Localized Ionospheric Particle Acceleration *and* Wave Acceleration of Auroral Ions: Amicist Data Set

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FINAL REPORT
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This report serves as the Final Report for both NAGW-3980 and NAGW-4772, as the two projects were effectively merged.

1 Primary Results of Final Year's Efforts

The end result of this study of auroral ion acceleration processes is a manuscript entitled "Auroral Ion Acceleration from Lower Hybrid Solitary Structures: A Summary of Sounding Rocket Observations", by Lynch, Arnoldy, Kintner, Schuck, Bonnell, and Coffey. This manuscript has been submitted for publication to the Journal of Geophysical Research.

2 Summary of Progress Made over Course of Grant Period

2.1 Principal results of data analysis

Research supported under these grants covered two main topics: auroral ion acceleration from ELF-band wave activity, and from VLF-spikelet (lower hybrid solitary structure) wave activity. The main results of the two topics, which overlap significantly, are summarized here in excerpts from the resulting journal papers:

Recent auroral sounding rocket data illustrate the relative significance of various mechanisms for initiating auroral ion outflow. Two nightside mechanisms are shown in detail. The first mechanism is ion acceleration within lower hybrid solitary wave events. The new data from this two payload mission show clearly that a) these individual events are spatially localized to scales approximately 100 m wide perpendicular to **B**, in agreement with previous investigations of these structures, and b) that the probability of occurrence of the events is greatest at times of maximum VLF wave intensity. The second mechanism is ion acceleration by broadband, low frequency electrostatic waves, observed in a 30 km wide region at the poleward edge of the arc. The ion fluxes from the two mechanisms are compared and it is shown that while lower hybrid solitary structures do indeed accelerate ions in regions of intense VLF waves, the outflow from the electrostatic ion wave acceleration region is dominant for the aurora investigated by this sounding rocket, AMICIST. The fluxes are shown to be consistent with DE-1 and Freja outflow measurements, indicating that the AMICIST observations show the low altitude, microphysical signatures of nightside auroral outflow.

In this paper, we present a review of sounding rocket observations of the ion acceleration seen nightside auroral zone lower hybrid solitary structures. Observations from Topaz3, Amicist, and Phaze2 are presented on various spatial scales, including the two-point measurements of the Amicist mission. From this collection of observations, we will demonstrate the following characteristics of transverse ion acceleration (TAI) in LHSS. The ion acceleration process is narrowly confined to 90 degrees pitch angle, in spatially confined regions of up to a few hundred meters across B. The acceleration process does not affect the thermal core of the ambient distribution, and does not directly create a measurable effect on the ambient ion population outside the LHSS themselves. Within the LHSS region, it creates a high energy tail beginning at a few times the thermal ion speed. The ion acceleration events are closely associated with localized wave events. Accelerated ions bursts are also seen without

a concurrent observation of a localized wave event, for two possible reasons. In some cases, the pitch angles of the accelerated tail ions are elevated above perpendicular; that is to say, the acceleration occurred below the observer and the mirror force has begun to act upon the distribution, moving it upward from the source. In other cases, the accelerated ion structure is spatially larger than the wave event structure, and the observation catches only the ion event. The occurrence rate of these ion acceleration events is related to the ambient environment in two ways: its altitude dependence can be modelled with the parameter B^2/n_e, and it is highest in regions of intense VLF activity.

2.2 Papers

A bibliography of journal papers supported by these grants is included at the end of this report.

2.3 Presentations

Presentations of the work done under this grant included:

- Lynch, Fall 1998 UNH EOS Seminar: "Untangling the Aurora: Multiple-Point Observations above the Northern Lights"
- Lynch et al., 1998 Cambridge Workshop, Portugal: "Transverse ion acceleration from lower hybrid solitary structures — auroral sounding rocket observations"
- Lynch et al., 1997 Interrelationships between Plasma Experiments in the Laboratory and in Space (IPELS) Conference, Maui: "Auroral Particle Acceleration and Electric Currents"
- Lynch et al., 1997 AGU Spring Meeting, Baltimore: "Ion Acceleration in the Auroral Zone: from Sounding Rockets to Polar"
- Lynch, Fall 1995 UNH Physics Seminar: "Auroral Ion Outflow on the Nightside"
- Lynch et al., 1995 IPELS Conference, Scotland: "Amicist: Two-Point Sounding Rocket Measurements of Ion Acceleration in the Nightside Auroral Zone"
- Lynch et al., June 1995 Invited Lecture, NRL: "Wave Acceleration of Ions in the Aurora: Topaz3 and Amicist Sounding Rocket Observations"
- Lynch et al., 1995 Cambridge Workshop, Bermuda: "Lower Hybrid Spikelets: Auroral Butterflies? or Magnetospheric Thermometers?"

2.4 Service

- Session convenor and chair, 1997 AGU Fall Meeting, San Francisco: "Auroral Zone Ion Acceleration and Outflow: Recent Progress"; 3 sections, 42 papers

- Employer: various undergraduate physics majors were employed as hourly employees under these grants. They learned: to handle large data sets in a Unix-based environment, to recognize and extract data patterns, something about auroral physics, much about data processing and programming.

2.5 Data Products

A productive result of these grants was the generation of a generalized data extraction and processing tool which incoporates data from an entire series of auroral sounding rockets. This allows the data from different missions to be quantitatively compared. The tool will continue to be used after the grant has expired for future data analysis projects and future rockets.

2.6 Continuing efforts

Work under these grants has produced an exhaustive analysis of the LHSS-TAI data from Topaz3 and Amicist. We have characterized and cataloged the observed LHSS-TAI events, and been able to detail the behaviour of the ion acceleration process. However, we still do not fully understand the underlying physics, and will continue to work with theoriticians to provide the observations to them as data products they can incorporate into their models.

Future data analysis studies on the part of the PI will move into a slightly different regime, focussing on the effects of structured electric currents on ion acceleration processes, using FAST data as a guest investigator, along with future sounding rocket data.

References

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