ANALYSIS TECHNIQUES AND SOFTWARE DEVELOPMENT

Substantial progress has been made in the development of programs for statistical analysis of boundary and 'structure' type files based on surveys of DE data. Programs that have been finalized during this period do the following tasks:

1. Plot L-shells of selected boundaries vs. Kp and fit and plot a least-squares fit straight line to the data.
2. Do the same for differences in L-shells for different boundaries (nearly simultaneously detected). These boundaries may be part of two different data files.
3. Plot L-shells of boundaries on an L-MLT dial plot, and plot the average L locus with selected MLT bin widths.
4. Plot two boundaries on the same L-MLT dial plot with straight line connecting the two different symbols for the two different boundaries.

Other programs nearing finalization are programs to plot the L differences between boundaries on a rectangular plot versus MLT, a circular pie histogram to indicate occurrence frequencies of data types vs. MLT, a rectangular histogram for plotting, in a given local time sector (or other criteria) the occurrence frequency distribution of different types of data, and the programs to do plotting of invariant latitude in the above schemes instead of L-shell. These programs are being currently used for data handling on such topics as the plasma boundaries in the inner magnetosphere, the structure of the plasmasphere and the heavy ion torus, and may be potentially useful in such areas as the statistics on the 'warm plasma cloak' and 'auroral ion fountain', i.e. wherever boundaries and plasma distribution structure is of interest.

Modifications to the thin sheath plasma parameter analysis program have been completed. Corrections for saturation effects have been incorporated into the program according to the model developed within the magnetospheric physics group. In addition, use of spin curves has been incorporated into the analysis procedure as an independent source of information. Temperatures are determined from the RPA data, as previously, but spacecraft potentials are now determined from the spin modulation of the unretarded data in an iterative procedure. Tests with "perfect" simulation data show that the new method converges to the correct values for both positive and negative values of the spacecraft potential. Similar tests with gaussian noise superimposed on the simulated data indicate that significant errors can occur when the amplitude of the noise becomes larger than 5-10%. With real data there is frequently found a difference in the density determined from the two different data curves; this difference is generally less than about 10%. The direction of the difference is systematic, although its magnitude appears to be somewhat variable; however the difference is small enough so that it is not a significant concern. Densities must now be cross-correlated with PWI densities once more for absolute calibration.

DATA ANALYSIS AND MODELING

A paper on the plasma boundaries in the inner magnetosphere was completed, circulated to co-authors and their comments received, and is almost finalized for submission for publication (Ref. 1). A coincidence between the Low-Energy Ion Transition (LEIT), the 100 eV electron plasma sheet inner edge and the auroral oval 100 eV electron equatorward edge is characteristically found in the evening sector. Distinct plasma sheet and auroral oval inner edges are not found characteristically in the dayside morning sector, although LEITs always are. All boundaries in the evening sector show an increase in L with rotation from midnight to dusk. Characteristic energy dispersion of the plasma sheet inner edge and auroral oval equatorward edge is virtually always observed in the evening sector, with the higher energy electron boundaries at the higher L-shells. This dispersion increases with rotation in local time into the dusk sector and decreases during enhanced geomagnetic activity. All edges show decreases of L with increasing Kp, with relatively good correlation of straight line fits in the .7 -.8 correlation coefficient magnitude range.

Progress is being made on the structure of the plasmasphere/ plasmapause work and on the heavy ion torus. Plots have been made of the L of the LEIT and other plasmaspheric boundaries versus Kp and versus local time, using data from the most of the available DE-1 RIMS survey data. More discussion of the work in this area will be done in the next progress report. On the heavy ion torus, similar types of plots are being readied for the boundaries of the O^{+} and O^{++} torus. Mr. T. Roberts is expected to complete his masters thesis before June

1985, and this will be followed by draft of at least one paper on this topic.

Initial work has begun on using the ion trajectory program to study some aspects of the destiny of the earthward ion beams in the tail, which have received attention recently as a possible power source for auroras. We have just begun this work, but indications are that mirroring at high altitudes prevents these beams from being observed and effective in the acceleration of auroral electrons.

An investigation of ion thermal structure near the plasmapause has been initiated. The basic objectives are to determine what the characteristic thermal structure is and how it varies with other environmental parameters. Initial attention has been directed at the steepness of the temperature gradient (at its steepest part) and (1) how this varies with the steepness of the density gradient at the same location; (2) how it varies with magnetic activity. Results from a small sample (ten passes), selected for high and low magnetic activity, are inconclusive. This sample shows no positve indication that either recent past or present geomagnetic activity correlates strongly with the magnitude of the temperature gradient, nor is the magnitude of the density gradient a strong correlator in this sample. Examination of a much larger set of passes is expected both to clarify any trends and to direct our attention to more precise conditions for the development of strong temperature gradients.

The study of molecular ions using the DE-1 RIMS data was completed, and a paper submitted (Ref. 2). The reviews were received, and required only modest changes in the paper. The paper was returned and accepted for publication.

Further analysis of the equatorially trapped plasma population has continued. A major new result of this study is that there is a local minimum in the plasma density at the magnetic equator in the outer plasmasphere. This may indicate that the plasmasphere filling process begins at high latitudes, with the shock front associated with the thermalization of the polar wind beginning at high latitudes and propagating towards the equator. An alternative to this process is that the steady state plasmasphere is being heated at the equator, and the requirement for a constant plasma pressure results in a decrease in the total density. This concept is being explored.

The initial study of O^{++} and N^{+} in the plasmasphere has been completed. Results from this work show that while thermal diffusion is important when equatorial temperatures are high (8000 K), ion drag from collisions with O^{+} is as important and at times is the most important term in the O^{++} diffusion equation. This effect is due to the increase in the O^{+} scale height at low altitudes which results from the transport of large amounts of heat from the assumed source in the equatorial region to low altitudes. Because earlier models of O^{++} did not solve the ion energy equation simultaneously with the diffusion equation, this effect has gone unnoticed. A paper has been drafted reporting these new results and will be submitted for publication (Ref. 3).

The determination of ion velocities during a micropulsation event, which is being studied in collaboration with a group of scientists headed by Dr. M. Engebretson, has been completed. The results show that for the three ions studied (O^{+},H^{+},He^{+}) the velocities were in a ratio of 4:2:1 for H^{+}:He^{+}:O^{+}; reflecting equal energization for all ions. The absolute magnititudes were 37 +/- 7 km/s, 20 +/- 6 km/s and 10 +/- 3 km/s for H^+, He^+ and O^+, respectively. A paper on this work has been completed and submitted to the Journal of Geophysical Research (Ref. 4). Similar work has been carried out in collaboration with MSFC/SSL scientists for a pulsation event from Day 82195 (Ref. 5). After extensive reworking of certain portions of the manuscript, only partially in response to referee comments, this paper has been returned for review.

A paper is nearing completion on results of a study of ion velocities in the plasmasphere using RIMS data (Ref. 6). In this work, examples of interhemispheric transport of ionization, flux-tube refilling and ion counterstreaming have been studied and related to the dynamical behavior of the plasmasphere. Several examples of high speed H^+ (and at times He^+) flows within recently depleted flux tubes have been found in the RIMS data. The flow velocities approach 1 km/s at times and are consistent with results from computer simulations of flux tubes after approximately two days of refilling.

SPACECRAFT SHEATH EFFECTS

We are in the process of consolidating several papers on spacecraft charging. Papers on the hidden ion population and the DE-1/RIMS aperture bias experiments were returned from the reviewers with favorable comments, and are being revised for publication(Ref. 7). The study of the spin modulation of the SCATHA satellite potential is nearly completed, and a draft paper on this topic is being submitted to co-authors for review (Ref. 8).

A review paper on charge control experiments on ATS5 and ATS6 has been accepted for publication and should be published in the next quarter (Ref. 9). A paper on the record charging events for ATS6 (-2 kV in sunlight and -19 kV in eclipse) has been completed (Ref. 10), and will be submitted during the next quarter.

LABORATORY PLASMA FLOW STUDIES

Further experiments were performed to identify consistent qualitative properties of the "sheath enhanced ionization" effect. The effect is the observed enhancement of ion flux directed upstream from a biased, conducting plate immersed in a drifting plasma. This ion flux is greater than the ambient plasma flow and has the following characteristics: (1) a value of the neutral pressure greater than p_0 (presently p_0 lies in the range 2-6 E-5 torr; (2) energy and current density of the upstream ion flux is a function of plate voltage; and (3) the ambient flow must be a plasma, i.e., the presence of both ions and electrons in the ambient flow are necessary for the effect to be initiated. Quantification of the above effects will be pursued in the next reporting period.

Experiments with two ion species plasmas will begin shortly at the University of Iowa under the direction of K. E. Lonngren. The complementary nature of these experiments to future experiments to be conducted at MSFC is now being discussed with him. Processes related to the plasma expansion of two ion species into a vacuum will be studied in the different experimental set-ups.

A short paper to present a comparison of an analytical model of the plasma expansion into a vacuum with the experimental results of

Wright et al. (Ref. 11) is underway, in collaboration with D. E. Parks and I. Katz of S-CUBED (Ref. 12).

INSTRUMENT DEVELOPMENT

- o Modifications were made to the large vacuum system.
- o Modifications were made to PDP heads being assembled.
- o Preliminary sketches were made of a gimbal system to be placed in the large vacuum system.

MEETINGS

Dr. Horwitz attended the International Space Simulation School-2 in Kapaa, Kauai, Hawaii, Feb. 4-12, 1985, and presented a paper on modeling and observations of the cleft ion fountain (Ref. 13).

Drs. Horwitz and Chandler were co-authors on a paper on the geomagnetic spectrometer which was presented at the Chapman conference on Solar Wind-Magnetosphere coupling in Pasadena in late February 1985 (Ref. 14).

Drs. Comfort and Chandler attended the DE Science Team Meeting at Goddard Space Flight Center, March 20-21, 1985, where Dr. Comfort presented some preliminary results on ion thermal structure near the plasmapause. Dr. Chandler also participated in IUE observ·tions while at GSFC.

Drs. Comfort and Horwitz presented papers (Refs. 15,30) to the The 62nd Meeting of the Alabama Academy of Science, which met in

Huntsville on March 27-30,1985. The University of Alabama in Huntsville hosted the meeting, and Dr. Horwitz was a co-convenor.

PUBLICATIONS

In addition to papers noted above, the following papers are at the indicated stage of the publication cycle.

Papers published during this period: A theoretical work on the relationship of electron energy dispersion to electric field in the dusk sector for non-equatorially mirroring electrons (Ref. 16); the report of RIMS ion temperature observations (Ref. 17)

Papers accepted for publication: dynamics of magnetospheric plasmas (Ref. 18), substorms during steady IMF (Ref. 19).

Papers submitted for publication and in review: a study of plasmapause structure observed by ISEE-1 (Ref. 20); two papers on the cleft ion fountain (Refs. 21,22); a paper on the Spacelab 2 Differential Ion Flux Probe (Ref. 23); and a paper comparing wake observations of the shuttle with those of small satellites (Ref. 24).

Papers in preparation : a comparative study of DE-1 and DE-2 plasmasphere and ionosphere observations (Ref. 25); a study of observations of ion fluxes in the wake of DE-1 (Ref. 26); an investigation of the dusk bulge from conjugate observations of GEOS-2 and DE-1 (Ref. 27).

Abstracts of papers submitted for presentation: ion acceleration due to the plasma-expansion-into-a-vacuum mechanism (Ref. 28); ion thermal structure near the plasmapause (Ref. 29), a review of new thermal ion composition measurements in the plasmasphere and plasmapause regions (Ref. 31), creation of supersonic ion outflows in the polar magnetosphere (Ref. 32), transport of accelerated ions in the polar magnetosphere (Ref. 33), ion acceleration at the magnetic equator (Ref. 34), and minor ion modeling (Ref. 35).

Richard H. Comfort

R. H. Comfort

James L. Horwitz

J. L. Horwitz

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FINANCIAL DATA

NAS8-33982

AMOUNT OF CONTRACT	$908,999.00
EXPENDITURES	947,134.80
BALANCE REMAINING AS OF March 31, 1985	(38,135.80) DEFICIT