The Ionospheric Alfvén Resonator and Magnetosphere-Ionosphere Coupling in the Pc1 Band.
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Introduction.
The current and proposed instruments of the Canadian Array for Realtime Investigations of Magnetic Activity (CARISMA) provide an excellent and growing opportunity to study wave phenomena in the high-frequency end of the ULF band. Short-period events that fall into this part of the frequency spectrum, from 0.1 to 5.0 Hz, are called Pi1 and Pi2 pulsations. Some phenomena of current and future research interest include magnetic signatures of the ionospheric Alfvén resonator, Pi1 pearl pulsations and PiB indicators of substorm onset. By observing and learning about these pulsations, a better understanding of the Earth-ionosphere cavity can be gained of the structure and dynamics of the Earth’s magnetosphere and ionosphere, including the complex interaction, or coupling, between them.

Research Tool: CARISMA.
CARISMA, the Canadian magnetometer array (formerly CANOPUS), currently consists of thirteen fluxgates which have been upgraded from 5 second resolution to a data stream sampled at 8 Hz. The increased resolution has enabled the study of the ULF spectrum to be extended to ~ 2 Hz. Furthermore, CARISMA will be expanded in the future; with fifteen new fluxgates and eight search coil magnetometers deployed throughout Canada and down into the northern United States. The expansion will extend coverage along the Churchill line and will provide coverage along another meridian stretching through Alberta. The induction coils will reinforce these meridional chains, as well as providing data sampled at 20 Hz. This high resolution magnetic data will enable the study of wave phenomena up to 10 Hz - great news for short-period ULF research.

Research Interest: Ionospheric Alfvén Resonator.
The ionospheric Alfvén Resonator (IAR) is a natural resonant cavity in the ionosphere formed between two regions of large Alfvén velocity gradients. The upper cavity boundary is typically located at a height of about 3000 km, while the lower boundary is formed on the lower side of the ionospheric F-region electron density maximum. Shear Alfvén waves (traveling along geomagnetic field lines) can become trapped in the cavity, and a vertical standing wave pattern may develop in the ionosphere. Leakage of waves from the resonator back to the Earth-ionosphere cavity can occur and be detected on the ground using magnetometers.

Figure 1. Existing and proposed CARISMA instruments. (Map courtesy of D.K. Milling.)

Figure 2. Spectral Resonance Structure observed at Geophysical Observatory Sodankyla (SGO) for two successive days. Intervals of visible SRS are marked by black bars above the spectrogram. [From Yahnin et al., 2003.]

It is possible that the structures may be absent in total power but appear clearly in the dynamic power spectra of the horizontal and vertical components in color-coded form, where R and L represent right-hand and left-hand circularly polarized components. The degree of polarization is expressed as a percentage, with red for right-hand and blue for left-hand polarization. It is possible that the structures may be absent in total power but appear clearly in the dynamic power spectra of the horizontal and vertical components in color-coded form, where R and L represent right-hand and left-hand circularly polarized components. The degree of polarization is expressed as a percentage, with red for right-hand and blue for left-hand polarization.

Figure 3. SRS in Polarization Properties.
(a) the power spectral density (PSD) of the magnitude of the horizontal magnetic disturbance (rose) vector of arbitrary scale (step or byte to the power of two per Hz).
(b) the degree of polarization in % for all PSD levels above 100 in (a).
(c) the ellipticity (e) = (L/R) + (R/L), where R and L represent the right- and left-hand circularly polarized components in color-coded form with red for right-hand (e = +1) and blue for left-hand (e = -1) circular polarization for all PSD levels with a degree of polarization greater than 70%.
(d) the angle of the major axis of the horizontal polarization ellipse with the direction of magnetic field in degrees.
(e) the amount of polarization positively in the counter clockwise direction. (Note: LT = UT + 1.5h). [From Bosinger et al., 2003.]

Future Research Interests: Pi1 Pearl Pulsations
Structured Pi1 pulsations called ‘pearls’ can be studied using ground magnetic data in the 0.1 to 5 Hz portion of the ULF spectrum. These pulsations get their name from the pearl necklace-like appearance of their amplitude-modulated sequence of ‘beads’ in the time domain. The frequency modulation of these pulsations is even more interesting and the search for mechanisms responsible for the frequency-amplitude modulation and propagation of these waves is still an important issue in the study of short-period pulsations today.

Figure 4. Pearl pulsations observed at Gilliam station. (CGM coordinates, L = 6.4, Long = 312.2, L-value = 6.4).

PiB Irregular Pulsations
PiB’s are broadband impulses made up of a train of PiB1 (T = 1 - 40 sec) and PiB2 (T = 40 - 150 sec) irregular pulsations. They are the first pulsation signatures of magnetic field line reconnection in the geomagnetic tail at the beginning of a substorm (Kangas et al., 1998). PiB’s have been studied as indicators of substorm onset, however, the temporal development of PiB1’s correlates well with onset and intensifications, suggesting that they may also be used as good monitors of substorm development (Yahnin et al., 1996). PiB research therefore shows great promise for the advancement of substorm onset timing and the understanding of complex substorm magnetosphere-ionosphere interactions.