ST−026

A TOOL TO INVESTIGATE THE PROPAGATION OF WAVES MEASURED BY THE STAFF EXPERIMENT ONBOARD CLUSTER

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STAFF Experiment

(Spatio Temporal Analysis of Field Fluctuations)

- search coil sensors (tri−axial, 0.1 Hz− 4 kHz)
- waveform analyzer (0.1 −180 Hz)
- spectrum analyzer

On−board analysis

- 27 frequency channels 8−4096 Hz, 26% bandwidth
- 3 magnetic (STAFF) and 2 electric signals (EFW)
- complex amplitudes $B_X(\omega)$, $B_Y(\omega)$, $B_Z(\omega)$, $E_Y(\omega)$, $E_Z(\omega)$
- spectral matrix 5x5: $S_{ij} = \langle X_i X_j^* \rangle$

S = (autospectra | cross− * spectra)

- power−spectral densities (recorded each 0.125s−2s)
- relative phase shifts, mutual coherency (each 1s−4s)

Data processing using PRASSADCO

(PRopagation Analysis of STAFF−SA Data with COherency tests, http://www−pw.physics.uiowa.edu/~os/PRASSADCO/) Computer program designed to analyze multicomponent measurements of electromagnetic waves.

Data: spectral matrices (1) from ESA CD−ROM data, preprocessed by a calibration program, or (2) calculated from another source

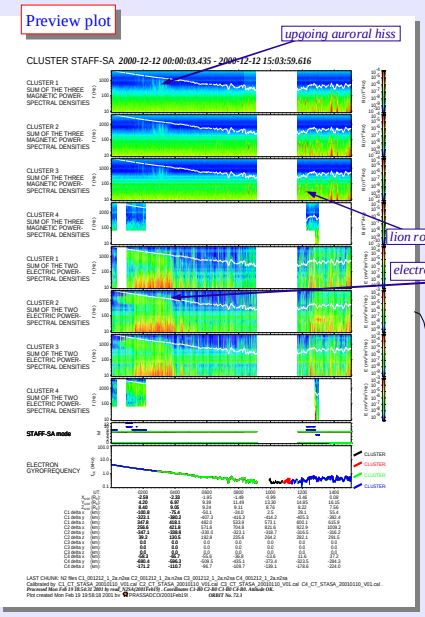
Results:

- power−spectral densities,
- wavevector direction from the magnetic field fluctuations
- planarity, ellipticity of polarization, sense of polarization
- mutual coherence of components, degree of polarization
- axes ot the polarization ellipsoid
- wavevector direction from both electric and magnetic fields
- index of refraction (wavelength, phase speed)
- parallel component of the Poynting vector
- complete direction of the Poynting vector
- Poynting flux
- auxiliary data (position, DC magnetic field)

Methods: *Means* [1972], *McPherron et al.* [1972], *Samson and Olson* [1980], *Santolík and Parrot* [1999], Singular value decomposition of the magnetic spectral matrix ($\boldsymbol{k} \cdot \boldsymbol{B} = 0$), or SVD solution to the set of equations from $\boldsymbol{k} \times \boldsymbol{E} = \omega \boldsymbol{B}$ using a combined electromagnetic matrix

Formats: PostScript figures, GIF figures, ASCII files

Preview plot



Plane−wave methods

$\nabla \times \mathcal{E} = -\partial \mathcal{B} / \partial t$ *Faraday's law*

($\boldsymbol{k}$ *wave vector*) (ω *frequency*)

$\boldsymbol{k} \times \boldsymbol{E} = \omega \boldsymbol{B}$

$\boldsymbol{E} \cdot \boldsymbol{B} = 0 \quad (\boldsymbol{B} \perp \boldsymbol{E})$

$\boldsymbol{k} \cdot \boldsymbol{B} = 0 \quad (\boldsymbol{B} \perp \boldsymbol{k})$

Wavevector direction (180° ambiguity):

$\boldsymbol{B} \cdot \boldsymbol{k} = 0 \quad (\boldsymbol{B} \perp \boldsymbol{k})$

$$\begin{pmatrix} \Re S_{11} & \Re S_{12} & \Re S_{13} \\ \Re S_{21} & \Re S_{22} & \Re S_{23} \\ \Re S_{31} & \Re S_{32} & \Re S_{33} \\ 0 & -\Im S_{12} & -\Im S_{13} \\ \Im S_{12} & 0 & -\Im S_{23} \\ \Im S_{13} & \Im S_{23} & 0 \end{pmatrix} \cdot \begin{pmatrix} k_1 \\ k_2 \\ k_3 \end{pmatrix} = 0$$

The third electric component:

$\boldsymbol{B} \cdot \boldsymbol{E} = 0 \quad (\boldsymbol{B} \perp \boldsymbol{E})$

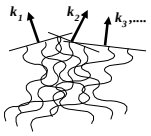
$E_3 = (E_1 B_1 + E_2 B_2) / B_3$

Wavevector direction,
Refractive index (kc/ω) ***−> wavelength, phase speed:***

$\boldsymbol{n} \times \boldsymbol{E} = \epsilon \boldsymbol{B}$

Wave distribution function

$G(\boldsymbol{k})$... ***distribution of the wave energy density***



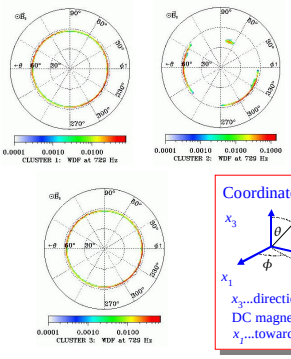
$S_{ij} = \int a_{ij}(\boldsymbol{k})\, G(\boldsymbol{k})$

$a_{ij}(\boldsymbol{k})$ ... spectral matrices predicted by the theory

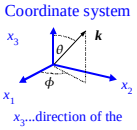
Analysis of upgoing auroral hiss

Cluster STAFF−SA

Wave distribution functions 2000−12−12 0257:36



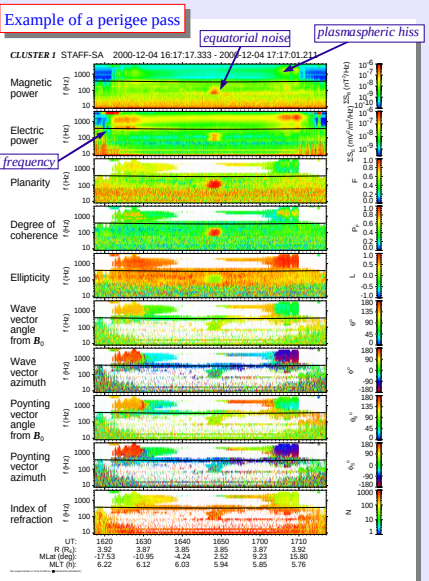
Coordinate system



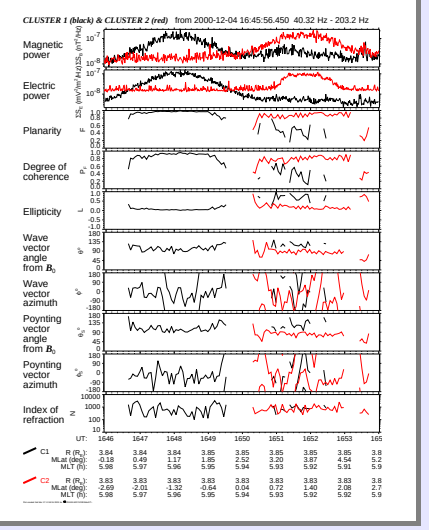
x_3...direction of the DC magnetic field

x_1...toward the Sun

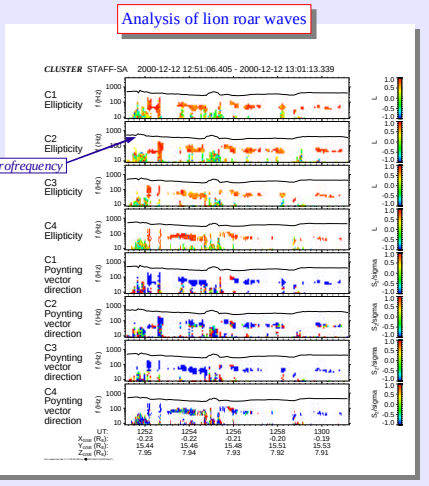
Example of a perigee pass



Analysis of equatorial noise



Analysis of lion roar waves



Lion roars