Type III Solar Radio Burst Directivity: Wind/Stereo observations

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SWG - Meudon, France, 20 – 22 April 2008
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Type III Solar Radio Burst

Solar Radio bursts

Ground-based

Space-based

Radio emission at \( F_p \) (Fundamental) And/or \( 2F_p \) (Harmonic)

\[
F_p \text{ (kHz)} = 9 \sqrt{N_e \text{ (cm}^{-3})}
\]

\[ \rightarrow F_p \propto 1/R \]
The S/Waves instrument

Deployed SWAVES
Electric Field Antenna (6 m)
dipole or monopole mode

- Fixed Frequency Receiver (FFR) : 30 or 32 MHz
- High Frequency Receivers (HFR1 and HFR2) 125-16025 kHz
- Low Frequency Receiver (LFR) : 2-160 kHz
Observations

- ~120 type III bursts simultaneously observed by STEREO A, B and Wind spacecraft during 2007.

- Separation angle A with B ~ 0° to 40°

Some very quiet periods

(http://secchirh.obspm.fr)

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Comparison with Wind/WAVES data

At the beginning of 2007 ➔ Wind, Stereo A & B at the Earth ➔ \( S_W \approx S_A \approx S_B \)

\[
S \left( \frac{W}{m^2 \ Hz} \right) = \frac{P(V^2/Hz)}{\gamma}
\]

Stereo A (Red), Stereo B (Blue), Wind (Black), 925kHz and 625kHz. Independent Calibrations

**F = 925 kHz**

**F = 625 kHz**

No significant intensity variation until July 2008
Directivity evidence

Type III source position determination:
1. Associated active region (flares, Nancay)
2. Spiral-like open magnetic field line
3. Density model

Max(I_A/I_B) \approx 10 for \Delta \varphi \approx 40^\circ

Need more statistics and larger angular separation between spacecraft to perform accurate radiation diagram determination.
Type III directivity study below ~ 1MHz using Wind/Ulysses observations during full solar cycle 23.

*(Bonnin et al., A&A, Accepted)*

**Longitudinal diagram:**

- Eastern shift of diagram axis:
  - $\phi_0 \sim -23^\circ$ at $f \sim 800$ kHz
  - $\phi_0 \sim -55^\circ$ at $f \sim 100$ kHz

- Large diagram aperture:
  - $\Delta \phi_2 \sim 96^\circ$ at $f \sim 800$ kHz
  - $\Delta \phi_2 \sim 124^\circ$ at $f \sim 100$ kHz

**Latitudinal diagram:**

- No correlation with longitudinal directivity.
- Weak directivity effects.
Radio Energy

\[ E_R(f) = \int_{4\pi} E(f) d\Omega \quad \text{with} \quad E(f) = \frac{1}{D(\varphi, \theta)} \int_{t_{\text{onset}}}^{t_{\text{end}}} S(t, f, \varphi, \theta) d^2 dt \]

- Energy Peak (?)
- Dispersion in energy when frequency decreases (?)
- \( !! \) Fundamental + Harmonic
- \( !! \) Radio energy losses by propagation effects

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Summary

• S/WAVES HFR data in good agreement with well calibrated WIND/Waves data.

• We begin to observe directivity effects but …
  – Need more statistics and larger angular separation between spacecraft to get Radiation diagram.

• However using diagram extrapolation, we are able to extract preliminary values of type III radio energy.
  – Energy Peak
  – Energy dispersion with frequency
Thank you
Calibration of High Frequency Receivers (HF1 & HF2)

Receiver background + shot noise removed  \rightarrow  Galaxy (+ antenna resonance)

\[ P_{gal}(V^2/Hz) \]
Galaxy model from Dulk et al. (2001) & Manning & Dulk (2001)

$S_{\text{gal}}(W / m^2 / Hz)$
\[ S_{\text{galaxy}} \left( \frac{W}{m^2/Hz} \right) = \frac{P_{\text{galaxy}} \left( \frac{V^2}{Hz} \right)}{Z_0 L_{\text{eff}}^2 \left( \frac{C_a}{C_a + C_b} \right)^2} \]

**Calibration**

Antenna gain $\gamma$