Electromagnetic emissions observed in the 2 May 1998 flare-CME event

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Event workshop in Turku, 14 Aug 2007
The 1998 May 2 event

- GOES X1-class flare at S15 W15
- Transequatorial loops connected to AR at N25 E25
- On-the-disk large-scale event
The 1998 May 2 event

- Radio emission from decimetric to kilometric wavelengths (Leblanc et al., JGR 2000)
Metric emission (Artemis IV)

(Pohjolainen et al., ApJ 2001)
Type III J-bursts in the spectrum

Activity in the pre-flare and rising phase (flare max. at 13:42 UT)
J-bursts tracing the transequatorial loops

May 2, 1998  J–bursts
J-bursts tracing the transequatorial loops
Potential field line extrapolations - the loop systems

Type II-like bursts in the spectrum (M1-M3)
Source locations of the type II-like bursts

Radio emission imaged by the Nancay Radioheliograph
- Chromosphere: $B$ and $\rho$ large $\rightarrow$ low Alfven speed
- Corona: density decrease $\rightarrow$ higher Alfven speed
- AR in corona: high density $\rightarrow$ lower Alfven speed
+ Radio emission at 300–100 MHz: height $0.1-0.5R_\odot$ above the photosphere
Determining the radio source height:

\[ f_p = 9000 \sqrt{n_e} \]

- Atmospheric models and white-light observations of density
- Over-the limb observations (but still some projection effects)
H-alpha Moreton wave
Driven shock or blast wave shock?

Radio type II–like bursts 13:41–13:45 UT

EIT difference 13:41 - 13:19

H-alpha 13:41:55
Radio continuum after the type IIs
A closer look: a type IV burst ('Africa')
The type IV source over EIT dimming
EIT and Moreton waves are certainly different parts of the same wave-like structure because they are almost cospatial - but does the wave create the radio bursts?

EIT dimming is due to depleted material (partly disappearing transequatorial loops) and the rising of the CME - confirmed by the radio type IV burst
Alternative explanation for the Moreton/EIT wave

- Stationary brightenings → electric currents and Joule heating due to CME lift-off?
- Jumps in connectivity could accelerate particles? But would these be sufficient for creating the radio bursts?

(Delannée et al., A&A, 2007)
The halo CME height-time plot

Position Angle = 329°
Acceleration = -28.82 m/s²
The halo CME front (and shock) location?
Propagating shocks observed by Wind WAVES
Several shocks?
Comparison with another event - similarities?
Shock arrival near-Earth on May 4 at 05:00 UT
May 2 13:40 → May 4 05:00, average transit speed 1080 km/s
Summary of timing

CONT
M3
M2
M1
M0

13:00 13:10 13:20 13:30 13:40 13:50 14:00 14:10 14:20

AR8210: GOES X1.1
AR8210: H-alpha flare
H-alpha wave

AR8214: GOES B6.5
AR8214: H-alpha flare

EIT (wave)
EIT (dimming)

type III/ J-/U-bursts