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PLASMA AND MAGNETOSPHERIC RESEARCH

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by

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ANALYSIS TECHNIQUES AND SOFTWARE DEVELOPMENT

An area of significant progress made during this period has been the development of an ion trajectory code that plots the paths of ions ejected from various source locations, principally the polar cusp ionosphere, as they move through the polar magnetosphere under the influence of gravitation, the magnetic mirror force, and polar convection electric fields. These trajectories are based on the integration of the parallel force equation for determination of ion parallel velocities, $\vec{v}_{\perp} = \vec{E} \times \vec{B}/B^2$ for convection velocities, and the further integration of both these velocity equations to obtain the trajectories themselves. We are now in the process of using these trajectories to calculate distribution functions and such bulk parameters as ion densities, temperatures and fluxes throughout the polar magnetosphere. We are preparing to produce contour plots of these parameters in the polar magnetosphere. These programs can be used to make comparisons with many of the features observed in the DE-1/RIMS data. A paper on the features of ion trajectories in the polar magnetosphere has been prepared and submitted to GRL (Ref. 1). An abstract for a paper comparing such trajectories with DE-1/RIMS observations has been submitted for the AGU Fall Meeting (Ref. 2).

A number of plotting programs have been developed or improved during this period, including software to plot: (1) positions of different plasmapause indicator locations as functions of local time and L-shell; (2) L vs. Kp and associated least-square fit straight lines; (3) magnetic activity, (Kp) time history leading up to the observation time for various types of profiles; (4) and local-time histograms of percent occurrence for each different type of profile. One of the principal improvements in most of these programs has been the incorporation of selection criteria for ranges of Kp, local time, L-shell, profile type, and the like, so that only those data meeting the specified criteria are plotted or used.

The investigation of saturation effects has advanced during this period. In a previous phase, comparisons between radial and Z heads were used to evaluate the parameter in a mathematical model of the saturated countrate of the form:

$$CR = F \exp(-F/F_o)$$

where CR is the observed countrate, F is the "true" countrate and F_o is the (instrumental) parameter characterizing the saturation. There seems to be general agreement among the experimentalists in the Magnetosphere Group that this model is appropriate to use for accounting for this condition. During this period an alternate approach was taken by fitting theoretical spin curves to the sides of the RIMS spin curves. The theoretical curves used the temperatures and approximate spacecraft potentials obtained from the RPA analysis of data in the ram direction; but the density was adjusted so that the theoretical and data curves agreed on the sides (spin angles ≥ 60°). The ratios between the saturated density and the densities from the fitted spin curves were then used to determine F_o in the model. Values of F_o around 180,000-195,000 counts per sample appear to represent the results fairly well. This also agrees well with the results obtained by the previous approach. Branch associates have incorporated this model into the software which generates the new calibrated data file which will replace the MAF1 file for much of the quantitative analysis. Revisions to the interactive RPA analysis program to run from this data file have been started.

Development of the SPAN "conference station" continues on two fronts. We are helping to define the capabilities and procedures for implementing the conference station concept, in cooperation with the programmer who is preparing the software. In addition, in his capacity as chairman of the Standards Subgroup of the Data System Working Users Group (DSWUG), Dr. Gallagher is organizing a survey of available graphics languages for DEC machines, which produce METAcode intermediate device independent output. The objective is to make it possible for the group to adopt a graphic language and/or METAcode. The result of such an agreement would be the beginning of the free exchange of graphic representation, of scientific information via computer networks between scientists throughout the space physics community. Results of the survey will be presented at the next DSWUG meeting to be held at Stanford University just prior to the Fall AGU Meeting. Adoption of a standard at that meeting is anticipated.

SATELLITE DATA ANALYSIS

The investigation of plasmasphere thermal structure has been directed toward response of plasmaspheric ion temperatures to geomagnetic activity during this period. Comparisons of several temperature profiles corresponding to different levels of magnetic activity suggest that heating of the interior of the plasmasphere may be decreased during magnetically active times from quiet time values. This results in depressed ion temperatures inside the steep density gradients at high altitudes and in reduced field aligned temperature gradients when magnetic activity is high. We plan to examine additional data and to look for corresponding effects at and beyond the plasma density gradient. These initial results are being included in the plasmaspheric ion temperature survey (Ref. 3), which will be submitted following incorporation of co-author comments. They will also be reported to the Fall AGU Meeting (Ref. 4).

During this period we have made significant progress in the creation of data files that pertain to the plasmapause and plasmasphere structure, as well as to the plasma sheet inner edges and equatorward boundaries of the auroral oval electron precipitation. We have surveyed the entire period of three years of DE-1 operation for which we have GSFC summary fiche and have characterized each available plasmaspheric pseudodensity profile into several classifications. These include "featureless" profiles, "multiple plateau" profiles, "bite out" type profiles and so forth. Similarly, the density gradient near the outer boundary of cold, isotropic plasma has been characterized as "sharp" (factor of 10 decrease in $< 0.5L$), "less sharp", or "ramp". In addition, times were recorded for the DE-1 crossings of the outer boundary of the cold, isotropic plasma, the breakpoint locations of the density gradient, as well as inner plasmapause gradients and inner and outer edges of the biteouts, if such were observed. This initial file was processed, through software we developed on the Sigma-9 computer at GSFC, to use the 0-A data residing on the Sigma-9 system to produce a new file containing such additional parameters as L, invariant latitude, local time, and the like. We further processed the results on the local PDP 11/34 computer to add the Kp value corresponding to the time of observation, using a previously prepared Kp data file. Similar data files have also been developed for the plasma sheet and the equatorward boundary of the auroral oval from electron precipitation data.

Combined analysis of SCATHA data from the UCSD (electrons-ions), MSFC (thermal ions) and GSFC (waves) instruments has focused on the magnetic equator, using the perspective obtained from DE to guide further study. The Light Ion Mass Spectrometer (LIMS) shows that the equatorially trapped plasma, which appears to be created by transverse acceleration at the equator, is predominately hydrogen. The UCSD data show an apparent correlation between the "equatorial noise" and the intensity of the 1-80 keV ion flux, that is, the ring current. We are attempting to establish a scenario wherein the observed high energy ion distribution can be used to generate the observed waves, with heating of the cold ambient plasma as a by-product. This work was presented to the URSI General Assembly in Florence, Italy (Ref. 5).

Analysis of the DE-1/RIMS aperture bias experiments on Day 81/287 is nearly completed. Use of electron data from the HAPI experiment has allowed determination of the night-side polar wind characteristics, showing that it is supersonic (Mach 2) near 3 R_E. Further analysis of the dayside polar wind, previously analyzed by Sojka et al. (Ref. 6), showed that the spacecraft potential was between 8 and 10 volts, substantially higher than the value assumed in their analysis. This changes the polar wind from transonic (Mach ∿1) to hypersonic (Mach ∿6) on the dayside at L = 6, near 4 R_E geocentric distance. Although it was anticipated that barrier effects might prevent the measurements, this proved not to be the case, due to the high flow energy (∿5 eV). A first draft of a paper on this work is almost ready for co-author comments (Ref. 7).

The study of equatorial plasma heating using DE data is progressing. Latitudinal density profiles have been made for a number of events and temperature distributions are being assembled. The draft of a paper on this topic (Ref. 8) is being revised to include the analysis of this additional data.

A study mapping the observed distribution of both instantaneous and time-averaged Auroral Kilometric Radiation (AKR) over the northern magnetosphere has been completed. All present generation mechanisms have the AKR emitted transverse to the magnetic field, resulting in a hollow emission cone. A significant finding of this study is that the emission cone is not hollow, rather it is uniformly filled. It will require either special propagation conditions or new generation mechanisms to resolve this conflict. A paper detailing these findings has been submitted to JGR (Ref. 9).

The Day 82/195 Pc5 study with Hunter Waite has taken some interesting turns. After learning that we had incorrectly used the expression for obtaining oscillation periods from field line mass loading and making appropriate corrections, we found periods much shorter than those observed. This prompted a re-examination of our densities. From a direct cross-calibration of end head densities with PWI densities for another day in the same time frame, we found that our densities were too low by a factor of 2.4. A re-examination of the EICS densities has indicated a substantial density contribution from warm O^+. The resulting mass loading of the field line now gives periods much closer to (although still smaller than) the observed periods. The paper on this study has been submitted to JGR (Ref. 10). A new study has been initiated on the Day 82/222 event with Cahill and others.

Examination of data from the Differential Ion Flux Probe (DIFP) on STS-3 indicates the existence of an interaction envelope on the ram side of the shuttle orbiter. A paper on this and other preliminary findings is being prepared (Ref. 11).

SPACECRAFT SHEATH EFFECTS

All of the spring, 1982 eclipses of the DE-1 satellite have been analyzed to obtain the plasma density, temperature, mass composition (H^+, He^+, O^+) and the shift of the satellite potential upon entering and leaving eclipse. This data set is being used to complement the RIMS calibration effort, and is the basis for a paper (Ref. 12) being prepared on the "hidden" ion population of the outer plasmasphere. One noteworthy result is that the thermal equilibrium between H^+ and He^+, previously noted in the plasmasphere, is found to extend out to density regimes below 100 cm^{-3}.

Analysis of data from all 1979 eclipses of the SCATHA satellite to determine radial electric fields has been completed. A draft of a paper (Ref. 13) on these fields, so small that they are observable only in eclipse in the absence of photoemission charging, is completed and under co-author review.

LABORATORY PLASMA FLOW STUDIES

The set-up of an experiment to investigate anomalous ionization in the sheath of a positively biased plate in a flowing plasma has been completed. This experiment will be performed in the next quarter.

Fabrication of the parts for the new dual ion plasma source has been completed. Final assembly and vacuum chamber testing of the source will take place next quarter.

A paper (Ref. 14) on the plasma expansion experimental results has been completed and submitted to the Journal of Plasma Physics for publication. Results of that study were also presented by U. Samir as part of a poster paper at the International Conference on Plasma Physics held at Lusanne, Switzerland. A paper summarizing this presentation appeared in the conference proceedings (Ref. 15). Some of these results were also reported to the URSI meeting in Florence, Italy (Ref. 16).

REMOTE OBSERVATIONS

Data taken with the Fabrey-Perot interferometer at College, Alaska last spring have been analyzed to determine neutral gas temperatures. An informal report has been prepared detailing the data reduction techniques used and results obtained.

INSTRUMENT DEVELOPMENT

- Parts were fabricated for the instrument to be flown on the next MAP rocket flight. The instrument consists of 3 heads (DIFP's) and an instrument box. The box was also subsequently modified.

- Two new Faraday cups were built, to be used in testing and calibration of flight instruments.

- Vacuum manifolds were modified for the large vacuum chamber.

- A rotating disc fixture for instrument testing was modified.

- The large tank on the dual ion source was bored, a tube matched to it, and a flange added. This assembly is stainless steel.

- The vacuum system was repaired and new seals were cut into flanges for copper seal rings.

- A jacking mechanism to lift the tower off the large vacuum system is being built.

PRESENTATIONS AND PUBLICATIONS

Drs. Comfort and Horwitz attended the DE Science Team, July 24, 25, 1984 at GSFC. They presented results of recent DE investigations and discussed collaborative activities with other DE investigators.

Dr. Olsen attended the 21st General Assembly on the International Union of Radio Science (URSI), August 27 - September 6, 1984, in Florence, Italy, where he presented a paper on SCATHA observations (Ref. 5), indicated above.

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

Papers appearing in print were the supersonic polar wind paper (Ref. 17) and the paper on formation of the outer plasmasphere (Ref. 18).

Papers accepted and in press are the papers on: electrostatic waves in the magnetosheath (Ref. 19), the relationship of dusk-sector electron energy dispersion to the electric field for off-equatorially mirroring electrons (Ref. 20), residence time heating effects on auroral conic generation (Ref. 21), and implications of solar flare dynamics for reconnection in magnetospheric substorms (Ref. 22).

Papers submitted and under review include papers on: structure of the plasmapause as observed with ISEE-1 (Ref. 23), and characteristics of substorms during intervals of steady IMF (Ref. 24).

Other papers in preparation are papers on : a comparison of DE-1 and DE-2 observations of the ionosphere and plasmasphere (Ref. 25), plasma boundaries in the inner magnetosphere (Ref. 26), high polar densities and flows (Ref. 27), and a review of fundamental plasmapause processes (Ref. 28).

A number of additional abstracts have been submitted for paper presentations to the Fall AGU Meeting in San Francisco (Ref. 29-34).

R. H. Comfort

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