Satellite Observations of Band-Limited Pc1 Waves Associated with Streaming H+ and O+ Ions in Earth’s High-Latitude Magnetosphere

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Introduction
Earth is protected from much of the Sun’s harmful radiation by the Magnetosphere. This protective shell is elongated on Earth’s nightside in the same way as a comet’s visible tail is elongated, each by the solar wind – this elongated region is known as the Magnetotail. The Cluster Satellite mission, a collaboration between the European Space Agency (ESA) and the National Aeronautics and Space Administration (NASA), provided a unique opportunity to observe a dawn side formation with an orbital apogee of 18.7 RE (Earth Radii) – that’s about 1/3 the distance to the moon.

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Procedure
The wave events observed in this study were originally encountered while searching a Cluster data set for a previous study of waves similar to those observed in this study were originally encountered while searching a Cluster data set for a previous study of waves. The wave events observed in this study were originally encountered while searching a Cluster data set for a previous study of waves. The wave events observed in this study were originally encountered while searching a Cluster data set for a previous study of waves. These waves, which are not monochromatic but are limited in frequency spread (“band limited”), are associated with bursts of protons (H+) amidst a sustained population of Oxygen ions (O+). From the lower 4 panels (D–G), it is apparent that these band-limited waves have some correlation to the increased population of protons. Additionally, waves occurred only when H+ ions were increased by factors of 10–1000 and energies of both ion species increased by factors of up to 10 (D–F). Also note, the band of O+ is quite obvious in the panel of all ion populations (D), with the O+ having approximately 16 times greater energy than the H+. The panels (D–G) show the pitch angles of the population of ions to be mostly aligned with the magnetic field. The spacecraft is near the southern polar cap on the dusk side during the event, so this means the population is advancing tailward, away from Earth. Comparison of the mass ratio of O+ to H+ (1:16) with the energy ratio (1:16) indicates that these ions move with the same velocity (~140 km/s).

In an attempt to discover more O+ band events, the entirety of the months before, during, and after the observed events were observed. The apogee of the spacecraft during both data sets (2002 & 2003) was near midnight at the beginning of the set, and near dusk at the end of the set.

Discussion
These observations raise two major questions. First, what is the detailed mechanism by which these streaming ions generate the observed waves? More puzzling, perhaps, is why two ion species, with the same charge but different masses, should flow along magnetic field lines at the same velocity. Acceleration by an electric field would produce a mass-dependent acceleration, for example. The well-known v x B drift velocity does in fact produce mass-independent drift, but in a direction perpendicular to B. Theoretical work is needed to determine whether field line curvature can convert such a drift velocity into motion parallel to the field.

Future Work
Though to date we have only discovered two such magnetic wave events associated with bursts of protons amidst a sustained O+ band, it would appear that the particle configuration is not uncommon. We plan to survey the supplementary months of 2002 and 2003 ion spectrometer data to observe the events throughout an entire precessional period. We will also compare the observed O+ band times with magnetometer data to assess whether there are any other events (other than the 2 displayed here) that exhibit a magnetic disturbance.

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