AN ANALYSIS OF FINE STRUCTURES IN THE RANGE 250-450 MHZ IN A RADIO BURST SEPTEMBER 23, 1998

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ABSTRACT

We study some fine structures of a complex radio event observed in the range 100-700 MHz on September 23, 1998; this included a type II burst (06:52-07:02 UT) associated with a flare (3B, M7.1) and followed by a long-lasting type IV continuum. The type II burst was related with ejections of chromospheric mass observed in CIV line (1550A) and the formation of a flare coronal hole. Between 08:00 and 08:10 some new fine structures appeared in the range 250-450 MHz and were recorded by the ARTEMIS-IV radio spectrograph; they consisted of a group of fiber bursts, zebra-pattern and fast pulsations in emission and absorption with complex circular polarization. Fine structures were observed simultaneously with the appearance of new magnetic loops on TRACE images in line 195A. At 08:03 the position of the radio source centre at 327 MHz (Nancay Radio heliograph) reported on TRACE images results to be above a new formed loop. We thus establish a possible association of fine structures with emerging magnetic loops; the observed spectral range (280-450 MHz) may be explained by the extension of these loops in the corona.

Key words: radio burst, flare, zebra-pattern, fiber-bursts.

INTRODUCTION

Zebra-patterns and fiber-bursts (also known as intermediate drift bursts) are well known fine structures that sometimes appear superposed on metric and decimetric type IV continua (cf. McLean & Labrum, 1985 and references therein). Their frequency range varies from ~50 MHz in the metric to some hundreds MHz in the decimetric (< 2000 MHz) wavelengths. In this paper we examine some fine structures present in a complex radio event using mainly dynamic spectra of the ARTEMIS-IV radio spectrograph (Caroubalos et al., 2001), single frequency polarization data of Trieste AO and 2D images of the Nancay Radio heliograph (NRH). These are combined with YOHKOH SXR images and SOHO and TRACE EUV recordings, which reveal the associated dynamic flare evolution in order to provide some evidence on the association between the time of appearance and the frequency range of the fine structures with the new emerging magnetic flux.

OBSERVATIONS and DISCUSSION

According to the Solar-Geophysical Data bulletin the flare 3B M7.1 started in AR 8340 (N18 E09) at 06:40 with maximum at 07:13. The radio event was observed between 06:45 and 11:00 (Figure 1, upper panels). It consisted of a type II burst which started at about 200 MHz and drifted to below 100 MHz (06:52-07:02, Figure 1) and a long-lasting type IV burst with intermittent activity. The SOHO/SUMER images in 1550A show a disruption of a bright arcade and loop movements just at the beginning of type II burst (cf 4 lower panels of Figure 1). At the same time a strong microwave burst began (type GRF after Altyntsev et al., 2001). Such an evolution of the event seems to be consistent with the flare reconnection model, and the type II burst is probably the result of a blast shock wave. The radio spectrum exhibits the typical "herring-bone" fine structure. Fine structures are visible also at higher frequencies (up to 2000 MHz) according to Ondrejov and Phoenix-II, Bleien reports. This sequence of events coincides with strong type III and II activity observed in the interplanetary space by WIND/WAVES.

Between 08:00 and 08:10 new fine structures were recorded by the ARTEMIS-IV radio spectrograph. They consisted of a group of fiber-bursts (08:03-08:04), zebra-pattern (08:05-08:06) and fast pulsations in emission and absorption (08:08-08:09). They are shown in Figure 2, top panel in the form of differential dynamic spectrum. Their main peculiarity was in the complex behaviour of the circular polarization with time and frequency. In particular the circular polarization (see the L- and R-polarized plots of the Trieste AO polarimeter) at 327 MHz was very low.

The evolution of the flare is shown in the four bottom panels of Figure 2. A long lasting two-ribbon H_α flare was observed along the eastern and western part of the neutral magnetic line. Two frames of the TRACE EUV at 195A (right panels) show numerous emerging bright loops on both sides of the neutral line. After 08:00 a new high and bright loop appeared in the southern part of the flaring region. At 08:03 the position of the radio

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source centre at 327 MHz (NRH) is reported on the TRACE image and it appears above this new loop (right bottom panel). At the same time the right source (nearest to the eastern neutral line and to the metric source) was brighter (left bottom panel in Figure 1). However the maximum energy release was emitted in the decimetric - metric range.

Altyntsev et al., (2001) and Ning et al., (2001) studied many aspects of the radio source structures in the microwave range. In particular the radio source at 5.7 GHz (SSRT) according to Altyntsev et al., (2001) presented double structure. In two images of TRACE line 195A we clearly see a dark region at the right side of bright loops (a dark hole), probably surrounded by the zigzag magnetic neutral line in accordance with SOHO/MDI magnetogram. It is noteworthy that ejections visible in 1550A in Figure 1 take place just inside this dark region. It is evident that the dark region appeared after the flare ejections, due to the escape of the bright (hot) mass, i.e. that's a flare coronal hole. Taking into account the almost simultaneous onset of the burst in different ranges (X-rays, EUV lines, radio waves from cm to dkm range), the overall scenario of the flare testifies the magnetic reconnection from the chromosphere up to the middle corona.

CONCLUSIONS

The zebra-pattern and the fiber bursts were observed simultaneously with the appearance of new bright magnetic loops. The bandwidth of fine structures between 280 and 450 MHz should be explained by the extension of these new loops in the corona. The location of the radio source near the top of such new loops showed that inside new loops instabilities of electrostatic plasma waves and low-frequency waves developed and they were responsible for the generation of fine structures.
The type II burst was related with ejections of chromospheric mass observed in CIV line (1550A) and the formation of a flare coronal hole.

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Figure captions

Fig.1. Top panels: ARTEMIS-IV (ASG) dynamic spectrum (intensity and differential) presenting an overview of the type II/IV event recorded in the range 100-700 MHz.; bottom panels: sequence of 4 frames from the SOHO/SUMER movie ; (1pixel =1 arc sec) in C IV (1550A), showing the disruption and movements of a bright loop at the onset of type II burst at ~200 MHz (06:54:15 and 06:55:15 UT). The peak temperature of ionization for C IV is 10^5 K

Fig.2. Top panel: the differential spectrum in the range 250-450 MHz (ARTEMIS-IV, SAO) shows fiber bursts, zebra pattern and fast pulsations. Second and third panels: time profiles of the polarization channels (TAO) demonstrating very weak polarization. The evolution of the flare is shown in the four bottom panels: the two-ribbon Hα flare was observed by Learmonth SO. Two frames of TRACE EUV 195A (right panels) show many emerging bright loops on both sides of the neutral line (space resolution: 1 pixel =0,47″, field of view = 8′ x 8′). After 08:00 a high bright loop appeared in the southern part of the flaring region. At 08:03 the position of the radio source centre at 327 MHz (NRH) is shown on the TRACE image. It was localized just above this new loop (right bottom panel). In the left bottom panel the brightness distribution of the radio sources at 5.7 GHz is given by SSRT.

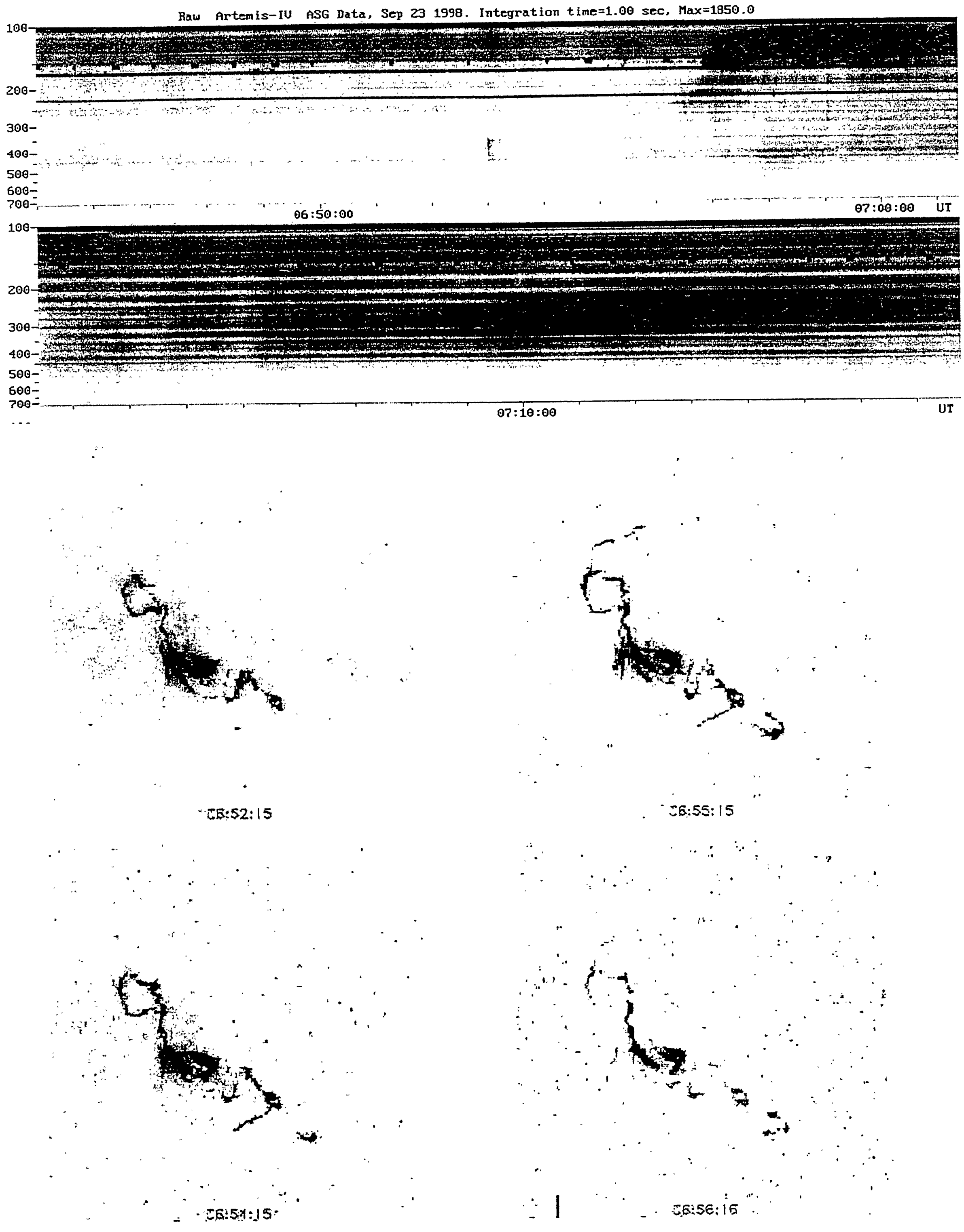
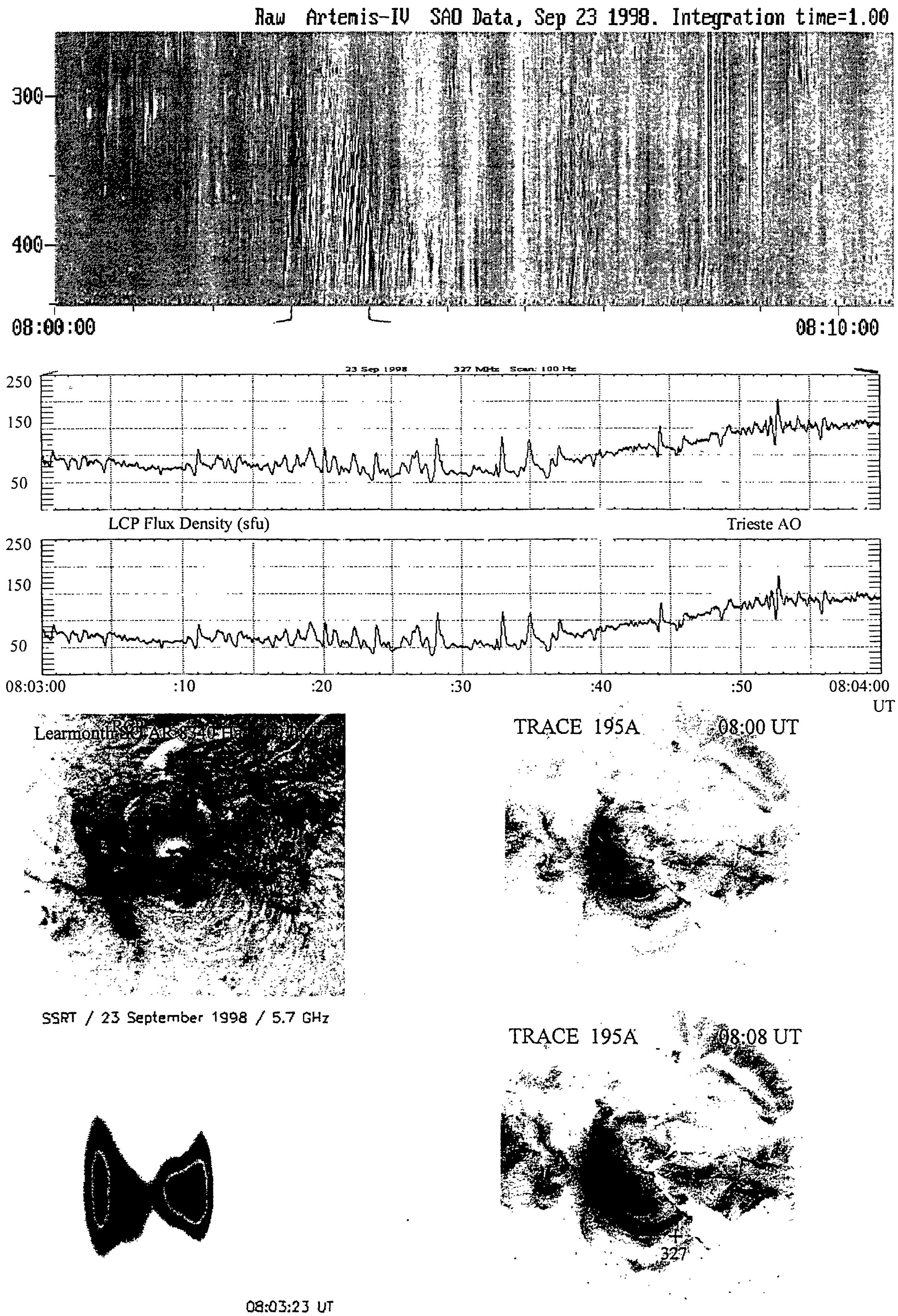

Raw Artemis-IV ASG Data, Sep 23 1998. Integration time=1.00 sec, Max=1850.0
100
200
300
400
500
600
700
06:50:00
07:00:00
UT
100
200
300
400
500
600
700
07:10:00
UT
06:52:15
06:55:15
06:54:15
06:56:16

Fig.1



Raw Artemis-IV SAO Data, Sep 23 1998. Integration time=1.00
300
400
08:00:00
08:10:00
23 Sep 1998
327 MHz
Scan: 100 Hz
250
150
50
LCP Flux Density (sfu)
Trieste AO
250
150
50
08:03:00
:10
:20
:30
:40
:50
08:04:00
UT
TRACE 195A
08:00 UT
SSRT / 23 September 1998 / 5.7 GHz
TRACE 195A
08:08 UT
327
08:03:23 UT