SPIKE GENERATION SCENARIOS AND WAITING TIME DISTRIBUTION FUNCTION OF CIRCULAR POLARIZED RADIOEMISSION COMPONENTS

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ABSTRACT

The waiting time distribution between individual maxima (flux >10 sfu) was calculated searching for self-organized criticality. Left and right polarization components were analyzed separately. The analyzed temporal interval presents two activity periods. The first related to HXR and gamma emission with both polarization millisecond events, and the following activity period is dominated by the right polarized component events. This behavior is considered evidence of two different dominant generation mechanisms for millisecond events.

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INTRODUCTION

Known as a special astrophysical object as early as 1981, and described mainly by its short duration (less than 0.1 sec) and high brightness \((10^{15} \text{ K})\), as described in many reviews [1, 2, 3]; millisecond events (spikes) lag from a generally accepted model. There are two main options to explain spikes, particle acceleration and plasma waves interaction that maybe combined to take account for observations. One of the parameters that can be used to analyze the correctness of a specific model is the polarization of the radio emission. A high degree of circular polarization can be interpreted as electron cyclotron maser emission [2,7], and harmonic emission points to gyro-synchrotron maser mechanism [4]. Both processes signed by peculiar polarization behavior. Lately the plasma particle interaction in a turbulent medium [5] is considered in the models.

In this paper we analyze de possible relation of spikes with the overall process of energy release and re-structuration in the active region in which they take place.

DATA AND METHODS

The observations were done by the Trieste Astronomical Observatory in the 2695 to 237 MHz range, with a temporal resolution of 100 Hz. The frequencies and observation intervals are shown in Table 1. To manage the files a set of IDL programs, available upon request, were developed. The programs allowed to chain the files together, to create new files in the IDL format, and to explore the data based in polarization diagrams as in flux profiles. Once the data was explored and intervals of interest selected, their characteristics were determined in all frequencies.

DATA ANALYSIS AND RESULTS

The general distribution of the activity in all the frequencies was analyzed. We considered there are two activity intervals. The first one at 10:20-10:40 UT and a second one at 10:40-11:00 UT. The diagram of the times of beginning, maximum and end of the activity intervals in all frequencies shows that the times go closer with the frequency diminution pointing to up-moving and down-moving sources. From X-Ray observations there are two events, but both are included in the first time interval...
of activity. One starts just after a data gap and reaches its peak at about 10:22 UT. In the second one, the hard X-Ray flux increases at approximately 10:24 UT, reaches a peak at approximately 10:27 UT and end at 10:30 UT. These peaks show very different characteristics [6].

The polarization diagrams of the event in each frequency (Fig. 1) show that the event goes from a simple source behavior, where you observe only an increase of the emission, but not any significant change in its characteristic, in 2965 MHz, to a more complex behavior in lower frequencies. The 610 MHz diagram shows clearly that the “spike activity” conserves approximately the polarization characteristics of the “initial” source. It is possible to notice that the intensity of the spikes diminish without changing significantly its behavior.

The presence of spikes should be detected by an increased amplitude of the components of the fluctuation in the over 1 Hz frequency interval of the spectrum. After appropriate treatment the power spectrum of the signal was calculated and no significant contribution to the overall energy release found.

### TABLE 1. Intervals with 100 Hz temporal resolution observations on July the 14th, 2000. Data provided by Trieste Astronomical Observatory. Capital X indicates the presence of millisecond events

<table>
<thead>
<tr>
<th>Intervals</th>
<th>Frequencies [MHz]</th>
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<tbody>
<tr>
<td>Begin [U.T.]</td>
<td>Duration</td>
</tr>
<tr>
<td>10:10:00</td>
<td>10 min.</td>
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<tr>
<td>10:20:00</td>
<td>10 min.</td>
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<tr>
<td>10:30:00</td>
<td>10 min.</td>
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<tr>
<td>10:40:00</td>
<td>10 min.</td>
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<tr>
<td>10:50:00</td>
<td>10 min.</td>
</tr>
<tr>
<td>11:00:00</td>
<td>10 min.</td>
</tr>
<tr>
<td>11:10:00</td>
<td>10 min.</td>
</tr>
<tr>
<td>11:20:00</td>
<td>10 min.</td>
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The possibility of a SOC flare behavior is an interesting point in the solar activity research. There are many details to be taken into account to be sure about such a behavior, but a relatively simple way to explore this possibility is to analyze the waiting time distribution function (WTDF) between successive individual spikes. We consider WT is an index related to the intrinsic behavior of the system to SOC -the storage and dissipation of energy. We take it to explore the SOC behavior of the spike generation process.
FIGURE 1. Polarization diagrams – up to down, left to right, 2695, 1420, 610, 408. In the lower corona (2695 MHz) the diagram is simple, but in 1420 MHz it is possible to see a much more complex structure. The initial linear branch (lower in black) with a superimposed structure related to the appearance of a source (mainly right polarized) and in gray the section related to a second activity period not visible on 2965 MHz. The 610 MHz diagram shows clearly that the spike activity conserves the characteristics of the “initial” source.

FIGURE 2. The WTDF in the 10:30-10:40 UT interval for LPC and RPC events. Notice a significant number of unpolarized events.
Only in RPC the number of millisecond spikes is big enough to estimate the WTDF of millisecond events in the 10:40-11:00 UT interval.

We selected those peaks with intensity greater than 10 solar flux units (1 sfu = $10^{-22}$ W m$^{-2}$ Hz$^{-1}$) in a 50 ms temporal window. The peaks were selected independently for left and right polarized components. Those observed in both components were marked as “un-polarized” ones.

It was found that the WTDF changes significantly from the 10:10-10:40 UT interval, in which it was possible to observe millisecond spikes in both polarized component with both high and low polarization degree; to the 10:40-11:00 UT interval when only right polarized millisecond events were observed (Fig. 2 and 3).

We compare these observational results with the gyro-synchrotron maser [7] and upper-hybrid turbulent hypothesis [5] and propose that observations in the first activity interval are more consistent with the turbulent hypothesis and the second one with the gyro-synchrotron maser hypothesis. The gyro-synchrotron maser hypothesis predicts the prevalence of highly polarized O1 radio emission that in the case of the 9077 NOAA active region following the leading spot field rule is the right polarized...
component. The upper-hybrid turbulent hypothesis does not predict the prevalence of a particular circular polarized component. The power-index (\( \gamma \)) and the coefficient (B) were calculated for each WTDF, and we found they are related as \( B = 9.8552 \exp \{4.862 \gamma \} \) (Fig. 4). We have not an explanation for that behavior but it seems to be related not to the intervals of observation, but to the nature of the system.

CONCLUSIONS

There are evidences supporting a millisecond event multiple mechanisms generation. Without solving this problem will be difficult to obtain a homogeneous data to compare with observations and accept or reject generation hypothesis. An analysis of the millisecond events profile could help to discriminate between different generation hypotheses.

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REFERENCES