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FIBER FINE STRUCTURES SUPERPOSED ON THE SOLAR CONTINUUM EMISSION NEAR 3 GHZ

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Abstract. On April 21, 2002, a broadband solar radio burst was observed at about 01:00 – 03:00 UT with the digital spectrometers of National Astronomical Observatories of China (NAOC). Also many fiber bursts superposed on the continuum bursts were detected in the frequency range of 2.6 – 3.8 GHz during the time interval. After data processing, some parameters of the fibers such as frequency drift rate, duration, bandwidth, and relative bandwidth were determined. The mean value of the frequency drift was in the range of 42.3 – 87.4 MHz s^{-1} (negative). A theoretical interpretation for the fibers was presented based upon a model of the velocity of Alfvén solitons. In this model, the source of the fiber emission was considered as the ducting of the solitons within the magnetic-mirror loop. Then the magnetic field strength of the fiber source was estimated to be about $130 \leq B_0 \leq 270$ G. Also a comparison of the magnetic field estimation was made with another model of whistler group velocity.

1. Introduction

Fibers, or intermediate drift bursts, were first observed in solar type IV continua by Young *et al.* (1961). Afterward more observations were reported by Bernold and Treumann (1983), Aurass *et al.* (1987), Chernov (1990), Wang *et al.* (2001), Zhong and Wang (2004) and so on. Fiber bursts may allow one to measure the strength of the coronal magnetic field in the radio burst source volume (Kuijpers, 1975). Fiber burst sources may be situated in the system of postflare loops formed below the erupting prominence and below the flare current sheet (Benz and Mann, 1998). Recently Aurass *et al.* (2005) proposed a new method to use fiber bursts as a probe of the magnetic field strength and the 3D field structure in postflare loops. Fiber bursts could be an important field-sounding method of coronal magnetic strength in postflare loops.

The main properties of fiber bursts were explained by the interaction of Langmuir waves with whistlers producing a transverse wave ($L + w \rightarrow t$), which can escape from the emitting plasma. The modulation of the emission into intermediate drift bursts was interpreted by a whistler wave packet propagating upward with the local whistler group velocity. This model was proposed by Kuijpers (1975) and modified

by Mann, Karlický, and Motschmann (1987) and Mann *et al.* (1989). However, Bernold and Treumann (1983) and Treumann, Güdel, and Benz (1990) invoked Alfvén solitons to explain fiber bursts. Benz and Mann (1998) summarized those earlier works and compared the existing models with each other. Mainly there are two models of the fiber bursts interpreting the drift rate corresponding to the Alfvén velocity and the whistler group velocity. In the present paper, we prefer to discuss the magnetic field by the model of Alfvén solitons (Bernold and Treumann, 1983) in detail first. Then we make some comparisons of the magnetic field estimation with the model of whistler group velocity.

On April 21, 2002, a high-energy X-class flare with a flare importance of X1.5/SF, was observed from 00:59 UT to 02:51 UT in the NOAA 9906 AR at position S14W84. It was simultaneously observed by several telescopes around the world. Accompanying with this flare, there were radio continuum emission and rich fine structures (FS) recorded by the solar radio fast dynamic spectrometer of NAOC at Huairou in the range of 2.6 – 3.8 and 5.2 – 7.6 GHz (no data in the range of 1.0 – 2.0 GHz during this interval) (Fu *et al.*, 2004). Many kinds of complicated zebra patterns were detected superposed on the continuum emission including zebra stripes accompanying with spike-like structures, zebra stripes, and fibers in the low-frequency edge, and zebra stripes beginning from a cloud of millisecond spikes (Figures 5 – 7 in Chernov *et al.* (2005). There were also several groups of isolated fiber structures that occurred in the frequency range 2.6 – 3.8 GHz for this event. In order to investigate fiber bursts in more detail, we will focus our discussion on the characteristics of these isolated fiber bursts.

In Section 2 of this paper, we report the continuum bursts and several groups of fiber bursts recorded on April 21, 2002. In Section 3, we carry out the data processing and determine the characteristic parameters of the fibers. In Section 4, firstly using the model of Alfvén solitons to make quantitative analysis, we obtain the magnetic field strength, the number of solitons in a single fiber source, the volume of the source, and the ducting parameters. Then we make a comparison of the magnetic field estimation with the model of whistler wave packet. Finally, Section 5 is devoted to discussion.

2. Observations

A composite of time profiles of the radio emission at 2.84, 5.80, 17, and 34 GHz (by the Nobeyama Radio Observatory – NRO, and National Astronomical Observatories of China – NAOC), and GOES-8 soft X-ray (SXR) flux on April 21, 2002 is given in Figure 1. The polarization of broadband continuum emission in 2.6 – 7.2 GHz was left-hand circularly polarized (LCP). The degree of polarization was high around 80% LCP.