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for

SEMIKINETIC MODELING AND OBSERVATIONS OF HIGH-LATITUDE PLASMA OUTFLOW

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Prepared by:

J. L. Horwitz
Department of Physics/ Center for Space Plasma and Aeronomic Research
The University of Alabama in Huntsville
Huntsville, Alabama 35899
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I RECENT PROGRESS

In one of the most exciting areas of progress, we have now developed a dynamic semikinetic model for examining the synergistic effects of waves and magnetospheric hot plasma populations on the outflowing ionospheric plasma. We have done this by imposing hot biMaxwellian 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 $\alpha = 90^o$ then 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 et al.[1985]. This formed a paper[Brown et al., 1995b] which was submitted and recently accepted by JGR. In addition, a full paper on the semikinetic modeling of conics formed through the Current-Driven Ion Cyclotron Instability(CDICI), is finally ready to be submitted to the *Journal of Geophysical Research*[Brown et al.,1995a].

The invited paper on plasma transport using semikinetic models[Horwitz et al., 1994b] for the Rarefied Gas Dynamics proceedings appeared.

We have also addressed the quasi-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 thirteen passes and tested our technique with reasonably good assurance in the derived parameters. We have obtained average altitudinal profiles for the density, temperature and field-aligned flow velocity of O^+ in the 3-5 R_E geocentric distance range. These results were published[Ho et al., 1994a] in *Geophysical Research Letters.*

A very exciting paper which was both submitted and appeared during this period in JGR [Horwitz et al., 1994c] concerned the centrifugal acceleration effects on the polar wind. Such parallel acceleration by convection is typically neglected in polar wind models. We found that it has major effects on H^+ and O^+ density, temperature and flow velocity profiles, and in particular is a viable explanation of the large (4-10 km/s) O^+ flow velocities observed in the low-to-midaltitude polar magnetosphere by the DE-1 and Akebono spacecraft, and also that, at least when the ionosphere is "cold", the escaping fluxes of O^+ from the topside ionosphere into the magnetosphere are increased by about a factor of 100 when the ionospheric convection electric field is increased from 0 to 100 mV/m.

In addition, a paper on observations and simulations of centrifugally-accelerated O^+ outflow was presented at the Substorms 2 conference in Fairbanks, Alaska and appeared in the proceedings[Ho et al., 1994b].

During this year, we also developed the extension of our GSK code to include the lower ionosphere and associated processes. Our initial goal has been to develop a relatively complete time-dependent flux tube model polar plasma transport describing H^+ and O^+ dynamics from 200 km altitude to several R_E. We achieved this by extending the GSK model down to 200 km, and including required collision, ionization, and chemical processes in the ion kinetic transport. During this year our progress included the following: (1) Added H^+ as a dynamic species, and included all chemistry and collisions kinetically needed to describe the H^+ and O^+ dynamics; (2) Incorporated our generalized electron fluid description into this code(which currently describes the electrons with a Boltzmann relation); (3) Incorporated the two-stream model for auroral electrons[Richards and Torr, 1990] including secondary and backscattered components.

There were two specific science projects for which these technical developments have already been applied. First, we studied the influence of the ionization and electron heating produced by soft auroral electrons on the topside ionosphere, and predicted the resulting outflows into the high altitude(several R_E) collisionless region. The initial results paper on this was presented at the October 1994 Guntersville workshop and has been submitted for the AGU monograph associated with it[Brown et al., 1995c].

Second, we were able to combine the two ExB effects on outflow described by Wilson[1994](low-altitude frictional heating) and Horwitz et al.[1994c](high-altitude centrifugal acceleration) into a unified self-consistent GSK model, so that we could study the ExB-driven outflow effects for various electric fields and associated time variations. The initial results paper on this was presented at the October 1994 Guntersville workshop and has been submitted for the AGU monograph associated with it[Ho et al., 1995a].

Finally, perhaps our most exciting project currently is a study of F-region upflows using a modification of the FLIP ionospheric fluid dynamics model of

Richards and Torr[1986] to allow for the effects of soft electron precipitation ionization and convection-driven ion heating, and performed comparisons with satellite and radar data. In this study we used two published cases from JGR in which latitudinal auroral oval profiles of electron precipitation characteristics and convection were presented. We then used a large number of flux tubes(10 FLIP flux tubes per degree latitude), and ran the model first for 24 hours without the observed convection and precipitation effects to attain an approximate initial equilibrium, and then for one further hour with the convection and precipitation characteristics for each latitude in each flux tube. The resulting ionospheric "outputs" of ion densities, upflow velocities and ion temperatures were then compared with the published profiles of these ionospheric parameters. We attained excellent agreement with the ion temperatures and reasonable similarity with the observed densities, and upflow velocities and fluxes. Therefore, we believe that, based on these initial indications, the combined effects of convection ion heating and abrupt ionization by soft auroral electron precipitation can indeed be identified as the principal mechanisms for driving F-region upflows in the auroral region, and that alternative proposed mechanisms involving convection-shear heating and electron temperature hot spots may not be significantly required. We are currently preparing a submission on this topic to *Geophysics Research Letters*[Liu et al., 1995a].

REFERENCES

Brown, D. G., J. L. Horwitz, and G. R. Wilson. Generalized SemiKinetic(GSK) modeling of auroral conic production due to the Current-Driven-Ion-Cyclotron-Instability(CDICI). *J. Geophys. Res., submitted*, 1995a.

Brown, D. G., J. L. Horwitz, and G. R. Wilson. Synergistic effects of hot plasma-driven potentials and wave-driven ion heating on auroral ionospheric plasma transport. *J. Geophys. Res., in press*, 1995b.

Brown, D. G., P. G. Richards, G. R. Wilson, J. L. Horwitz, and C. W. Ho. Effects of precipitating auroral electrons on ionospheric plasma transport: A dynamic semikinetic model. In N. Singh J. L. Horwitz and J. L. Burch, editors, *Cross-Scale Coupling in Space Plasmas*. American Geophysical Union, 1995c.

Gorney, D. J., Y. T. Chiu, and D. R. Croley, Jr. Trapping of ion conics by downward electric fields. *J. Geophys. Res., 90*, 4205, 1985.

Ho, C. W., J. L. Horwitz, and T. E. Moore. DE-1 observations of polar O^+ stream bulk parameters and comparison with a model of the centrifugally-accelerated polar wind. *Geophys. Res. Lett., 21*, 2459, 1994a.

Ho, C. W., J. L. Horwitz, and T. E. Moore. Observations and simulations of centrifugally-accelerated polar O^+ ouflows. In J. D. Craven S.-I. Akasofu and J. R. Kan, editors, *Proceedings of International Conference on Substorms II*, pages 577–581. 1994b.

Ho, C. W., J. L. Horwitz, G. R. Wilson, and D. G. Brown. Field-aligned transport of ionospheric O^+ ions from 200 km to 1 r_e due to exb convection heating and centrifugal acceleration: A generalized semikinetic(GSK) treatment. In N. Singh J. L. Horwitz and J. L. Burch, editors, *Cross-Scale Coupling in Space Plasmas*, page submitted. American Geophysical Union, 1995a.

Horwitz, J. L., G. R. Wilson, J. Lin, D. G. Brown, and C. W. Ho. Plasma transport in the ionosphere-magnetosphere system using semikinetic models. In B. D. Shizgal and D. P. Weaver, editors, *Rarefied Gas Dynamics: Experimental Techniques and Physical Systems*, volume 158, pages 500–511. AIAA, Washington, D. C., 1994b.

Horwitz, J. L., C. W. Ho, H. D. Scarbro, G. R. Wilson, and T. E. Moore. Centrifugal acceleration of the polar wind. *J. Geophys. Res.*, *99*, 15051, 1994c.

Liu, C., J. L. Horwitz, and P. G. Richards. Effects of convection ion heating and soft-electron precipitation on high-latitude F-region upflows. *Geophys. Res. Lett.*, *to be submitted*, 1995a.

Richards, P. G., and D. G. Torr. Thermal coupling of conjugate ionospheres and the tilt of the earth's magnetic field. *J. Geophys. Res.*, *91*, 9017, 1986.

Richards, P. G., and D. G. Torr. Theoretical modeling of the dependence of the N_2 second positive 3371 Å auroral emission on characteristic energy. *J. Geophys. Res.*, *95*, 10337, 1990.

Wilson, G. R. The generation of O^+ upflowing velocity distributions via ExB convection in the transition region. *J. Geophys. Res.*, *99*, 17453, 1994.