The morphology and characteristics of Equatorial Magnetosonic Waves in the Terrestrial Inner Magnetosphere

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**Equatorial noise**

- Electromagnetic fluctuations observed in the frequency range $\Omega_p < \omega < \omega_{LH}$
- Distances in the range $L=3-5$
- The waves were elliptically polarised
- $k$-vector almost perpendicular to $B_0$—confined to a few degrees equatorial region
- $\Delta B$ directed parallel to the external magnetic field.
- Complex frequency structure, dominant oscillations at ion gyroharmonics
- Finer substructure characterised by frequencies $\Omega_p/8$ and $\Omega_p/2$.

- Occurrence coincident with peaks in the energy spectra of 90° pitch angle protons (ring-like ion distributions)

The dispersion obtained was characterised by multiple branches at frequencies $\omega=\pi \Omega_p$, reducing to the cold plasma dispersion $\omega \sim k_{\text{perp}} V_A$ as ring density $\rightarrow$ zero.
This study uses data from STAFF-SC magnetometer.

To study higher frequencies limited to burst science mode (BM1)

Sampling 450Hz, 180Hz filter
Propagation Properties

Wave amplitudes

Banded structure

Ellipticity

Ratio intermediate to maximum eigenvalues

Typically $\frac{e_{int}}{e_{max}} < 0.1$

K-vector direction wrt external magnetic field

Almost perpendicular

Maximum eigenvector direction

Parallel to external field – compressive wave
K-vector distribution

Distribution of wave vector directions

For a 20 second period
  • minimal frequency change

Use wavelet frequency decomposition
  • Each frequency has \( \sim 9000 \) k-vector

Histogram of values shows peak
  • 88-92 degrees (resolution 0.5 deg)

Two basic distributions
  • Peak either side of 90 degrees
  • Single peak at 90 degrees

Evidence for two generation mechanisms,
  • one for \( \theta_{Bk} < 90 \),
  • another for \( \theta_{Bk} = 90 \) [Chen 2015]
Pillar type emissions usually consist of

- Well defined set of bands
- Frequencies are unrelated to the local background magnetic field.
- Observed in the frequency range $n \Omega_p$ where $1 < n < 5$
- Some instances $n > 15$ (see left)
- Typically observed North of the magnetic equator
- All magnetic local times
- Inside plasmapause, $2 < L < 3.5$
Pillar - Location

Distribution of locations when ‘pillar type’ emissions were observed during burst data periods in the SM X-Y plane:

- Solid lines indicate periods when emissions were observed.
- Colour (black, red, green, blue) indicates satellite C1, C2, C3, or C4.
- Model plasmapause location calculated using model of Liu and Liu (2014) based on Dst (crosses) and AE (circles).
Funnel Properties

- Not all observations of magnetosonic waves show a clear frequency structure.
- An example of a ‘funnel shaped’ emission
- Does not appear to possess any clear discrete emission lines.
- The individual spectra on the right confirm this.
Funnel Location

As can be seen from the figure, these emissions were observed

- From 03-18 MLT
- Inside the model plasmapause.
Rising Tone Spectrum

Rising tone magnetosonic waves

- First reported Fu 2014 (VAP), Boardsen, 2014 (THEMIS), Nemec 2015 (Cluster)
- Periodic occurrence, typically 1-2 minutes
- Emission frequencies coincident with gyroharmonic frequencies
- Usually accompanied by other magnetosonic emissions above or below periodic emissions
Rising Tone Spectrum
Rising Tone v Magnetic Field
Non-Time Continuous
Properties
Shown various examples of Equatorial Magnetosonic Wave emissions

Banded emissions
• Track proton gyrofrequency emissions
• Propagation almost perpendicular to eternal field
• Evidence for propagation exactly perpendicular (different generation mechanism)

Funnel shaped emissions
• No Frequency structure

Rising tone emissions
• Occurrence related to low frequency magnetic field oscillations

Non time continuous emissions
• Sometimes emissions follow gyrofrequencies
• Other times emissions show frequency changes independent of local field

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