WG2 Report

CMEs, shock waves, and their radio diagnostics

(B. Vrsnak, A. Nindos)

Europska Unija
Ulaganje u budućnost
Projekt je sufinancirala Europska Unija iz Europskog socijalnog fonda

Topics

CMEs:

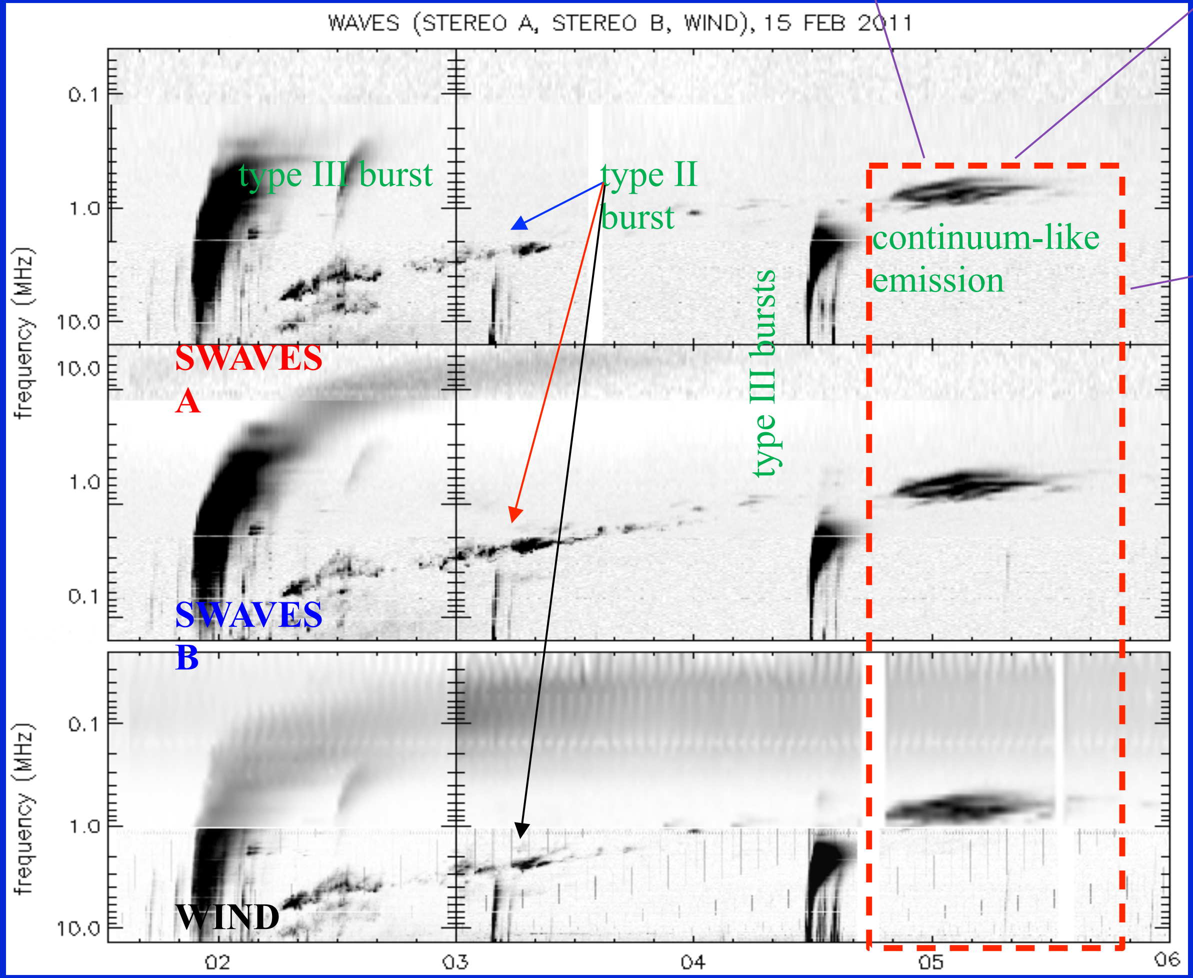
- CME-CME interactions
- Interaction of CMEs with ambient structures
- Radio emission from CMEs

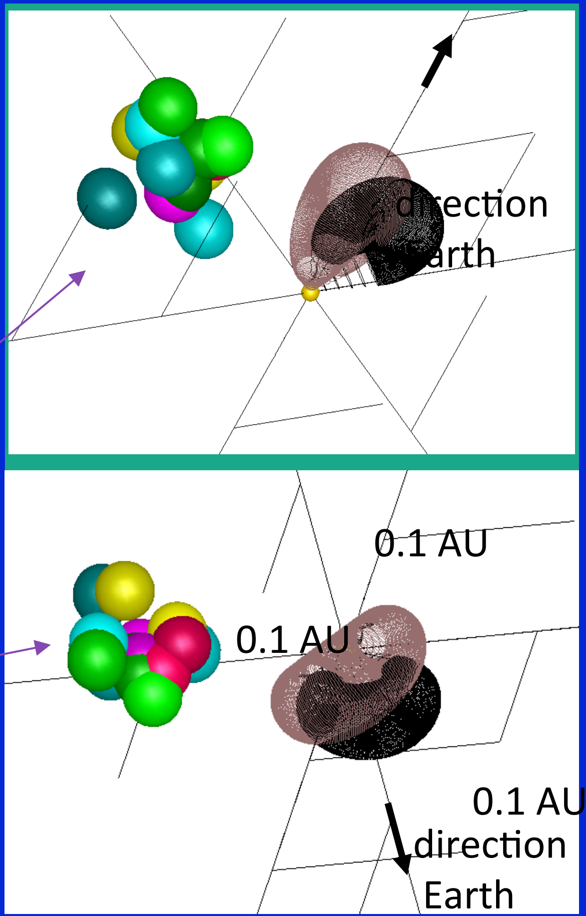
Shocks (mainly type II bursts):

- Location & characteristics of radio sources
- Band split
- Formation and propagation

Jasmina Magdalenic

Radio triangulation (Stereo-A,B/Waves) of the continuum-like emission associated with CME-CME interaction (2011 Feb 15)





<u>Results:</u>

a) really "continuum" since several frequencies at the same ~stationary sources (~1-4 MHz at ~20-30Rs);

b) radio source far from CMEs!

<u>Suggestion</u>: shock-shock interaction (?) *<u>Discussion</u>*: CME1 was slow, no shock signature? -> maybe sheath/shock; <u>Question</u>: what was spatial extent of the shock? -> check at STEREO A&B for the in-situ shock signature (?)

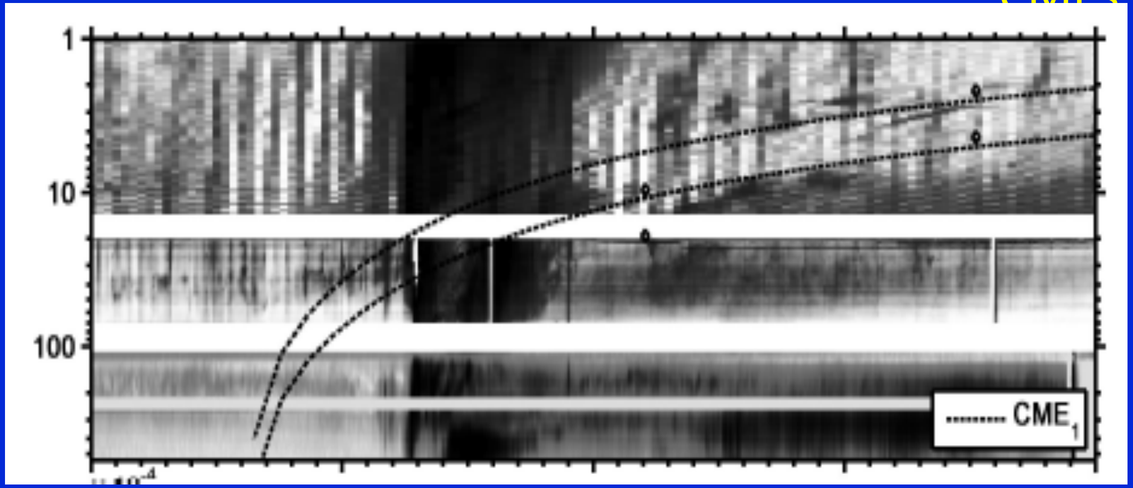
Additional information on triangulation source position (Vratislav Krupar) + showing 1/f -> different speeds, not compatible with v=const. source (both type II and III)

Alexander Nindos

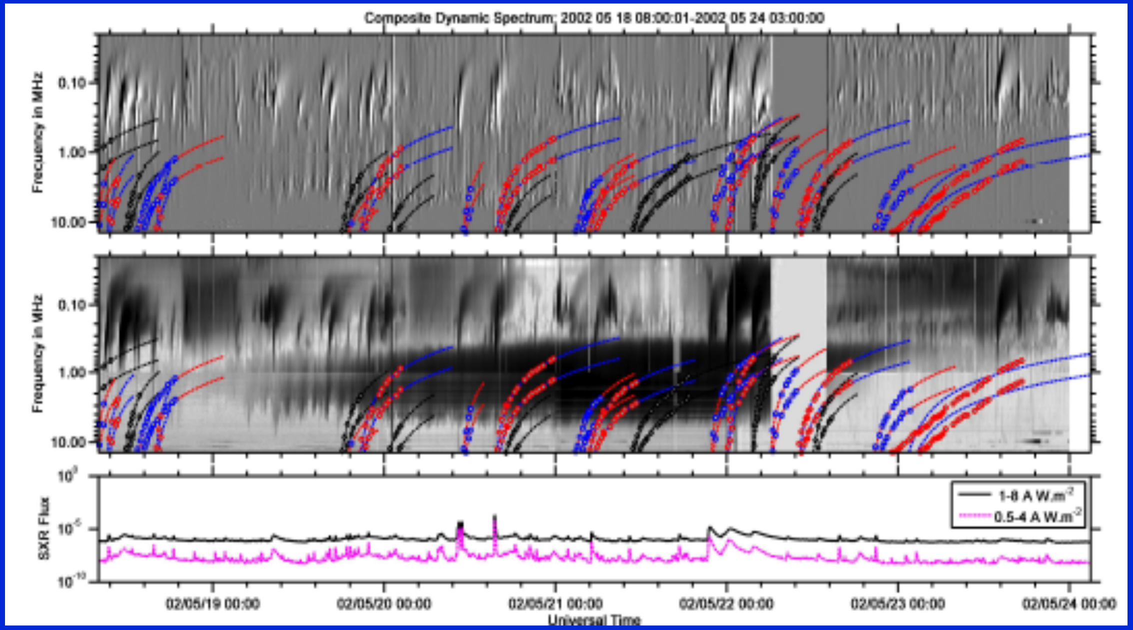
Interplanetary Type IV Bursts (continuum emission)

48 IP typeIV Wind/WAVES - characteristics of associated CMEs

Compact events



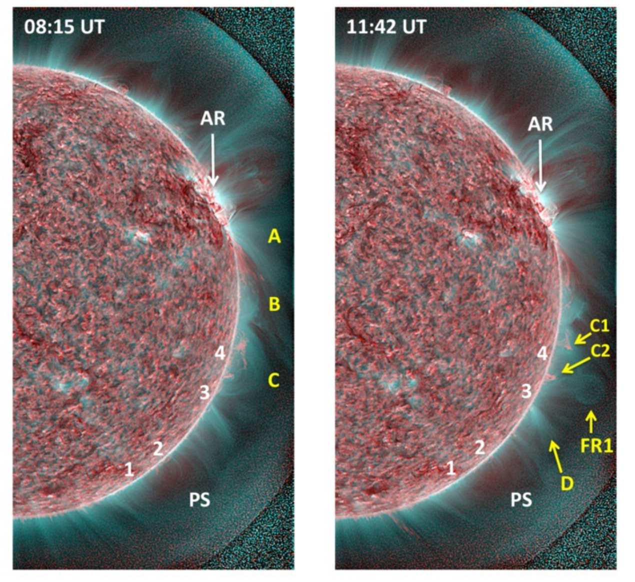
Extended events



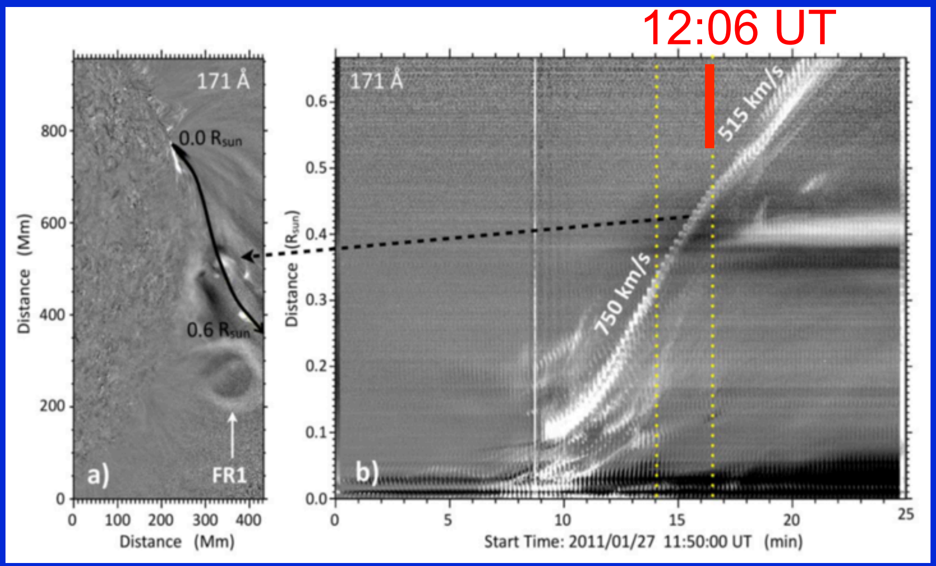
- CME kinematics -> f(t), compared with dynamic spectra
- Example: an extended even lasting for more than 100 h
- Distribution of durations: two classes – compact (45 events), extended (3 events)
- Distribution of compact events: CMEs are much faster and wider (mostly halo) than average; mostly M/X class flares; average duration 106 min.
- In 43/45 events CMEs were subject to reduced drag (propagating in the wake of previous CME
- Extended events: weak flare/CME events

Monique Pick

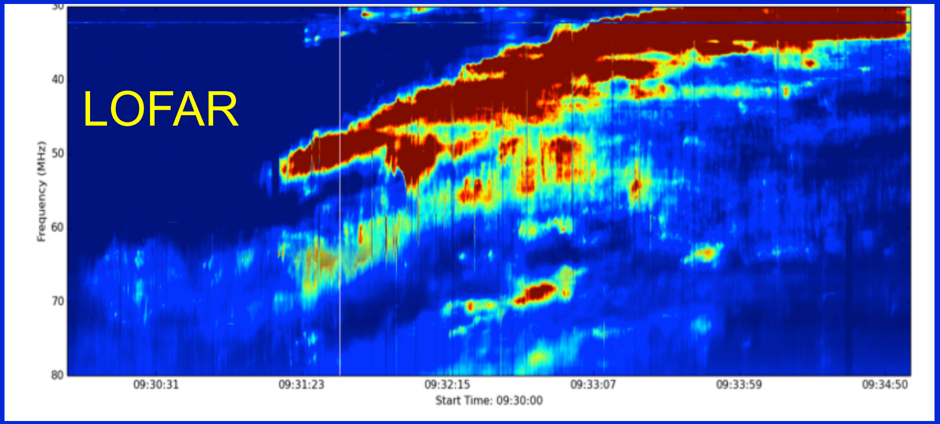
CMEs, associated shocks, and their interactions with the ambient medium



- Two successive CMEs on 2011 Jan 27, both having type II bursts; AR at the NWlimb; at SWlimb several distinct structures (prominences, flux rope FR1,…) and PILs; **analysis of 2nd CME.**
- When the CME encounterred FR1 a series of short-lived narrowband bursts at the FR1 contour occurred; the CME speed and direction changed (deceleration + initially, filament eruption was strongly SW-inclined, but then deflected upwards); deflection is mainly due to the arcade in between FR1 and CME; there was also an EUV wave
- type II bursts: F/H (HarmStart~65 MHz), band-split; 1xS-2xS applied: shock speed 480-560 km/s, MA=1.25-1.5(perp.-long.), CMEspeed=485 km/s; type II fades as shock comes to open field region (decrease of MA=deceleration+ampl.decrease due to perpendicular-to-longitudinal regime transition)
- vA estimated also through SDO/AIA emission measure and SOHO/LASCO polarization brightness and PFSS; good agreement (note: vA(h) steep decrease, minimum, broad maximum (1.5-2 Rs), decrease beyond

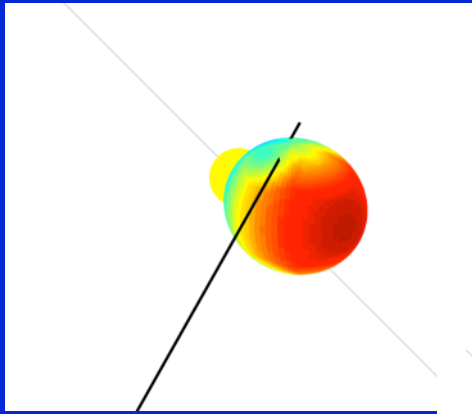


Pietro Zucca

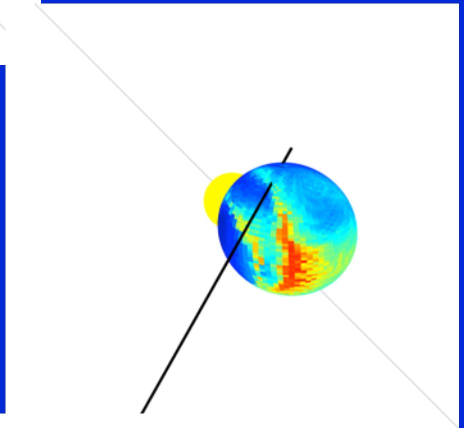


3D triangulation

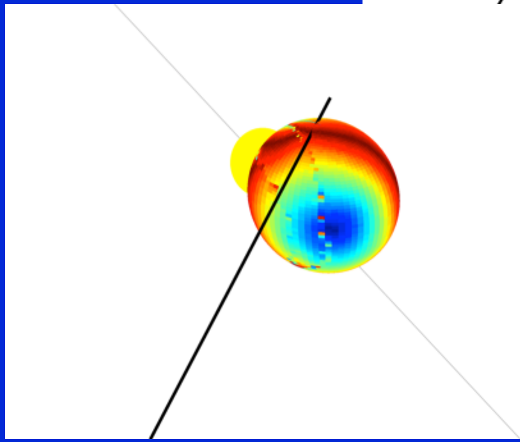
CME speed (using SDO and STEREO):
Flank expansion 360 km/s,
Apex speed 540 km/s



Mach Number (using the CME front propagation speed and the local Alfven speed):
Mach number at the flank 1.2 to 1.5



Shock geometry (comparing B-field orientation (PFSS) with the normal to the CME front):
The CME flank shows a quasi-perpendicular geometry

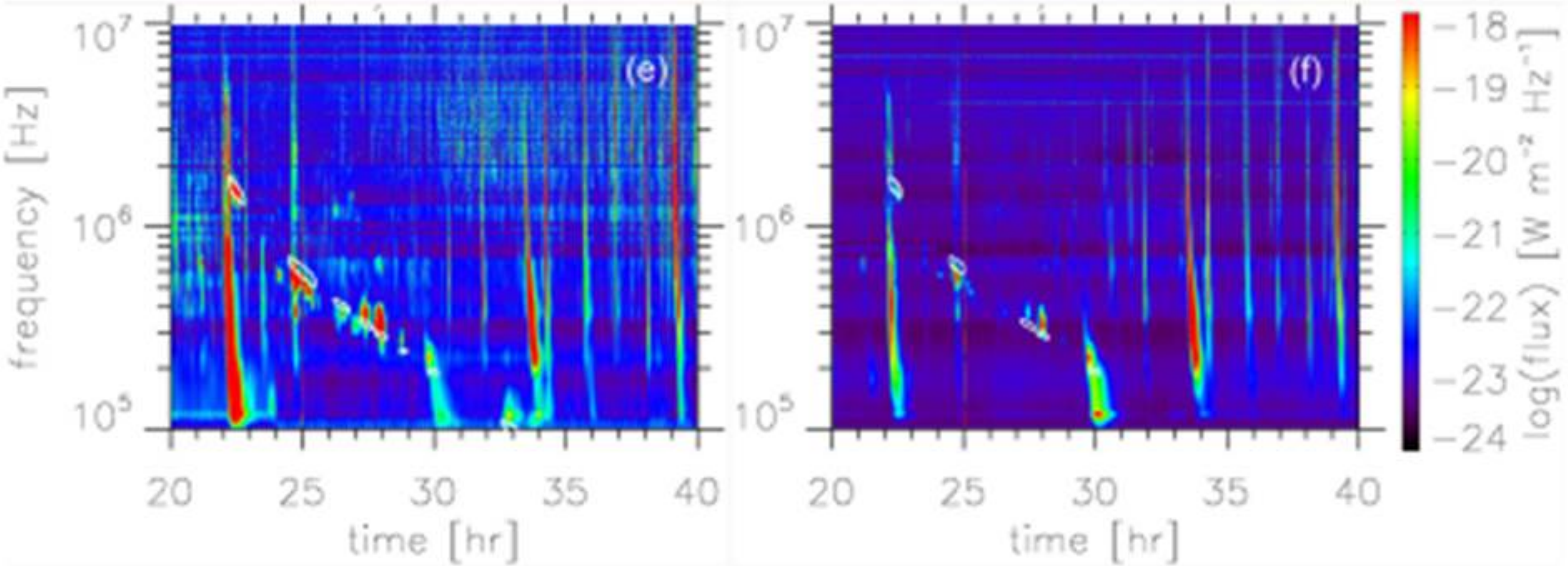


Discussion: processes of the shock wave formation and the location of the radio-source (favorable conditions for emission)

Joachim Schmidt

Comparison of model and observations (plasma emission processes modeled on the MHD „background"): multi-source emission

Very good agreement for high corona (5 - 0.1MHz)

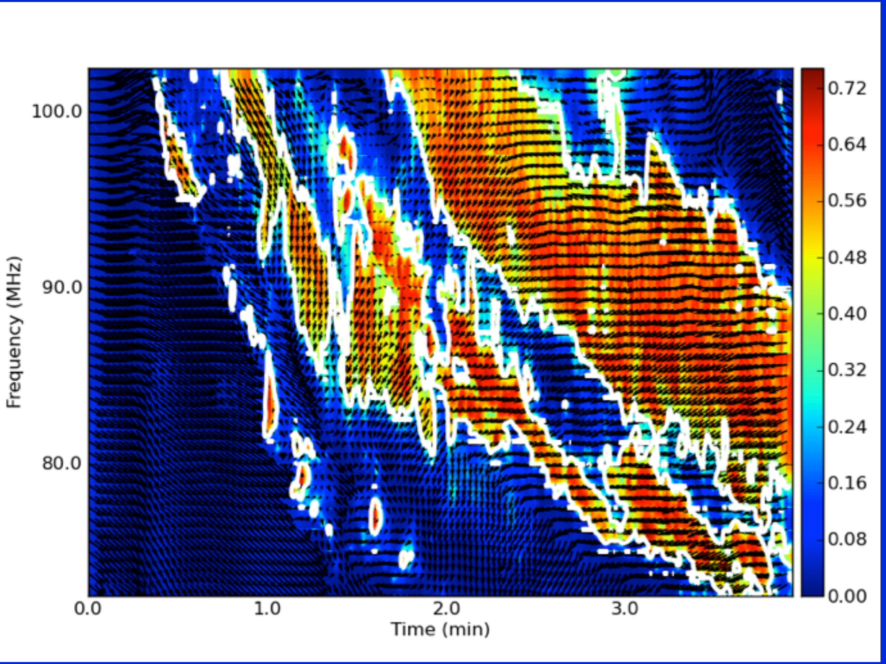


- Very good agreement for both STEREO A and B (separated by $\Delta r \approx 1$ AU):
  - agree within factor 10 in flux, 20% in f, 1 hour in time
  - variations of > 10^4 in flux, 10^2 in f, 20 in t
- Comparisons of source locations with simulations / theory still TBD.

Divya Oberoi

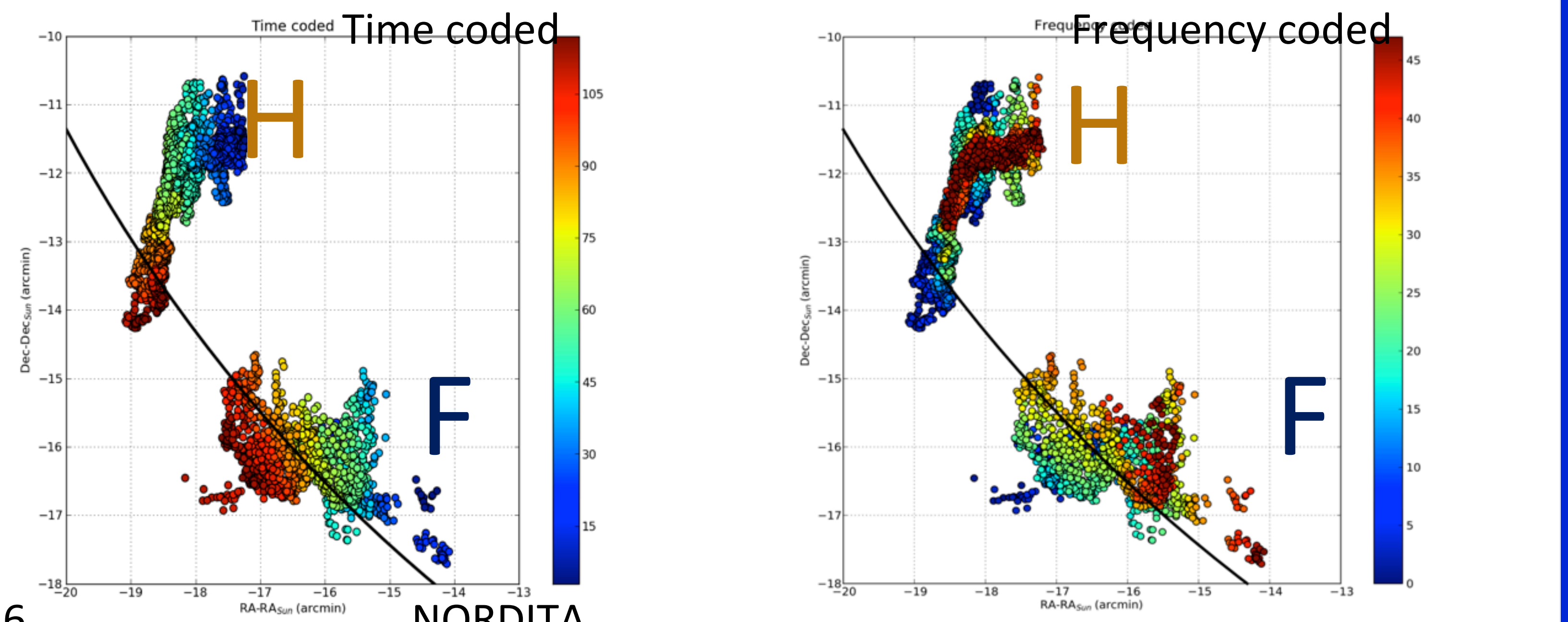
Study of 2014 Sep 07 Type II (Murchison Widefield Array)

- preexisting source at the same location
- motion of F- and H- band sources is very complex (probably propagation effects)
- sources of band split are cospatial (?)



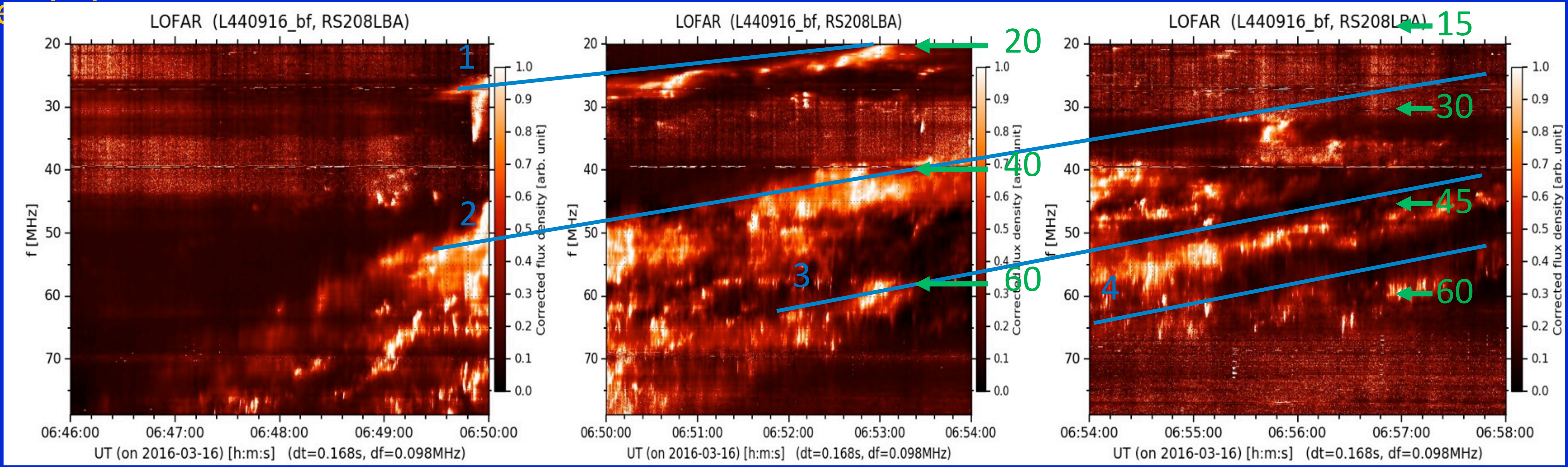
Conclusion

- Propagation effects are important
- Observed source size ∝ λ (influenced by strong scattering?)
- Apparent location strongly influenced by refraction (+ turbulent structures?)



Frank Breitling

Possible LOFAR observation of a type II burst with 4th harmonic emission



fundamental-harmonic structure at 06:57 UT

F: ~ 15 MHz

1 H: ~ 30 MHz

2 H: ~ 45 MHz

3 H: ~ 60 MHz

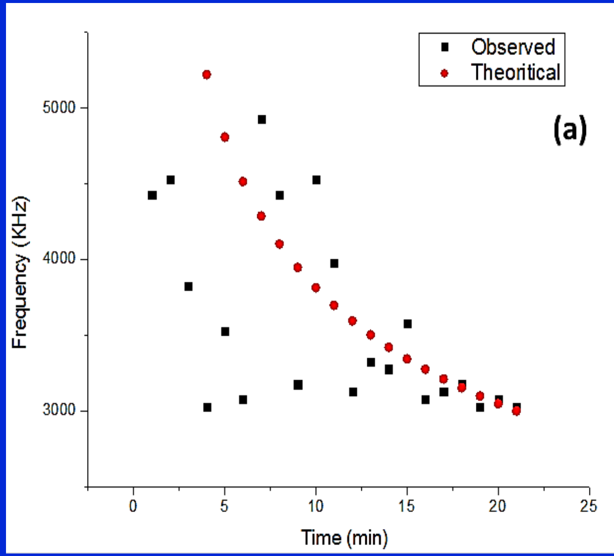
Hariharan Krishnan

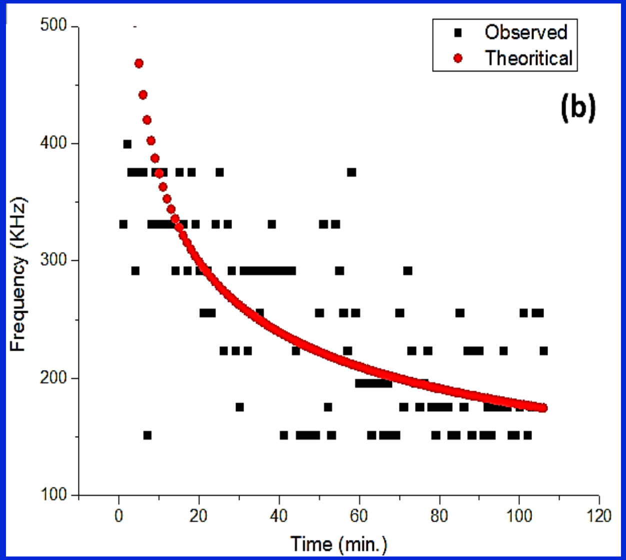
Near-Simultaneous Split-band
Solar Type-II Radio Bursts
(Gauribidanur Radio Observatory)

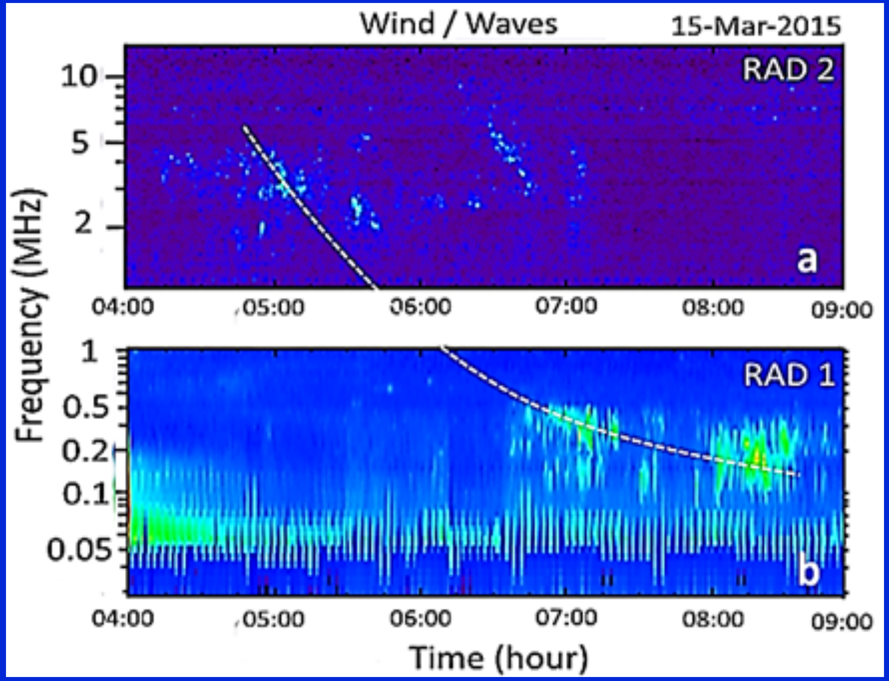
- Coronal magnetic field in upstream region ***B* ~ 1.3 - 1.1** G at r ~ 1.49 – 1.58 Rs („1st" type II burst) ***B* ~ 1.3 - 1.0 G** at r ~ 1.49 – 1.58 Rs („2nd" type II burst)
- Using the DCP values and magnetic field estimates the corresponding viewing angles for the bursts were estimated
- The bursts were found to be associated with MHD shock that excited emission at different segments (shock was driven by a CME that interacted with a preceding CME and a pre-existing coronal streamer)

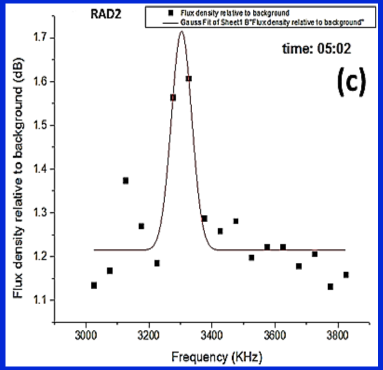
Khaled Alielden

Characteristics of a shock associated with CME using solar radio bursts (2015 Mar 15)









Gaussian was fitted for central frequency at each moment

Saito density model was applied, providing a good fitting of the observed emission.

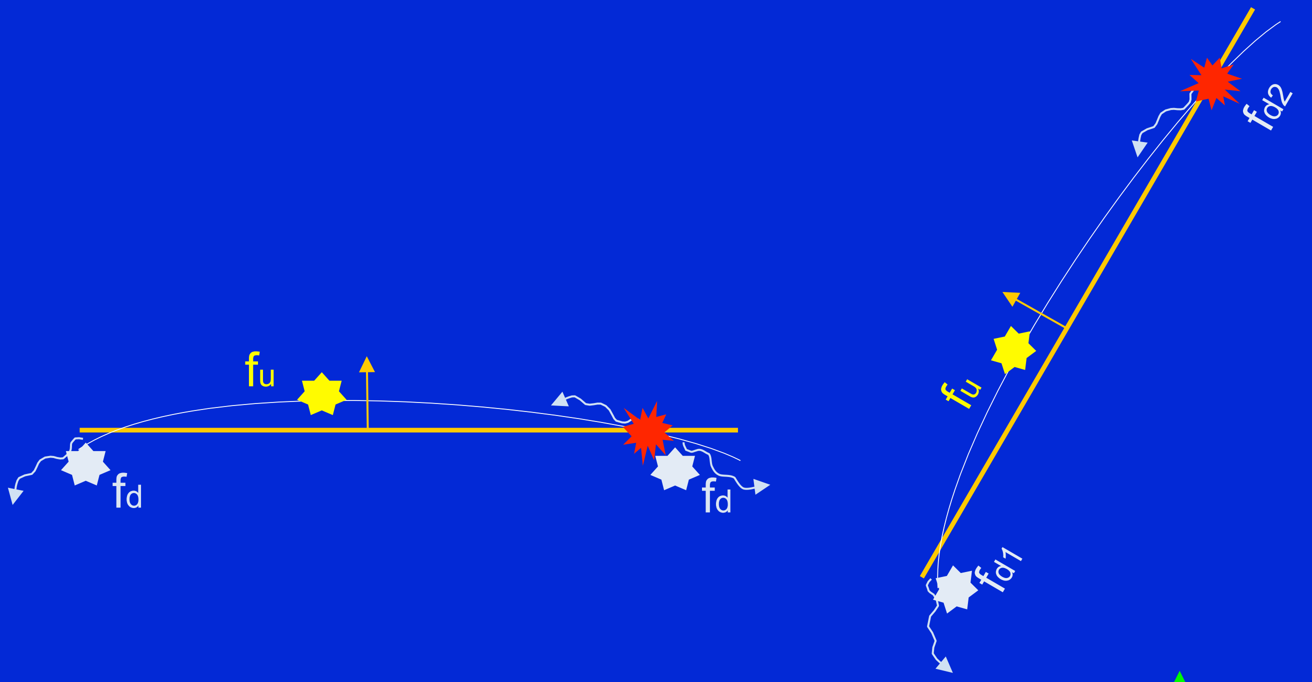
<u>*Suggestion:*</u> radio emission is due to blast and in the IP medium is due to high energy and abrupt change in wave characteristics. Hypothesis: Sedov-type of solution for the blast kinematics

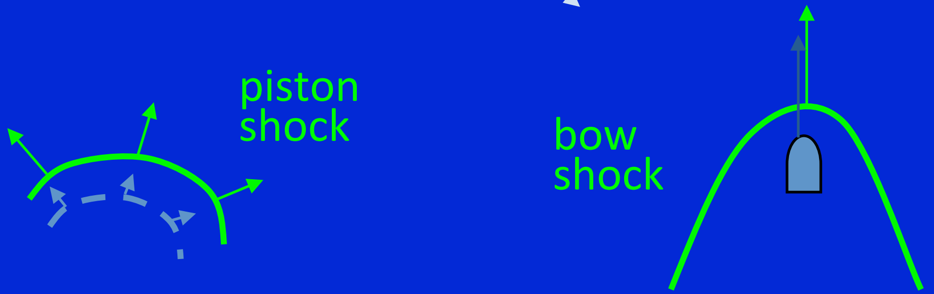
D<u>*iscussion*</u>: The ambient solar-wind medium, electron density distribution and the other parameters play important role in the change of the energy of the blast wave. Matching of the theoretical frequency and observed frequency is very good; from the matching we can tracethe shock and study its characteristics.

Bojan Vršnak

Band split (interpretation / diagnostics):

- Multi-source
- Upstream/downstream





Shock formation & propagation:

- Formation: CME acceleration phase & overexpansion
- Propagation – driven (bow-shock / piston-shock); freely propagating (detached)