DELAY BETWEEN THE CIRCULARLY POLARIZED COMPONENTS IN FINE STRUCTURES DURING SOLAR TYPE IV EVENTS *

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Abstract. We analyzed intermediately polarized (20–80%) fine structures (pulsations, sudden reductions, fiber bursts and zebras) that were recorded in type IV events. The mean polarization degree was practically the same for all the fine structures recorded in an interval lasting a few minutes and it was similar to the polarization of the continuum. A detailed analysis during the evolution of single structures reveals changes in polarization (in particular an 'undulation' at flux density minima) even stronger than 20%. They were caused by a delay, up to 0.1 s, between the two circularly polarized components. The weaker polarimetric component was delayed in 2 sets and the stronger one in 1 set. In the event of April 24, 1985 different types of fine structures were sporadically detected in more than one hour long time interval. Short delays of the stronger or of the weaker component were sometimes observed.

The events characterized by fine structures are generally totally polarized in the ordinary mode. We assume that this holds also for the phenomena studied here. The observed intermediate polarization therefore requires a depolarization due to propagation effects. We discuss the mode coupling and the reflection of the original radio signal that could also generate the delay of the weaker and the stronger component respectively. The possibility of polarization variation due to the change of the angle between the direction of the propagation and the magnetic field in a quasi-transversal region and in a low intensity magnetic field in a current sheet is also given.

1. Introduction

Fine structures (pulsations, sudden reductions, fibers, zebras) are sometimes present in type IV solar radio bursts at meter wavelengths (Kuijpers, 1980; Bernold, 1980; Slottje, 1981). They can be used as important diagnostic indicators of the phenomena going on in the active coronal plasma. In the majority of cases (Zlobec *et al.*, 1987) they are totally polarized, as well as the underlying continuum. Chernov's (1976) theory explains the generation of these structures in ordinary mode.

In the IZMIRAN and Trieste Astronomical Observatory records we found four contemporaneous observations of fine structures that were intermediately (20–80%) polarized. Examples of the spectra and polarimetric data are shown in Chernov and Zlobec (1994) where the basic properties of the intermediately polarized fine structures are given:

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(a) the mean polarization in a group of structures is essentially the same;

(b) there is no remarkable difference in polarization for different types of fine structures which appear almost simultaneously;

(c) the polarization of fine structures has nearly the same value as the continuum.

Here we report new interesting results from a more detailed analysis of fine structures, a general discussion and a possible explanation of the observed phenomena.

We used polarimetric data that were recorded at the Trieste Astronomical Observatory at 237 MHz; the rate of digital measurements was 29.3 Hz prior to 1983 and 50 Hz afterwards. A simultaneous signal at both (left-handed (L) and right-handed (R)) inputs reveals in laboratory tests a delay smaller than 1 ms between the outputs of the two channels (Comari, 1994). IZMIRAN spectral data in the range 180–270 MHz were recorded on film with a 50 Hz sweep rate and 0.2 MHz frequency resolution.

The problem of the evaluation of the polarization degree during the lifetime of a fine structure (in emission or in absorption) can be heavily influenced by the subtraction of the background in the two channels. To avoid this problem, it is necessary to use a method that is unbiased by the background subtraction (Kattenberg and Van der Burg, 1982; Wentzel, Zlobec, and Messerotti, 1986). This can be derived from plots where $L - R$ versus $L + R$ (or R versus L) data are reported, however the trend of the polarization can be identified directly only on polarization degree versus time plots. Due to the presence of the background noise, which is rather strong in type IV events, we normally used the running averaging technique on 3, 5, or even 7 adjacent measurements in order to obtain smoother signal profiles. Such a mathematical tool introduces the same time delay in the two channels.

Let us remark that in order to avoid the negative sign in polarization data we always considered its absolute value characterized by the symbol 'L' (left-handed) or 'R' (right-handed).

2. Characteristics of the Fine Structures Studied

In Table I the characteristics of fine structures that were analyzed during the four type IV events considered are given. For each group of samples studied the order is the following: date, starting time, type of the selected fine structures, number of the samples considered, maximum modulation depth in respect to the continuum, mean polarization of the samples, their standard deviation, minimum of the estimated absolute error, background polarization, polarization of the signal of the delayed channel and amount of the delay (uncertain data are marked by '?').