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Sporadic radio emission of the Sun in the decametre range

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Abstract. Results of the last observations of solar sporadic radio emission at the UTR-2 radio telescope (Kharkov, Ukraine) at the frequencies 10 - 30 MHz are presented. The use of new backend facilities, the DSP and 60-channel spectrometer, allows us to obtain data with time resolution up to 2 ms and frequency resolution of 12 kHz in the continuous frequency band 12 MHz. Usual Type III bursts, Type IIIb bursts, U- and J-bursts in the decameter range are discussed. Special attention is paid to detection and analysis of Type II bursts and their properties, newly discovered fine time structures of Type III bursts, Type III-like bursts, s-bursts, new observational features of drift pair bursts, and 'absorption' bursts.

Keywords. Sun: radio radiation

Solar sporadic radio emission has been studied in the decameter range with UTR-2 (effective area 150 000 m^2; working frequency band 10 - 30 MHz) since the 1970s. Until the end of the 1990s, the focus was on Type III bursts, Type IIIb bursts, and drift pairs. After putting into operation new backend facilities, DSP (bandwidth 12 MHz; time and frequency resolution 2 ms and 12 kHz, respectively; dynamic range 70 dB; Kleewein *et al.* 2004) and 60-channel spectrometer (single channel bandwidth 3 kHz; time resolution 10 ms; dynamic rage 40 dB), the number of phenomena investigated has increased dramatically. Today, there are opportunities to observe Type II bursts, inverted U- and J-bursts, s-bursts, decameter spikes, Type III-like bursts, and bursts in absorption.

Type III bursts are usually considered to have a smooth time profile. This indicates a uniform electron stream, which generates the bursts. For the first time in 2002, observing with DSP we found great number of Type III bursts with fine time structures. In the most cases the parent Type III burst consists of sub-bursts with 1 s durations, which drift from high frequencies to low frequencies. These cases can be divided into three groups of bursts: (*i*) drift rates equal to or greater that for parent Type III burst; (*ii*) rates about 1 MHz s^{-1}; and (*iii*) rates smaller than 100 kHz s^{-1}. There are some cases when Type III bursts consist of sub-bursts with positive and negative drift rates at the same time.

Decameter Type III-like bursts were registered in the 2002 - 2004 observation campaigns. Their durations were about 1 - 2 s and their drift rates were sometimes that of usual decameter Type III bursts rates. We found that the number of Type III-like bursts is at a maximum when the active region associated with them is situated near the central meridian. The effects of propagation seem to play an important role in the formation of these bursts.

The inverted U- and J-bursts with turning frequency near 10 MHz, which are generated by fast electron streams in high (up to 2 $R_\odot$) coronal loops, were observed for the first

time. The spectral and frequency characteristics of ascending branches of these bursts are close to those of usual Type III bursts. Thus, about identical electron streams are propagating in the average corona and into loops. The relations of turning frequencies in observed harmonic J-burst pairs changed in the range 1.5 - 2 with an average value of 1.78.

S-bursts are observed have durations of 0.3 - 0.5 s (Dorovskyy *et al.* 2006). Their drift rates are close to that for drift pairs bursts and are equal to about $1\,\mathrm{MHz\,s^{-1}}$ (Mel'nik *et al.* 2005). In contrast to drift pairs, s-burst drift rates depend upon the frequency. This dependence is approximately similar to well-known dependence for Type III bursts. It seems that in both cases radio emission sources propagate in average corona.

For the first time, we have observed Type II bursts in the decameter range 10 - 30 MHz in 2001 (Mel'nik *et al.* 2004). Such bursts, including Type II bursts with herringbone structure, are registered at UTR-2 regularly, with on average 1 - 2 bursts a month. Our observations show that not only do Type II bursts with herringbone structure consist of sub-bursts, but usual decameter Type II bursts have fine time structure in the form of sub-bursts with positive and negative drift rates. This is evidence for electron acceleration on both sides of the shock. We found a wave-like radio emission of Type II burst backbone, which is interpreted as shock intersection of coronal structures. There are different properties of sub-bursts on both sides of backbone. It gives an opportunity to diagnose plasma before and behind a shock.

The burst in absorption was observed in frequency range 10 - 30 MHz in 2003 (Konovalenko *et al.* 2005). Its drift rate was $120\,\mathrm{kHz\,s^{-1}}$ and duration was about 1 min. The absorption region was very large and it moved with high linear velocity (more than $2000\,\mathrm{km\,s^{-1}}$). The cause of this phenomenon is still unclear.

Our results show that ground based observations with high frequency and time resolution in the frequency range 10 - 30 MHz promise to give new interesting information about processes and phenomena occurring at heights 0.5 - 2 R_s in the solar corona, which can not be obtained by other methods. So creation of new large radio telescopes (LOFAR, LWA) is extremely urgent.

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