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by

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INTRODUCTION

During the course of this grant, we have worked on a variety of topics and have a number of significant accomplishments. These have been documented in publications and presented to the scientific community in a variety of forums. Since we have also submitted extended discussions in the progress reports, the discussion below is limited to a summary of significant accomplishments, followed by chronological listings of the publications and presentations which have resulted from research supported in part under this grant.

ANALYSIS TECHNIQUES AND SOFTWARE DEVELOPMENT

Empirical Model Data Base

We have participated extensively in the efforts to develop an empirical model of the plasmasphere from observations made by the Retarding Ion Mass Spectrometer (RIMS) on Dynamics Explorer 1 (DE1). As part of this effort the thin sheath formulation was completely reworked to incorporate two additional features. First, the energy dependence of the solid angle was included, using calibration data to provide values for the relevant parameters of the different ion species. Then the instrument response function was modeled and included. The first modification affects all ion species, while the latter has practical consequences only for the heavy ions with the smaller response range. Both features were developed analytically so that they were easily implemented in the current computer codes. This has had particular benefits for improving the accuracy of analysis of the heavy ion species.

In conjunction with the empirical model group, we have developed a complete set of procedures for using end head energy analysis in conjunction with radial head spin analysis to optimize and make consistent our analysis of all ion species for the time frame following the development of the anomaly in the radial head operation. Each step has been extensively tested and compared with radial head results for times when that head was at full operation. The procedures implemented are as accurate as we can make them.

Data Reduction for Archiving

Students working under this grant have completed the integration and conversion of data from telemetry tapes to the mission analysis files usable by scientists for data analysis. All data on hand have been processed and resulting files have been archived on optical disk. This was a major milestone for RIMS data analysis and for the archiving effort. This has resulted in a significant improvement in the capability for undertaking statistical studies which examine data from the entire RIMS data set.

SCIENTIFIC INVESTIGATIONS

Semikinetic Modeling of Low Energy Plasma in the Inner Terrestrial Magnetosphere and Ionosphere

During the course of this grant we have developed a new time dependent plasma modeling technique. It is referred to as a semikinetic model since the ions are described in a kinetic fashion using some of the standard particle-in- cell techniques, while the electrons are modeled by using ordinary transport equations. The first, and simplest version of this model was used to study the outflow of polar ionospheric plasma along open field lines [Ref. 3, 9, 20]. Later the polar outflow model was upgraded to include a field-aligned current and wave-particle interaction effects. With these improvements Brown et al. [Ref. 8] studied the effects of waves produced by the current-driven electrostatic ion cyclotron instability and was able to produce O^+ and H^+ conics in a self consistent fashion. The model has also been applied to the study of early time kinetic effects occurring during the refilling and re-establishment of the plasmasphere following a magnetic storm [Ref. 10,18]. The effects of Coulomb collisions on the refilling process were also studied [Ref. 17]. The semikinetic model, with Coulomb collisions incorporated, has been applied to the study of this transition region [Ref. 17] for H^+ ions outflowing through an O^+ background.

O^+ Outflows

We have utilized measurements of core(0-50 eV) and energetic ion composition, plasma waves, and auroral images from DE-1, and plasma ions and electrons from DE-2 to examine some of their properties in the context of the polar cap environment. It is found that two distinct populations of O^+ beams are observed: 'high-speed' (10-30 eV or higher streaming energies) and 'low-speed' (generally $\leq$ 10 eV streaming energies). The 'high-speed' polar beams show an 'auroral' connection, i.e., they are observed on or near field lines threading the dark polar cap and may be convected from the cleft ion fountain. The low-speed streams are generally much more stable in energy and flux, while the high-speed streams tend to be bursty. In general, the streams are convecting anti-sunward, with velocities of 5-14 km/s in the orbital plane. Plasma wave measurements generally indicated little auroral hiss in the polar cap for the cases examined; however, one case showed densities in the range 1-5 e/cm^3. Estimates of electrostatic potential drops above the DE-2 satellite have been made using the energy-angle spectrograms of DE-2/LAPI atmospheric photoelectron data. Potential drops often are in the 20-40 volt range. At other times the potential falls below the ~5 volt instrument threshold or there are insufficient photo-electron fluxes for estimation. There is a suggestion of a trend for the largest potential drops to be

just poleward of the cleft and a decline of the magnitude of the drop in the anti-sunward direction. No obvious correlation between the potential estimates and 'nearby' O^+ streaming energies is seen.

We have also begun to address the statistical properties of outflowing O^+ through bulk parameter analysis of DE1/RIMS observations when DE1 was in the mid altitude polar cap magnetosphere. We have selected a technique which relies on analysis of the DE1 radial head RPA data near the magnetic field direction for obtaining the O^+ bulk parameters of density, temperature and flow velocity from these measurements. We have so far analyzed four passes and tested our technique with reasonably good assurance regarding the derived parameters. Initial results were presented at the San Francisco AGU meeting [Ref. 78].

Equatorial Plasma Trough

We are presently conducting a statistical study of the properties of the transition between the trapped and field-aligned ion fluxes in the equatorial region, using RIMS core ion data from DE1 orbits which nearly "skim" along the L=4.6 shell. In this very preliminary study, we have identified and considered statistical trends in four parameters for 44 latitudinal transition events. Indicated trends at this stage include the following:

1. Transition latitudes occur at latitudes below 14°, and about 20% of these occur very close to the equator at $\Lambda \leq 2°$.
2. A broad range of equatorial ion anisotropies are seen, but the typical values would be consistent with bi-Maxwellian temperature ratios of $T_\perp/T_\parallel$ of about 2.
3. The latitudinal scales for the edges of the trapped ion populations display a rather strong peak in the 2-4° range.
4. It appears that there might be two distinct general classes of events based on penetration ratio, broadly for $P \leq 0.5$, indicating relatively strong decrease of flux beyond the transition region toward the equator, and $P \geq 0.5$, indicating lesser inhibition of the incoming flux.
5. There is a clear trend for the penetration ratios to decrease with higher equatorial trapped ion anisotropy. This may be interpreted in terms of larger equatorial anisotropies being associated with larger positive electric potential peaks, leading to greater repulsion and flux diminishment of incoming field-aligned ion streams from reaching the equator, hence the decrease of the penetration ratio.

Plasma Wave Ray-Tracing Studies

With support from this grant we have made extensive modifications to an existing plasma wave raytracing code developed by S. D. Shawhan and J. L. Green. We replaced the dipole magnetic field with the Mead-Fairfield model. We also replaced the diffusive equilibrium plasma distribution model with empirical models developed by D. L. Gallagher and A. Persoon, and

added He^+ and O^+ in a rudimentary plasma composition model. A number of diagnostics were added, with particular emphasis on assessing the validity of the WKB approximation.

The model has been used to examine Pc3 waves and Pc1,2 waves launched at the dayside equatorial magnetopause. Results have shown that the inclusion of O^+ and He^+ in the plasma composition has a critical effect on the propagation of compressional waves for these ULF frequencies. Pc3 results have been submitted for publication [Ref. 24]

MEETINGS

In addition to presenting results at many different meetings, we also participated in convening them and contributing extensively to them. Among these were: The Second Huntsville Workshop on Magnetosphere/Ionosphere Models, held at UAH on October 11-13, 1989 [Ref. 9-12; Ref 25-29]; The Workshop on Plasmasphere Refilling, held at UAH on October 15-16, 1990 [Ref. 15-18; Ref. 39-41]; and the 3rd Huntsville Workshop on Magnetosphere-Ionosphere Models: Sources, Transport, Energization, and Loss of Magnetospheric Plasmas, held at Lake Guntersville State Park, October 5-8, 1992 [Ref. 64-74].

PUBLICATIONS

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