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Ground-based and spaceborn observations of the type II burst with developed fine structure

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Abstract

The combination of two huge ground-based radio telescopes (UTR-2 and URAN-2) operated in decameter wavelengths with three spatially separated spacecrafts (SOHO, STEREO-A and STEREO-B) equipped with white light coronagraphs, UV telescopes and decameter-hectometer band radio telescopes created a unique opportunity to investigate the high energy solar transients, such as CMEs and their manifestations in radio bands – type II bursts. In this paper we made detailed analysis of the powerful and complex event occurred on 7 June 2011 consisted of Halo-CME and type II burst with rich fine structure.

1. Introduction

The beginning of the 24-th solar cycles is characterized by increasing the number of high energetic events, such as Coronal Mass Ejections (CME). CMEs are one of the most geoeffective events among the variety of all types of solar activity. Type II bursts are most indicative manifestation of extremely powerful, fast and heavy CMEs, capable to affect the space weather conditions near the Earth.[1] In this presentation we discuss the properties of the type II burst that occurred on 7 June 2011.

2. Observations and discussion

The type II burst appeared to be a part of more complex event that started with sudden increase of the background emission by almost five orders of magnitude at 6:26:40 UT in wide frequency range (3-33MHz). Ten minutes later the type-II burst started. The event was observed from 6:36:10 UT till 7:30:00 UT in the whole decameter range from 30 MHz down to 5 MHz and had rich fine structure in the form of herringbone. In addition some herringbone "branches" had their own fine structure similar to type-IIIb in frequency domain (Figure 1). It was registered simultaneously by three different instruments: UTR-2 radio telescope, URAN-2 radio telescope with the possibility of polarization measurements and S/WAVES devices installed onboard of two STEREO spacecrafts

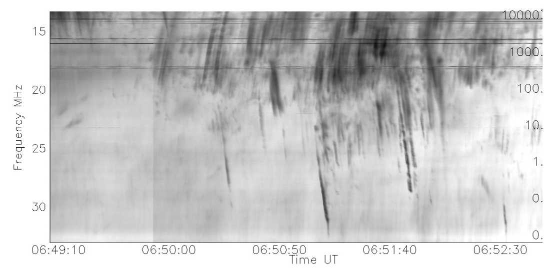

Figure 1: Fragment of the type II bursts with both time and frequency fine structure (UTR-2 data).

Frequency drift rate of the back-bone of the burst is approx. -20 kHz/s at 20 MHz that is typical for decameter wavelengths. [2] This drift corresponds to the linear velocity of the source of about 600 km/s. We have analyzed approximately 200 sub-bursts with negative frequency drift rate and 100 – with the positive one. Extended statistical analysis shows that negative drift rates vary from -0.3 MHz/s to -3.4 MHz/s with average value -1.2 MHz/s and distribution peak at 0.8 MHz/s. The positive drift rates were in range from 0.9 to 2.6 MHz/s with mean value of 1.7 MHz/s and distribution peak at 1.4MHz/s. It is evident that sub-bursts with positive drift rates drift approximately twice as fast as those with negative drift rates. The continuation of this burst was also found at lower frequencies down to 3MHz by the S/WAVES devices (Figure 2). The drift rate at this frequency equaled -8 kHz/s. This value corresponds to linear velocity of 550km/s and is consistent with ground-based measurements.

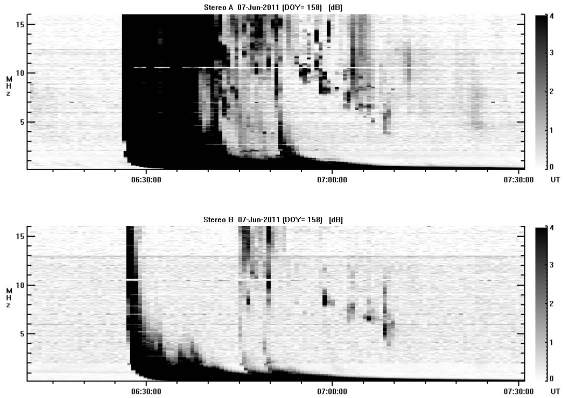

Figure 2. S/WAVES A and B dynamic spectra.

Unlike UTR-2 radio telescope, which doesn't give information on the polarization of solar bursts, URAN-2 instrument does. The "branches" of the herringbone structure of the type II burst showed much higher polarization degree than cloud-like components of the burst and surrounding type III bursts – up to 60%. The remarkable property of the burst is the opposite sign of circular polarization of different groups of sub-bursts (Figure 3).

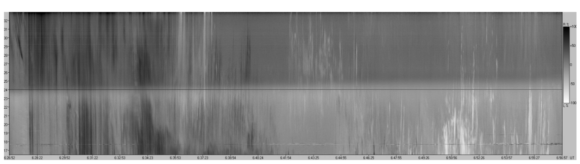

Figure 3. Polarization of the type II burst.

It may indicate that the accelerated electrons responsible for generation of these sub-bursts move in opposite directions with respect to the magnetic field lines and observer. Together with radio data analysis coronagraph data was used. Observed type II bursts apparently was initiated by Halo-CME that moved in South-West direction and was observed by all three coronagraphs available: LASCO, COR-A and COR-B. The corresponding active region 1226 was located at S22W52. The shock front velocity from coronagraphs data was estimated as 1200km/s, what was twice faster than derived from the type-II bursts frequency drift rate. In this case probably radio emission originated from the flanks of the shock rather than from its forehead.

Acknowledgements

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