MILLISECOND RADIO SPIKES ON LONG CENTIMETRE AND SHORT DECIMETRE WAVELENGTHS AND OCCURRENCE FREQUENCY

JI SHUCHEN XIE RUIXIAO and WANG MIN
Yunnan Observatory, Academia Sinica, Kunming, China

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Abstract. High time-resolution data observed in two periods, respectively, by three frequencies (1.42, 2.84, and 3.67 GHz) or four frequencies (1.42, 2.00, 2.84, and 4.00 GHz) of fast sampling radio-telescopes were processed. Obtained were some significant results showing that during the obviously rising or maximum phases of solar cycle 22, the occurrence frequency of millisecond radio spikes at three or four frequencies decreased with the frequency increase and the highest occurrence frequency was at 1.42 GHz. If we assume the second $\alpha$-mode is predominant in the growth rate of ECM instability, we calculate the magnetic intensity of source regions with spike bursts at the four frequencies and interpret the occurrence frequency of millisecond radio spikes on long centimetre and short decimetre wavelengths. Finally, this paper suggests that, owing to the Razing effect, when $f \leq 126 \text{ MHz}$ the occurrence frequency of millisecond radio spikes starts to decrease.

I. Introduction

At present, we use the word 'spike', introduced by de Groot (1962), which is well established by the solar radio astronomers; and restrict it to a narrow-band peak of less than 100 ms total duration. The duration of spikes, order of magnitude shorter than any other type of radio emission, led to their important discoveries, such as their high brightness temperature of up to $10^{15} \text{ K}$, 'strong' polarization to $100\%$, very small intrinsic bandwidth of $1.5\%$, and small source of less than 200 km in diameter, etc.

These discoveries are a challenge to the theory of solar radio bursts and attract the attention of theoreticians. In order to interpret these new discoveries and to answer the question on the number of spike producing processes, people attempt to use the electron cyclotron emission (Malville et al., 1967) and plasma emission (Tarnstrom and Filip, 1972) to explain spike emission. Detailed calculations on the plasma emission process have been carried out for Langmuir waves by Zheleznyakov and Zaitsev (1975) and Kuijpers et al. (1981). The cyclotron mechanism has been quantitatively investigated and applied to spikes by Melrose and Dulk (1982) and Sharma et al. (1982). Although the growth and escape of the various modes and harmonics have recently been proposed in the ECM instability, the emission mechanism of spike is still unclear.

On the other hand, many spike events have remained unobserved to date. The propagation conditions in the source region may often prohibit the escape of spike radiation. Above all, it is still unknown the occurrence frequency of millisecond radio spikes at different wavelength during the different phase of solar cycle.

The aim of this paper is to search for occurrence frequency of millisecond radio spikes at 1.42, 2.00, 2.84, and 4.00 GHz during the rising and maximum phase of solar cycle 22.
In the next section, the observation and data analysis will be given. The occurrence frequency of millisecond radio spikes will be interpreted in Section 3. The conclusion and discussion will be left in Section 4.

2. Observation and Data Analysis

From January 1987 to December 1988, we have already obtained the synchronous observation data with both time constants of one second and one millisecond at three frequencies of 1.42, 2.84, and 3.67 GHz at Yunnan Observatory. However, our selected period was from May 1987 to December 1988 when it was the obviously rising phase of solar cycle 22. Thirty-six events of millisecond radio spikes and their maximum flux both were processed. The occurrence frequency of spike in that period was already studied by Ji et al. (1989). The main results demonstrated that the millisecond radio spikes occurred at 1.42, 2.84, and 3.67 GHz were 24, 13, and 3, respectively, i.e., the ratio among the three wavelengths of spike group events was 24:13:3.

From 1990 to now, solar activity is maximum phase of the cycle 22. Nineteen events of spikes were obtained. Table I lists the microwave bursts with time resolution of one second and the spike bursts with time resolution of one millisecond at four frequencies. The results indicate that the millisecond radio spikes occurred at 1.42, 2.00, 2.84, and 4.00 GHz are 12, 8, 7, and 6, respectively.

We can see from fifty-five events in the two periods that the occurrence frequency of millisecond radio spikes at 1.42, 2.00, 2.84, and 4.00 GHz was decreased with the frequency increase and the most occurrence frequency was at 1.42 GHz.

In addition, the most typical one among fifty-five events was millisecond spike burst in great solar microwave burst on 16 December, 1988. The relative increment, peak flux and complexity of the burst with many fast structures were the greatest. The both time profiles of one second and one millisecond at three frequencies are shown in Figures 1, 2, and 3, respectively. It is necessary to point out where noted down by letters a, b, c, d, e, f, g, h, i, j, k, and l on three curves in Figure 1 occurred millisecond spike emissions. Figures 2 and 3 show abundant fine structures of millisecond radio spikes. The occurrence frequency of spikes at 1.42, 2.84, and 3.67 GHz are 11, 4, and 0, respectively.

Above significant results lead us to investigate the possible reason of occurrence frequency of spike emission, which is restricted by the plasma characteristic parameters of solar atmosphere, especially magnetic field strength.

3. Preliminary Interpretation

It is now clear that the emission frequency \( f \) can be obtained from

\[
f = s \frac{eB}{2\pi mc},
\]

where \( B \) is magnetic field strength, \( s \) the harmonic numbers \((1, 2, 3, \ldots)\).