Observations of the Presence of Solar Wind Ion Velocity Distributions in the Downstream Magnetosheath, Eos, 74 (Supplement), 534, 1993.

Ashour-Abdalla, M., L. A. Frank, W. R. Paterson, K. L. Ackerson, F. V. Coroniti, L. M. Zelenyi, S. Kokubun, D. H. Fairfield, and A. J. Lazarus, On Cold Ion Beams in the Distant Tail, Eos, 74 (Supplement), 528, 1993.

Coroniti F. V., L. A. Frank, W. R. Paterson, K. L. Ackerson, M. Ashour-Abdalla, S. Kokubun, and D. H. Fairfield, Plasma Distributions at the Distant Tail Lobe-Plasma Sheet Interface Measured by the Geotail Comprehensive Plasma Instrumentation, Eos, 74 (Supplement), 527, 1993.

Frank, L. A., W. R. Paterson, K. L. Ackerson, S. Kokubun, M. Ashour-Abdalla, F. V. Coroniti, G. L. Siscoe, D. H. Fairfield, R. P. Lepping, and A. J. Lazarus, Recent Results From Plasma Measurements in Earth's Magnetotail and its Environs With the Geotail Spacecraft, Eos, 74 (Supplement), 533, 1993.

Fujita, A., H. Kojima, H. Matsumoto, S. Kokubun, T. Yamamoto, L. A. Frank, and W. R. Paterson, Wave Signatures During the Plasmoid Encounters Observed by Geotail, Eos, 74 (Supplement), 535, 1993.

Kaymaz, Z., G. Siscoe, L. A. Frank, K. L. Ackerson, W. R. Paterson, and R. P. Lepping, Dawn-Dusk Flows in the Magnetotail: Predictions and Geotail Observations, Eos, 74 (Supplement), 534, 1993

Kojima, H., I. Nagano, A. Fujita, H. Matsumoto, S. Kokubun, T. Yamamoto, L. A. Frank, and W. R. Paterson, Plasma Wave Features of the Boundary Layers in the Magnetosphere, Eos, 74 (Supplement), 533, 1993.

Matsumoto, H., H. Kojima, T. Miyatake, Y. Omura, M. Okada, L. A. Frank, and W. R. Paterson, Nature of the Broadband Electrostatic Wave in the Magnetotail, Eos, 74 (Supplement), 532, 1993.

Nishimura, O., H. Matsumoto, R. R. Anderson, L. A. Frank, W. R. Paterson, S. Kokubun, and T. Yamamoto, Electromagnetic Electron Cyclotron Harmonic Waves near the Magnetopause Observed by Geotail, Eos, 74 (Supplement), 535, 1993.

Paterson, W. R. and L. A. Frank, Survey of Magnetotail Plasmas With the Comprehensive Plasma Instrumentation Aboard the Geotail Spacecraft, Eos, 74 (Supplement), 534, 1993.

Siscoe, G. L., L. A. Frank, K. L. Ackerson, W. R. Paterson, and M. Ashour-Abdalla, Interpretation of Long-Period Velocity Dispersive Plasma Events at 100 R_e and Beyond in Terms of Comparison With an Expansion Fan Model, Eos, 74 (Supplement), 528, 1993.

Shodhan, S., G. Siscoe, L. A. Frank, K. L. Ackerson, W. R. Paterson, K. Paularena, J. D. Richardson, A. J. Lazarus, and R. P. Lepping, Tail Positions for Geotail Observations, Eos, 74 (Supplement), 534, 1993.

Presentation at the International Conference on Substorms-2, Fairbanks, March 1994.

Frank, L. A., W. R. Paterson, K. L. Ackerson, S. Kokubun, M. G. Kivelson, and D. H. Fairfield, On the Nonadiabatic Acceleration of Ions in Earth's Magnetotail: Observations from Galileo and Geotail.

Publications

Frank, L. A., and W. R. Paterson, Survey of Electron and Ion Bulk Flows in the Distant Magnetotail with the Geotail Spacecraft, Geophys. Res. Lett. (submitted), February 1994.

Frank, L. A., W. R. Paterson, K. L. Ackerson, S. Kokubun, T. Yamamoto, D. H. Fairfield, and R. P. Lepping, Observations of Plasmas Associated with the Magnetic Signature of a Plasmoid in the Distant Magnetotail, Geophys. Res. Lett. (submitted), February 1994.

Frank, L. A., W. R. Paterson, K. L. Ackerson, S. Kokubun, M. G. Kivelson, and T. Yamamoto, Ion Velocity Distributions in the Vicinity of the Current Sheet in Earth's Distant Magnetotail, submitted for publication in the Proceedings of the International Substorm Conference-2.

Kojima, H., H. Matsumoto, T. Miyatake, I. Nagano, A. Fujita, L. A. Frank, T. Mukai, W. R. Paterson, and R. R. Anderson, Relation Between Electrostatic Solitary Waves and High Energy Plasma Flow in the Plasma Sheet and the Plasma Sheet Boundary Layer, Geotail Observations, Geophys. Res. Lett. (submitted), February 1994.

Paterson, W. R., and L. A. Frank, Survey of Plasma Parameters in Earth's Distant Magnetotail with the Geotail Spacecraft, Geophys. Res. Lett. (submitted), March 1994.

Siscoe, G. L., L. A. Frank, K. L. Ackerson, and W. R. Paterson, Irregular Long-Period Boundary Oscillations Beyond ~100 R_e: Geotail Plasma Observations, Geophys. Res. Lett. (submitted), February 1994.

Siscoe, G. L., L. A. Frank, K. L. Ackerson, and W. R. Paterson, Further Properties of the Mantle-Like Boundary Layer: Geotail Data Compared with a Mantle Model, Geophys. Res. Lett. (submitted), February 1994.