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Decameter type IV burst associated with behind-limb CME observed on November 7, 2013

V.N. Melnik (1), A.I. Brazhenko (2), A.A.Konovalenko (1), V.V. Dorovskyy (1), H.O. Rucker (3), M. Panchenko (4), A.V. Frantsuzenko (2), M.V. Shevchuk (1)
(1) Institute of Radio Astronomy, National Academy of Sciences of Ukraine, Kharkov, Ukraine (melnik@rian.kharkov.ua / Fax:+38-057-7061415),(2) Gravimetrical Observatory, Poltava, Ukraine, (3) Commission for Astronomy, Graz, Austria, (4) Space Research Institute, Austrian Academy of Sciences, Graz, Austria

Abstract

We report the results of observations of type IV burst in the frequency range 22-33 MHz, which is associated with the CME initiated by behind-limb active region (-150° E). This burst was observed also by the radio telescope NDA in the frequency band 30-60 MHz. CME's core was situated at the distance about $3R_s$ at the moment, when type IV burst registered at frequencies 22-60 MHz. We conclude that the radio emission escape from the center of CME's core at frequency 60 MHz and comes from the periphery of the core at frequency 30 MHz due to occultation by the solar corona at corresponding frequencies. We find densities in these regions supposing plasma mechanism of radio emission. We show that the frequency drift of the leading edge of type IV burst is governed by expansion of CME's core.

1. Introduction

Type IV bursts were distinguished in the separate class of bursts by Boischot in 1957 [1]. There are stationary and moving type IV bursts [3]. They consider that high coronal arches are responsible for the former and CMEs are in charge of the latter. At present, the plasma mechanism seems to be the mechanism of type IV bursts. Places of radiations of stationary type IV bursts are coronal arches but from what regions radio emissions of moving type IV bursts escape do not understand. In most cases, observed type IV bursts are connected with active regions, which are on the visible solar disk [2].

Type IV burst, which was observed by STEREO A and B on November 7, 2013, was associated with behind-limb CME [2]. We report about observations of this burst by the radio telescopes URAN-2 and NDA at frequencies 22-60 MHz and discuss the places of CME from which radio emission escapes.

2. Observations

The dynamic spectrum of type IV burst registered by URAN-2 from 10:22 UT to 10:44 UT in the frequency band 22-33 MHz is shown in the Fig.1a.

a)

b)

c)

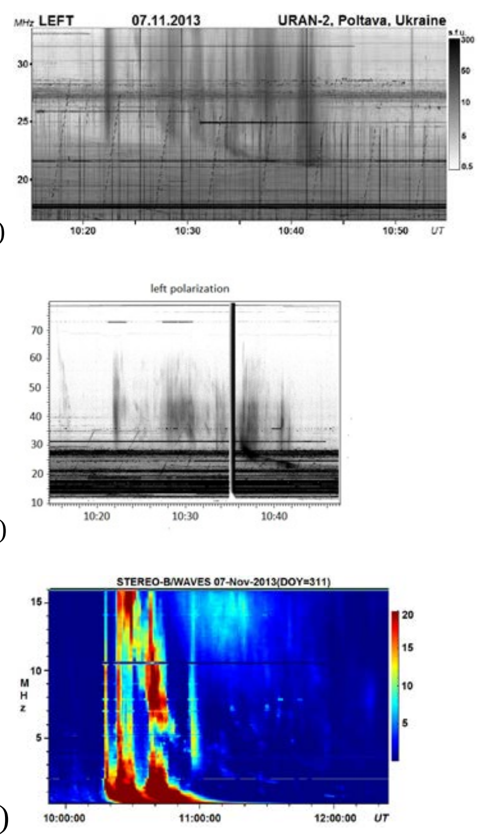

Figure 1: Type IV burst observed by URAN-2 (a), NDA (b) and STEREO B (c) on November 7, 2013.

The radio telescope NDA was also observed this burst at frequencies 30-60 MHz (Fig.1b). A little later, at 10:50-11:30 UT, this burst was observed by STEREO B at lower frequencies, 11-16 MHz (Fig.1c). It says that this type IV burst was moving but not stationary one (compare with [2]). This conclusion is confirmed by the fact that the forehand of the burst drifted in both frequency bands 22-33 MHz and 11-16 MHz. Their drift rates were 30 kHz/s and 8 kHz/s correspondingly.

3. Discussion

Radio emission of behind-limb type IV burst was occulted by the coronal plasma and therefore this radio emission at 30 and 60 MHz could be observed from the regions, which were situated to the left to dashed and solid lines in the Fig.2. In this Figure the CME's core, the Sun and the Earth are shown at

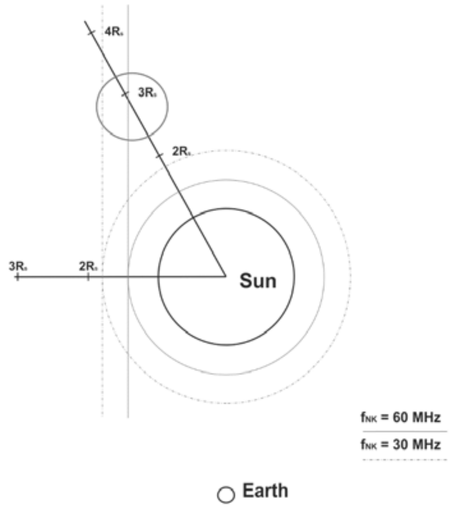

Figure 2. Schematic positions of CME's core, the Sun and the Earth at 10:22 UT, when type IV radio emission occurred at frequencies from 30 to 60 MHz.

10:22 UT, when radio emission of type IV burst began to observe by both radio telescopes NDA and URAN-2 at first. We see that radio emission at 30 MHz escapes from periphery regions of CME's core. So the density $1.3\cdot 10^{7} cm^{-3}$ needed for radio emission at this frequency according to plasma mechanism exists here. It is reasonable to suppose that in the center of the core the plasma density achieves the value of $4.5\cdot 10^{7} cm^{-3}$ providing radio emission at 60 MHz. If this is a case and assuming exponential distribution of the density $n(r)\propto \exp(-\alpha r)$ (where r is the distance from the centre of the core) in the CME's core, we can find that mass of the core equal approximately $\approx 10^{16} g$. This is close to the estimated CME mass (https://cdaw.gsfc.nasa.gov/CME_list/ UNIVERSAL/2013_11/univ2013_11.html). The periphery density decreases as $n\propto 1/R^{2}$ with time according to conservation of core's mass at its inflation. The core keeps the form by magnetic field with the strength $6\cdot 10^{-2}G$ at the temperature of the core plasma $10^{5}K$ and $0.2G$ at temperature $10^{6}K$. According to SOHO data, the speed of core inflation is about 400 km/s. If the frequency drift rate of type IV forehand is governed by the speed of inflation then we find the frequency rate in accord with the equation

$$df\ /\ dt = f\ /\ 2\cdot dn\ /\ ndr\cdot dr\ /\ dt \qquad (1)$$

The obtained frequency drift rate for the frequency range 22-33 MHz equals to about 30 kHz/s that is in good correspondence with the observed value.
Thus, we conclude the radio emission of type IV burst really radiated by CME's core. Its density is larger significantly the density of surrounding coronal plasma. The inflation of core is responsible for the observed frequency drift rate. Needed mass of the CME's core is enough for that.

References

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