“Radio and EUV analysis of a shock wave reflected by an equatorial coronal hole”

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Introduction

A **Type II radio burst** is characterized by a **pair of slowly drifting bands decreasing from high to low frequencies**. The drift is usually **due to the propagation of a shock wave away from the Sun**.
In an extremely rare cases a **reverse Type II radio bursts** can happen → shock propagation toward the solar surface or at some angle in the direction of a local enhancement of the coronal electron density.

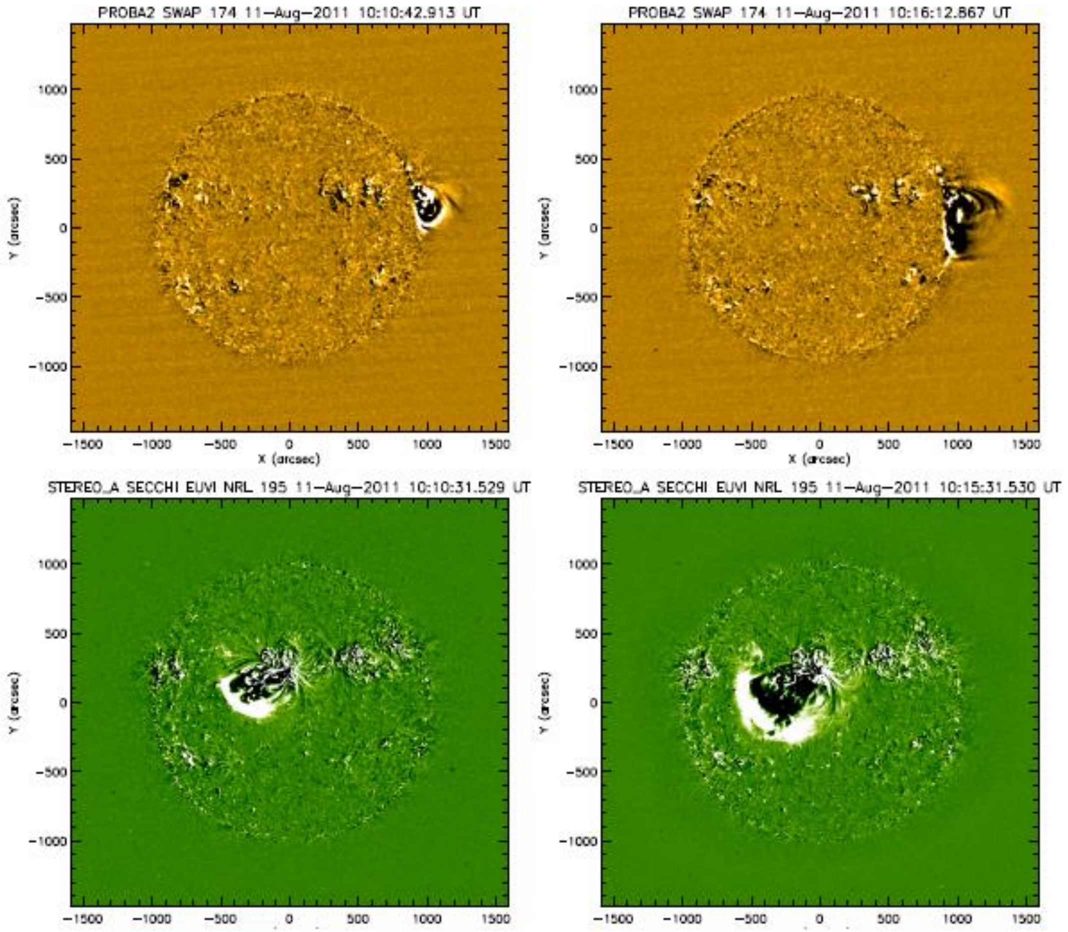
Coronal shock waves are **often associated with EUV waves**, whose interpretation is still debated. The wave interpretation is supported by the observation of reflections and refractions at regions with strong gradients in Alfvén speeds. If the EUV waves speeds exceed the magnetosonic speed of the ambient plasma can evolve into shocks and a a Type II radio bursts can appear if favorable conditions are satisfied.

Shock waves reflections in the inner corona were detected from EUV observations, but direct observational evidence in the radio band is still lacking.

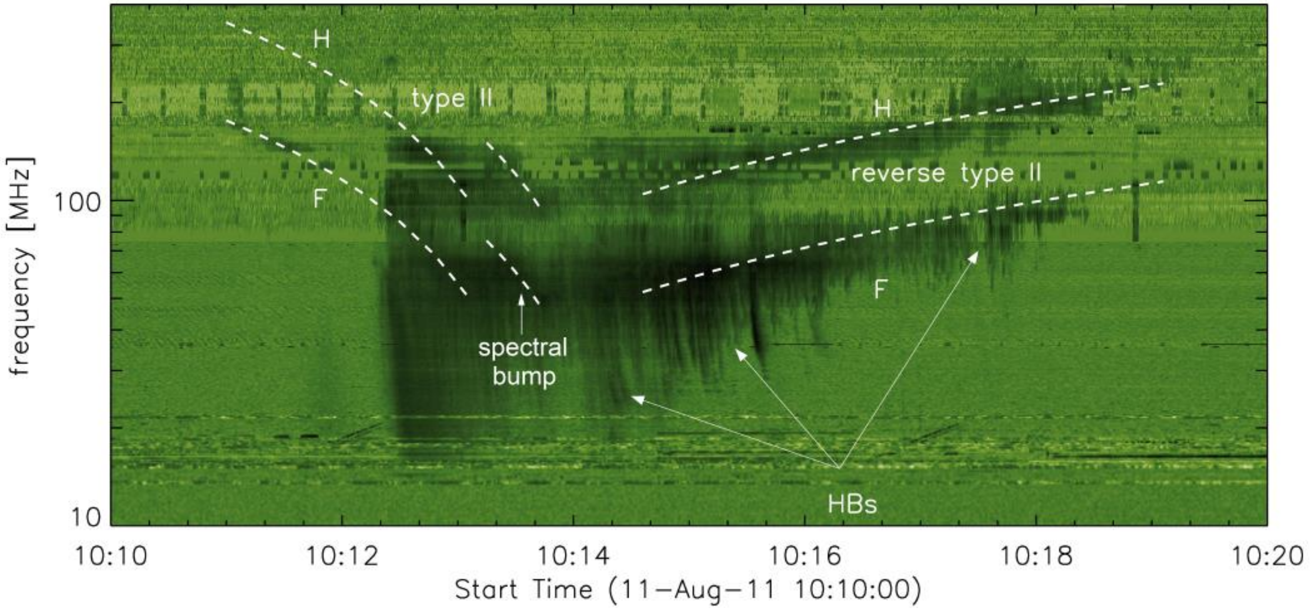
Here we analyse the event characterized by a coronal EUV front steepening into a shock wave and **report the first direct observational evidence of a type II radio burst with reverse frequency drift due to the sunward reflection of a portion of the coronal shock wave.**

Observations

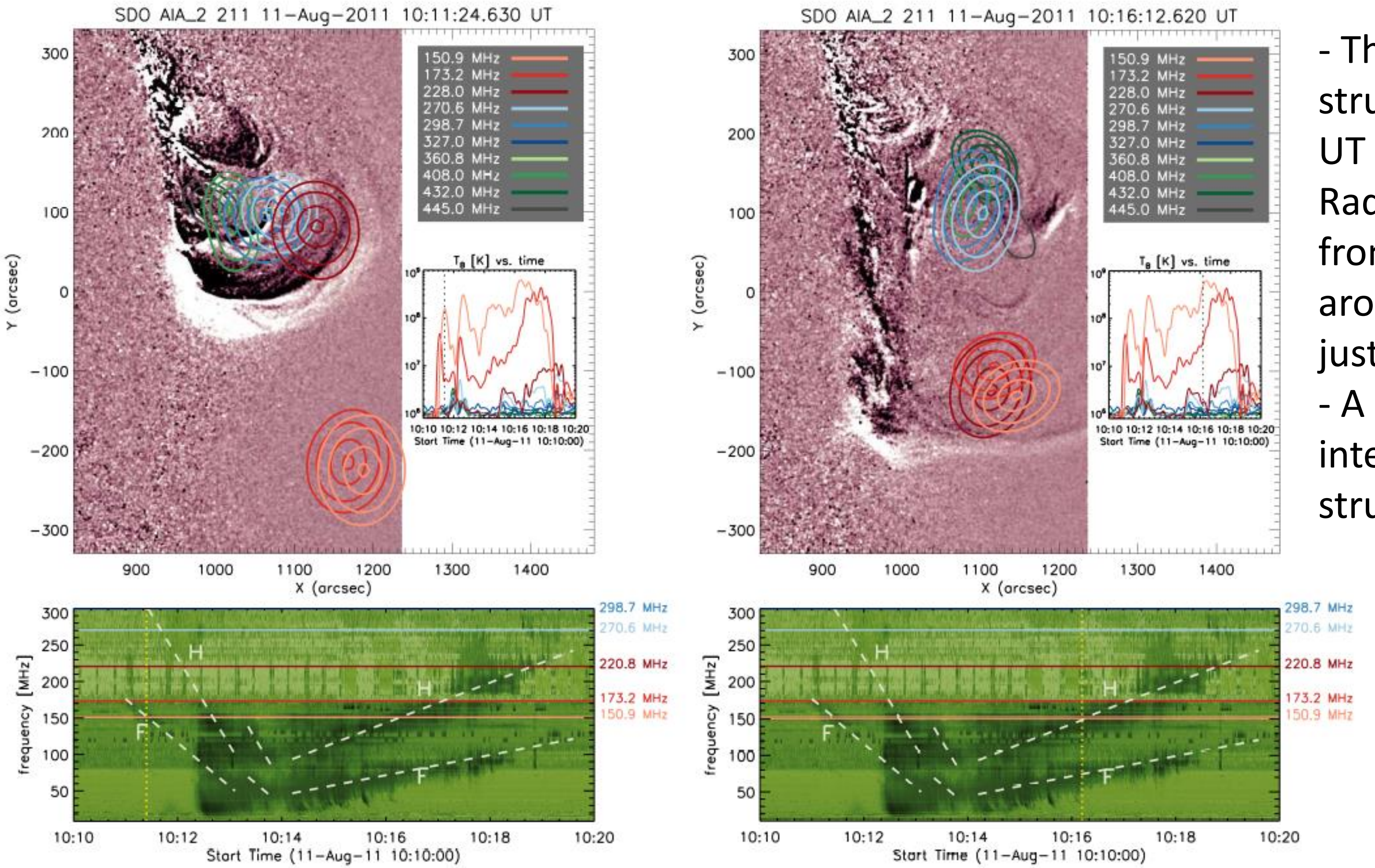
The 2011 August 11 eruption originated from NOAA Active Region 11263 involving a C6.2 class flare, an EUV wave, and a partial fast halo CME (median speed ~ 976 km/s).



The shock wave was detected at ~ 10:11 UT by ground-based radio spectrometers (appearance of a metric type ii radio).



Type II radio bursts often reveal a variety of morphological features: backbone (BB), fundamental (F) and harmonic (H) emissions, herringbone (HB) structure, etc.
The BB emission corresponds to the slowly drifting emission lane considered as the signature of a shock wave traveling away from the Sun through the corona.

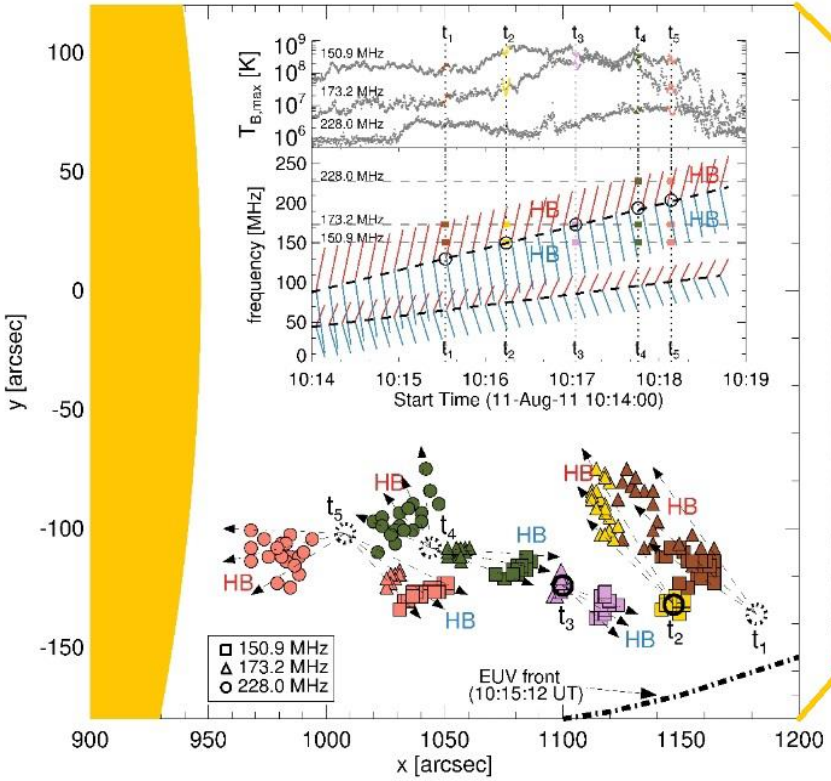


- The patchy, slowly negatively drifting F-H structure of the type II burst started at about 10:11 UT -> The position of the radio sources (Nancay Radioheliograph) corresponding to the emission from the negatively drifting BB H lane was imaged around 10:11 and 10:12 UT and was found to be just ahead of the EUV front.
- A spectral bump, probably caused by the interaction of the shock with a denser coronal structure is visible between 10:13 and 10:14 UT.

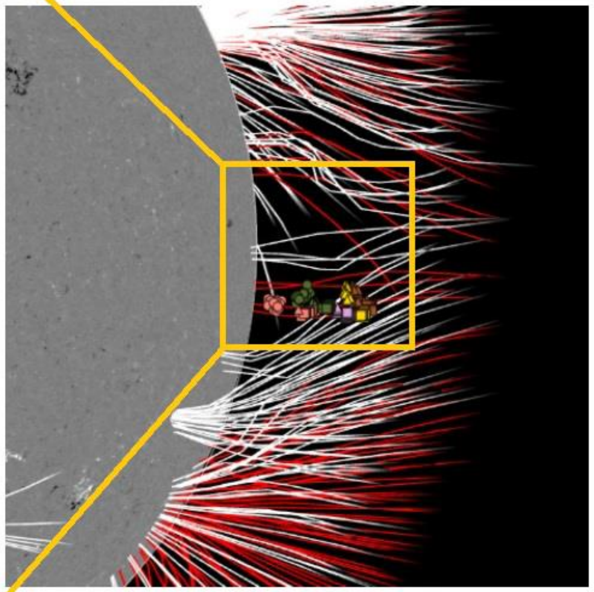
Type II radio bursts occasionally exhibit a type III-like fine HB structure emanating from the BBs toward both high and low frequencies. Both F and H HBs, generally attributed to plasma emission from electron beams accelerated by shock drift acceleration (SDA) beams in the upstream region, can be seen throughout the entire radio event. However, electrons accelerated by a curved shock can propagate upstream along open magnetic field lines toward both the higher and lower corona. In this event, the presence of HBs suggests an open field configuration and quasi-perpendicular shock propagation.

Data Analysis

Spatio - temporal evolution (after 10:14 UT) of the BB + HB emission at 150.9, 173.2, and 228.0 MHz:



Solid circles at times t_2 and t_3 indicate the observed positions of the BB emission; dotted circles at times t_1, t_4, and t_5 denote inferred positions of the BB emission on the basis of the observed HB emissions



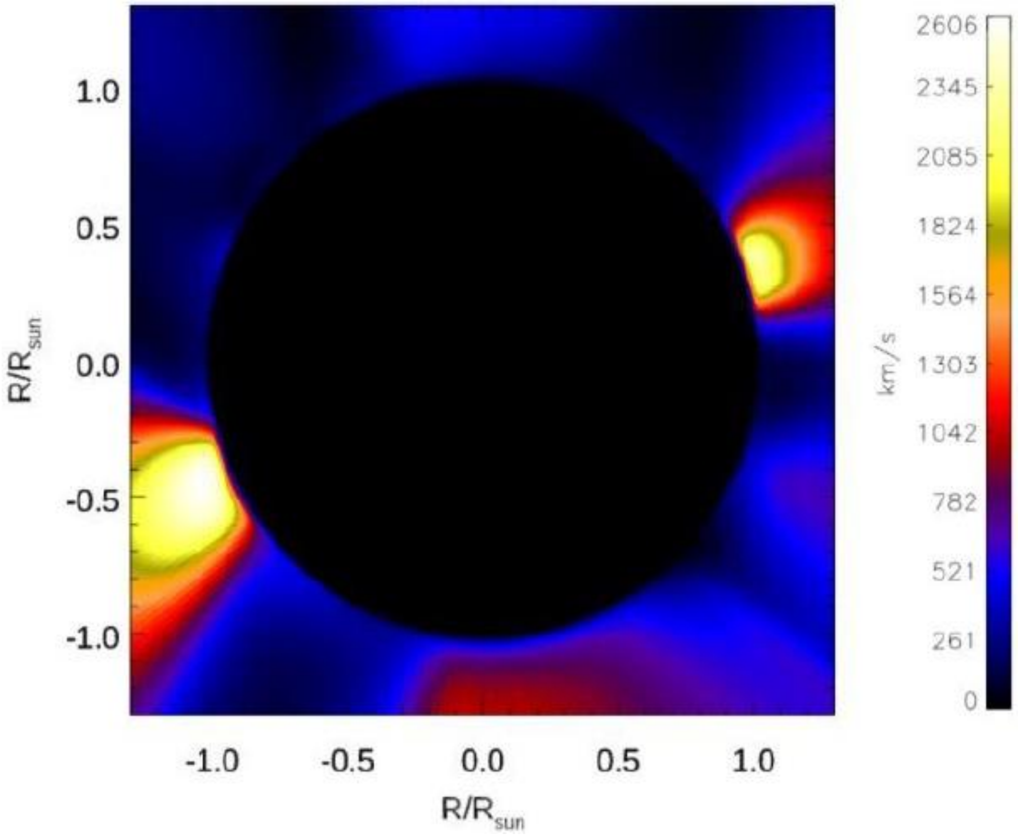
Coronal magnetic (PFSS approximation). White and red lines correspond to closed and open magnetic field, respectively.

From NRH observations we estimated the locations of the centroids of the radio sources.

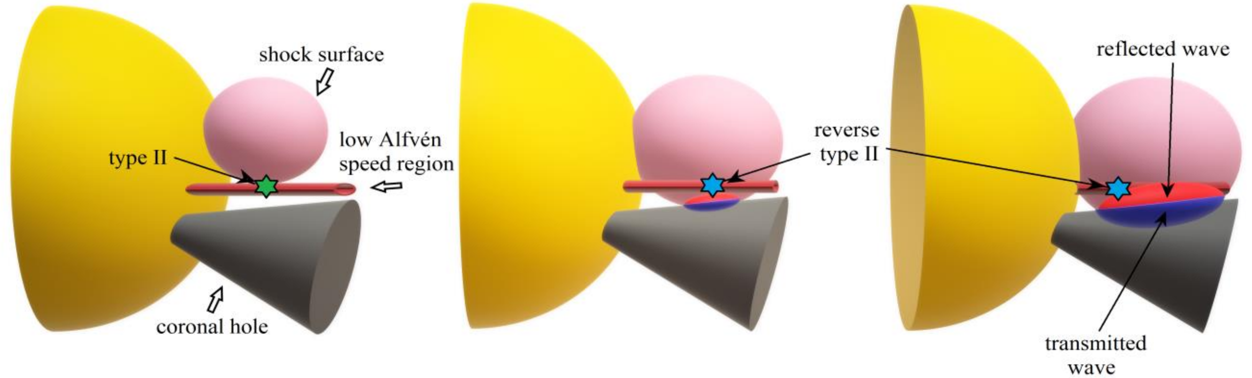
The shock-related radio emission from the H BB of the reversely drifting type II radio burst is seen to propagate radially toward the Sun.

From the extrapolated magnetic field, we infer that the BB + HBs radio emission was emitted in correspondence with an open field region, thus implying that the accelerated particles could easily escape the shock front via SDA.

Type II radio sources can be thought of as a sort of visualization of the low-Alfvén speed structures -> this event, as expected, happened near a large corona hole.



2D maps of coronal Alfvén speed @ 9:00 UT on POS (MAS model, Predictive Science)



Interpretation: The reverse type II radio spectral feature was emitted at the intersection of the shock wave, reflected at the coronal hole boundary, with an intervening low-Alfvén speed region characterized by an open field configuration.

This interpretation is in agreement with simulations of the temporal evolution of the incoming wave, its impact with a low-density region and the subsequently evolving secondary reflected, transmitted, and traversing waves were performed by Piantschitsch et al. (2017): as the wave moved toward the coronal hole, a steepening of the wave that subsequently developed into a shock was observed. At the coronal hole boundary, a reflection of the incident wave occurred as an immediate result of the impact of the wave on the coronal hole.

Thank you!

More details can be found here:

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LETTER TO THE EDITOR

Radio evidence for a shock wave reflected by a coronal hole

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