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During this reporting period we have been engaged in a number of different investigations. A summary of the progress in each area is presented by topic.

SCIENTIFIC INVESTIGATIONS

Generalized Semikinetic Model

In this investigation, we seek to continue to develop and apply a technique which we will now call Generalized SemiKinetic(GSK) modeling to the variety of plasma outflow phenomena observed in the high-latitude ionosphere-magnetosphere region, to analyze data (chiefly from DE-1) on these outflow, and, if and where possible, to connect the modeling and observations. In brief, the GSK approach involves treating the ions as gyrocenters moving along the magnetic field lines, subject to macroscopic forces (gravity, mirror force, ambipolar electric field) and microscopic processes (collisions, electromagnetic wave packets). The term Generalized at this stage is employed to distinguish several advances we at UAH have introduced beyond previous semikinetic models, such as time-dependence, incorporation of collisions, generalized transport electron formulation, and self-consistent wave heating through instabilities. General areas where we have and/or expect to apply the GSK technique for major advances include comparisons of time-dependent outflows in GSK and generalized transport formulations, transition regions, and auroral transport. We presented a quasi-invited talk on this at the Vancouver Symposium on Rarefied Gas Dynamics in August, the paper for which has been accepted for publication in the proceedings [Ref.1,2]. We will also present an invited talk on GSK modeling to the Spring AGU meeting [Ref.3].

In the area of GSK modeling of L = 4-7 core plasma evolution, we presented an invited review talk [Ref. 4] on this at the August MIT theoretical Geoplasmas Meeting and the paper has been accepted for publication in the proceedings [Ref. 5]. Specific treatment of ion and electron heating effects on hemispheric decoupling was also presented at the Fall AGU meeting and at the MIT meeting and accepted for the MIT proceedings [Ref. 6-8]; and an expanded work has been submitted for publication in the *Journal of Geophysical Research (JGR)* [Ref. 9] . We have also presented to AGU and submitted to *JGR* a comparison of baseline refilling predictions from hydrodynamic and semikinetic codes [Ref. 10,11]. We are also collaborating with a group at the University of Michigan on the modeling of dynamic convection effects on the plasmasphere, specifically on the issue of whether detached regions or streamers are created during enhancements of convection [Ref. 12,13].

We have now had accepted for the *Journal of Geophysical Research* the paper [Ref. 14] in which we compare the expansion into near-vacuum and the evolution of density perturbations, in the form of altitude-localized density cavities and enhancements, in the H^+/electron polar wind, for the hydrodynamic and semi-kinetic models. In general, we have found that there is significantly less tendency to form shocks and steep gradients in the semikinetic model than in the hydrodynamic model; owing to particle dispersion, such steep gradients tend to dissipate in the semikinetic description. We have also found increasing divergence between the two approaches generally as higher moments are considered; in particular, the parallel temperatures often deviate significantly. The general subject of hydrodynamic versus semi-kinetic modeling results is of significant interest currently, and we believe this work will be of substantial importance. It has been found, for the types of outflow situations considered, that the inclusion of heat flow has a major effect in bringing to closer agreement the parallel temperature profiles for the hydrodynamic and semikinetic models. We have received the referee's comments on this paper and have revised the paper in response to them and are almost ready to resubmit the paper. These results were also presented to the MIT Geoplasmas workshop [Ref. 15] and accepted for the proceedings[Ref. 16] and were presented to the Guntersville workshop on Magnetospheric plasma models [Ref. 17].

In one of the most exciting areas of progress, we have now developed a dynamic semikinetic model for examining the synergystic effects of waves and magnetospheric hot plasma populations on the outflowing ionospheric plasma. We have done this by imposing hot bi-Maxwellian ion and electron distributions at the top of our auroral simulation flux tube (4 R_e), as well as a spectrum of waves with altitude which perpendicularly heats the ionospheric ions. For example, when the hot ions are more strongly peaked at $\alpha = 90^{\circ}$ than the hot electrons, a positive potential develops at the top boundary, hence downward electric fields. With transverse wave heating below, this leads to a dynamic and partially self-consistent version of the ``pressure cooker" concept proposed by Gorney and coworkers. These and other new features of the behavior of Mesoscale Auroral Plasma Transport (MAPT) were presented at our recent Guntersville workshop and to the AGU Fall Meeting [Ref. 18, 19] and further results will be presented to the AGU Spring meeting [Ref. 20]. This will form the completion of the Ph. D. dissertation of Mr. D. G. Brown.

We have submitted a new paper [Ref. 21] to Geophysical Research Letters on a comparison between the measured polar magnetosphere total density altitudinal profile of Persoon et al.{1983} and densities from a semikinetic model of the state polar wind using the densities and flow velocities from Chandler et al [1991] as boundary conditions at 4000 km altitude. We find that we can almost perfectly reproduce the observed density profile using various combinations of warm base ion and electron temperatures in the semikinetic polar wind. For example, base ion and electron temperatures of 8000 K produce density profiles which match the Persoon et al profile, as do a base ion temperature of 5000 K and a base electron temperature of 10000 K. In these cases, it is found that O^+ is the dominant ion species in the polar wind up to 8 Re geocentric, with O^+/H^+ density ratios typically ~ 10.

A review paper on theoretical progress on polar plasma outflow was presented to the October workshop by [Ref. 22]. A summary report on the October workshop was submitted for publication in EOS [Ref. 23].

Collision-Collisionless Transition Model

We have prepared an O^+ transition region model to study the effects of diminishing O^+ - O^+ self collisions on the outflow of E X B heated O^+ at low altitudes. We found that the upflowing ions will first be entrained with the background ions, producing a thermal population with an elevated temperature. At higher altitudes the distribution splits into an upgoing, nearly conical population flowing through a Maxwellian core. Most of these results were presented at the Guntersville meeting [Ref. 24]. After that meeting ,we upgraded the transition region model to include ion-neutral collisions and reactions. As it currently stands, the model has polarization and resonant charge exchange collisions between O^+ and O, polarization collisions between O^+ and N2, chemical loss of O^+ to N2 and H, and photoionization of O.

Observations of O+ Outflows

We have also begun to address the statistical properties of outflowing O^+ through bulk parameter analysis of DE-1/RIMS observations when DE-1 was in the midaltitude polar cap magnetosphere. We have selected a technique which relies on analysis of the DE-1 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. 25] and further results will be presented to the Spring AGU meeting [Ref. 26]. Eventually we hope to analyze approximately 80 DE-1 northern hemisphere polar cap passes to provide statistical properties of the outflowing O^+.

Equatorial Transitions

We have initiated a statistical analysis of the properties of the equatorial latitudinal transition between trapped ions and field-aligned ion streams on $L \sim 4.6$ field lines with DE-1 RIMS measurements. In this study we are hoping to document the trends in the latitudinal location of this transition, the abruptness of the transition and the degree of penetration of the ion streams into the equatorial region, as well as the correlations with such parameters as equatorial total density and energetic ion anisotropy. We presented the initial results of this work at the Fall 1992 AGU meeting [Ref. 27] and have submitted an abstract on continued work for the Spring AGU [Ref. 28]. These studies together with the $L = 4\text{-}7$ plasma evolution modeling will form the basis of the Ph. D. dissertation of Ms. Joyce Lin.

Inner Plasmasphere-Ionosphere Coupling

We have re-initiated studies of the plasmasphere-ionosphere system from DE1/2 observations, focusing primarily on analysis of the ion temperatures at the high and low altitudes and using them to estimate ion heat fluxes into the topside ionosphere and compare heat conduction-dominated temperature profiles with additional field line crossings from the same satellites. A presentation was given at the Fall 1992 AGU meeting [Ref. 29], and a brief report is being prepared for submission to the Journal of Geophysical Research.

Plasma Wave Physical Processes

The emphasis of this research is to investigate how waves grow, propagate, and are absorbed and altered in inhomogeneous plasma media. One major objective is to estimate the coupling between the observed waves and the observed particle distributions (i.e. by estimating velocity space diffusion coefficients). In order to do this, we have concentrated initially on computer code development.

We have developed computer subroutines that compute the divergence of the group velocity for cold plasma wave modes. These subroutines have been incorporated into cold plasma ray tracing codes. This allows a more realistic estimate of the change in the energy density of the wave along a ray path.

We also incorporated hot plasma wave growth subroutines from the WHAMP (Waves in Hot Anisotropic Multi-component Plasmas) code into a cold plasma ray tracing code to estimate the path integrated gain of the wave amplitude. This code was then used to study the fine structure of equatorial fast magnetosonic waves that are destabilized by ring current velocity space distributions.

In a theory-observation comparison, we performed a detailed analysis of one observed velocity space ring distribution and concluded that the present model distributions available for use in the hot plasma code cannot adequately model this feature observed in the particle data. However, we have found a model distribution that is adequate; and we are currently developing the susceptibility tensor based on this model distribution for incorporation into the hot plasma code.

As a warm plasma complement to the ULF wave study described below, we have used standard mode conversion theory to investigate the effects of the hot plasma resonance cutoff at twice the O^+ cyclotron frequency on the propagation of low frequency compressional waves in the Earth's magnetosphere. We found that if the O^+ density and temperature are sufficient, waves above 0.1 Hz will be reflected out of the magnetosphere from this resonance. These results were reported to the ULF Wave Chapman Conference [Ref. 30].

ULF Wave Ray-Tracing

In this study of cold plasma raytracing, we have found that the magnetosphere can present a major barrier to the propagation of ULF waves in the Pc3 frequency range which have been generated at the magnetopause. The physical cause of this barrier is the He^+-O^+ cutoff between the respective gyroresonances. As a result of the frequency dependent location of this cutoff, the magnetosphere behaves like a low-pass filter for Pc3 compressional waves, so that only the lower frequency components can penetrate to the inner magnetosphere. Results are consistent with previous satellite observations. This filter action strongly depends on the relative concentration of He^+ and O^+ and is, therefore, sensitive to solar and magnetic activity. These results have been reported to the ULF Wave Chapman Conference in Williamsburg, VA [Ref. 31] and have been submitted for publication in JGR [Ref. 32].

Nighttime Anomalous Electron Heating Events

In our study of electron heating events observed at night by the Millstone Hill incoherent scatter radar, we are enlarging the data base, presently from 1967 - 1974. We are also establishing objective criteria so that weaker events can be included in the survey in order to carry out a statistical parametric analysis. These sudden heating events occur in almost all months except summer, making the usual suggestion, conjugate point photoelectrons, difficult to defend. To some extent, the behavior resembles subvisual SAR arcs, but the expected association with magnetic activity appears to be lacking, and the relatively short duration (typically 2-3 hours) also argues against this explanation. We are attempting to develop sufficiently large data base to characterize this phenomenon thoroughly so that its relationship to other geophysical parameters or events will be clarified. Preliminary results were presented to the Guntersville meeting [Ref. 33].

ANALYSIS TECHNIQUES AND SOFTWARE DEVELOPMENT

Empirical Model

RPA and spin curve analysis techniques for obtaining temperatures and spacecraft potentials from radial and end head data have been examined, tested, and finalized. The empirical model group (UAH, SSL and Boeing) are presently trying to track experimental uncertainties through the procedures in order to establish meaningful error bars on the results. We are also at the point of applying calibration to the countrates to determine absolute densities.

MEETINGS

Dr. Horwitz was co-convenor (with Dr. T. E. Moore, SSL) of 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. Members of our group were authors or co-authors of 12 papers presented to that meeting [Ref. 7, 12, 17, 18, 22, 24, 33, 34-38]. In addition, members of our group participated in the 18th Symposium on Rarefied Gas Dynamics, Vancouver, Canada, July, 1992 [Ref. 1], the Workshop on "Controversial Issues and New Frontier Research in Geoplasmas", Cambridge, Mass, August, 1992 [Ref. 4, 6, 15], the COSPAR 29th Plenary Session, Washington, D.C., August 28-September 5, 1992 [Ref. 39, 40], the Chapman Conference on Solar Wind Sources of Magnetospheric ULF Waves, Williamsburg, VA, September 14-18, 1992 [Ref. 30, 31], and the Fall Meeting of the American Geophysical Union, San Francisco, CA, December 7-11, 1992 [Ref. 10, 11, 13, 19, 25, 27, 29, 41, 42].

PUBLICATIONS

In addition to those noted above, the following papers are at the indicated stage in the publication cycle: Papers accepted and in press are those on semikinetic modeling for outer plasmasphere flux tubes [Ref. 43] and electrostatic charging of ring dust clouds [Ref. 44]. Paper submitted and under review is one on the relation of bi-Maxwellian plasma distributions to parallel electric fields [Ref. 45].

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