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Properties of decametre spikes

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Abstract

In this paper properties of decameter spikes observed by radio telescope UTR-2 in July-August 2002 are considered. These bursts are placed chaotically on dynamic spectrum. They have duration about 1 s and frequency bandwidth 50-70 kHz. The bandwidth is increased linear with frequency. A model for decameter spikes is proposed.

1. Introduction

Spikes as a separate type of solar sporadic radio emission was identified by Elgaroy [2] and de Groot [3]. These bursts were observed at decimeter and meter wavelengths. There are association between them and type I bursts, type III bursts and type IV bursts. Spike durations are <0.1 s, and frequency bandwidths are 1-3% of observation frequency [1]. There is a tendency that the duration of spikes is decreased with frequency but their bandwidth is increased with frequency. Spike fluxes are not larger than 500 s.f.u. For interpretation of spikes both the plasma mechanism [7, 8] and the cyclotron mechanism [4] were proposed.
In this paper we report about results of observations of spikes registered by radio telescope UTR-2 in frequency range 18-30 MHz. Properties of decameter spikes and a model of their generation are discussed.

2. Observations

Spikes were observed by radio telescope UTR-2 in July-August 2002 in 18-30 MHz band with digital spectral polarimeter (DSP). It provided the time resolution 10 ms and the frequency resolution 12 kHz. In this paper we analyze the decameter spikes observed during the passage of the active region N260 (http://www.gao.spb.ru) across the solar disk. It was appeared on the east side on July 20 and disappeared on the west side on August 3. Spikes were registered from July 27 to August 2. During these days some thousands of spikes were observed. Only spikes from a ten minute interval were chosen for analysis. About 350 bursts got into such interval. We measured duration, frequency bandwidth and flux of every spike at 12 frequencies. Decameter spikes are background for other components of solar radio emission. They are placed chaotically in the dynamic spectrum. This differ them from striae, which are similar to spikes but striae met in the chains forming type IIIb bursts. Decameter spikes have durations about 1 s and frequency bandwidth 50-70 MHz. The frequency dependence of spikes duration is mainly in a good agreement with the frequency dependence of time of particle

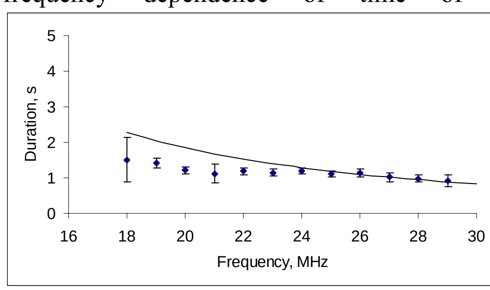

Figure 1: Duration via frequency dependence for spikes observed on August 1, 2002 (solid line presents the collisions time for temperature $10^6 K$).

collisions for plasma with temperature $10^6 K$ (Fig. 1). It says that the spike duration is explained exclusively with particle collisions.
The frequency bandwidth of spikes Δf shows the linear increase with frequency (Fig.2) $\Delta f = A \cdot f$ with the constant A , which is changed from $1.4 \cdot 10^{-3}$ to $2.5 \cdot 10^{-3}$ for different days of observations. The frequency bandwidth does not depend on the place of associated active region on the solar disk. It tells that the frequency bandwidth is formed due to processes in the place of spike generation and does not defined by some effects of radio emission propagation in the solar corona. Fluxes of decameter spikes are mainly not larger than

200 s.f.u. In the most cases their fluxes are decreased with frequency according to power law

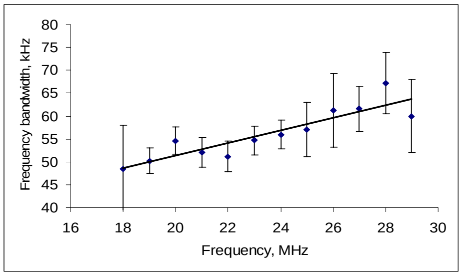

Figure 2: Frequency bandwidth via frequency dependence for spikes observed on July 28, 2002.

$I \propto f^{-\alpha}$ sometimes (27-30 July) with $\alpha = 4 - 5$, and another days (31 July-2 August) with $\alpha \le 1$.

3. Discussion

We suppose following to [7, 8] that the sources of both spikes and type III bursts are fast electron beams. Type III bursts are generated by electron beams with high density and spatial sizes. This explains large fluxes of type III bursts ($10^5 - 10^6 s.f.u.$) and their large durations (6-12 s). Fast electron beams with low density and small spatial sizes are responsible for decameter spikes. The low density of electron beams leads not only to low fluxes of spikes but also to high effectiveness of Langmuir waves generation due to quasilinear relaxation at large distances from the flare. It explains appearance of spikes at low frequencies. If the distribution function of fast electrons is stable then Langmuir waves will be generated in limited spatial regions [5] but not continuously along the track of radio emission as in the case of type III bursts, for which electron distribution function is unstable. Langmuir waves are generated near the plasma frequency ω_{pe} with the frequency bandwidth $\Delta f / f = \omega_{Be}{}^2 \sin^2 \theta / 2\omega_{pe}{}^2$ (ω_{Be} is the electron cyclotron frequency and θ is the solid angle, in which fast electrons are enclosed). In the processes $l + i = t + i$ they are transformed into electromagnetic waves in the same frequency bandwidth. Comparing the obtained equation with the empirical one $\Delta f = A \cdot f$ we can find the angle θ using magnetic field $B = 2G$ from S-bursts observations [6]. It is turned out that θ is in the limits of $13^\circ - 18^\circ$.

4. Conclusions

Decameter spikes firstly observed by UTR-2 are an extension of decimeter and meter spikes in low frequency band. Their durations are in limits of 1-2 s and seem to be determined by particle collisions. The frequency bandwidth is increased linear with frequency and changed from 50 to 70 kHz. As a rule spike fluxes are decreased with frequency. The properties of decameter spikes can be understood if to suppose that they are caused with fast electron beams with low density and small spatial sizes. If their distribution function is stable then Langmuir waves are generated in limited spatial region far from the place of flare. Spike generation originates near local plasma frequency in the frequency bandwidth, which is defined by value of magnetic field in the place of generation and by the angle, in which fast electrons are flying off.

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