The ARTEMIS IV radio spectrograph: The 14th of July 2000 large solar events.

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Abstract

We present a statistical analysis of type IV fine structure (mainly fiber bursts) appearing during the large solar event of 14 July 2000, using high time resolution (100Hz) data recorded by ARTEMIS IV multichannel radio spectrograph in the range of 270-450 MHz. The fiber bursts present intermediate positive and negative frequency drifts which are produced by unstable electron populations.

1 Introduction

On the 14 July 2000 a major solar event took place and was recorded by the ARTEMIS-IV radio spectrograph at Thermopylae and many other observatories as well. The emission at metric wavelengths consisted of a variety of bursts a moving and a stationary type IV, impulsive bursts and pulsating structures; the dynamic spectrum showed a complex pattern of emission, including impulsive bursts, continua and pulsations. Descriptions of the event have been given by Zhang et al (2001), Klein et al (2001) and Karlicky et al (2001). In a forthcoming paper (Caroubalos et al 2001b) we describe the main stages of the event evolution, always in conjunction with the radio spectral data from ARTEMIS-IV and ancillary data sources. In this report we concentrate on a brief presentation of the events fine structure; we present high time and spectral resolution observations of pulsations and fiber bursts.

2 Observations & Results

Our observations were obtained with the ARTEMIS-IV solar radiospectrograph (Caroubalos et al 2001a). This instrument uses two receivers operating in parallel. One, the Global Spectral Analyser (ASG), is a sweep frequency receiver which covers the frequency range of 110 to 687 MHz, with a time resolution of 10 samples/s. Due to its bandwidth and dynamic range of 60db the ASG is used for the observation of the general structure of metric radio events; in figure 1 we present the full dynamic spectrum of the event of the 14 July 2000. The second receiver, the Acousto-Optic Spectrograph (SAO), is a high sensitivity multichannel acousto-optical receiver covering the 265-450 MHz range, with high frequency and time resolution (100 samples/s). Due to these characteristics, the SAO is ideal for studies of fine temporal structure. The high resolution observations reveal considerable fine structure and practically no frequency drift of the individual components. An

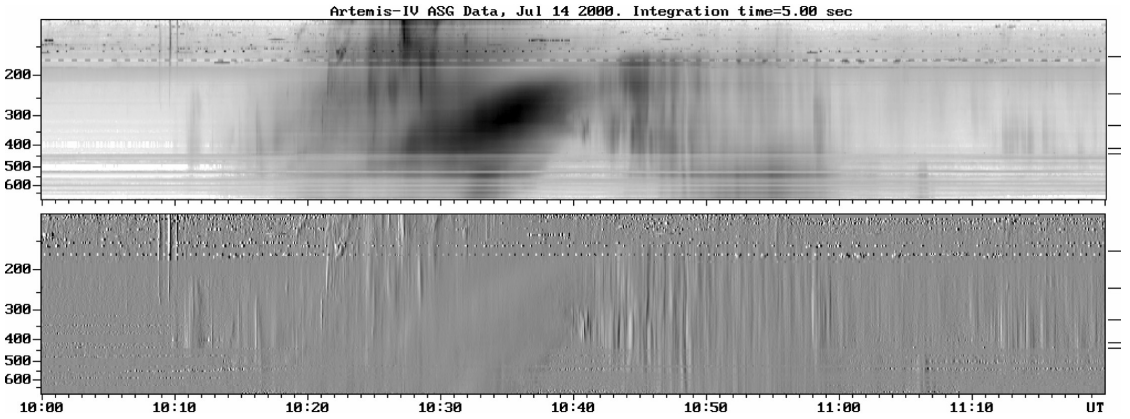

Figure 1: The dynamic spectrum of the 14 July 2000 event observed with the ARTEMIS-IV ASG; the second panel shows the time derivative of the flux, which helps to identify rapidly varying structures.

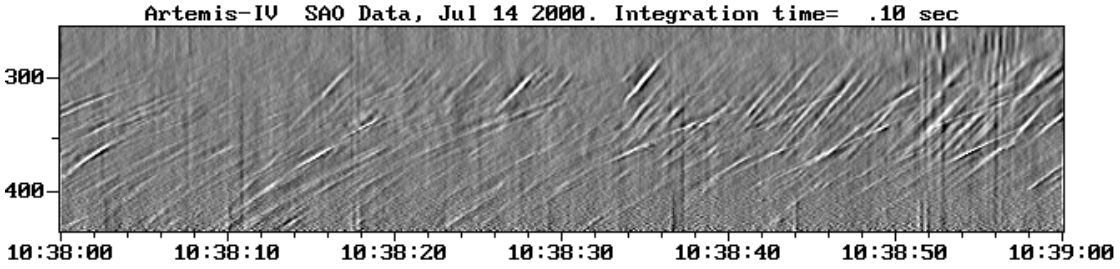

Figure 2: Time derivative of the dynamic spectrum observed with the SAO over a one minute interval in the 265-441 MHz range.

one minute long differential dynamic spectrum in the interval 10:38 to 10:39 UT is shown in Figure 2; the plot of the time derivative of the flux eliminates underlying continuum emission and enhances fast varying structures. The most prominent feature in the spectrum is the fine, drifting bursts (fiber bursts) of $\sim$300 ms duration. They appear at frequencies above 280 MHz and at least two families with different drift rates coexist.

Three more examples are shown in figure 3, at different periods during the late stages of evolution of the event. Both the flux and its time derivative are shown; in the flux spectrum, the average value has been subtracted in order to show better the fine structure. The top spectrum shows a mixture of fiber bursts and pulsations, in the interval 10:40-10:42 UT. The fiber bursts have similar characteristics to those of Figure 2; the pulsations, with periods of $\sim$200 ms, were limited into the spectral range 290-410 MHz, and appeared in groups. Later in the event (*second* spectrum in Figure 2), the pulsations became more numerous and extended beyond the 265-445 MHz SAO band; they became the predominant feature still later (*third* spectrum of Figure 3), for a period of almost one hour after the flare and 40 minutes after the estimated onset of the CME.

We are in the process of developing numerical methods for studying the statistical properties of the numerous fine features seen in the spectra. We have already developed a feature tracking algorithm, on the basis of which we can compute the distribution of the drift rates of fiber bursts. An example is shown in Figure 4, where we give the histogram of drift rates for the same interval as in Figure 2. As expected, most features show negative frequency drifts and the two fiber burst families of Figure 2 are discernible, associated to histogram peaks at -6 and -12 MHz/s; the histogram also shows a few reverse (positive) drift structures.

We presented a preliminary statistical analysis of fiber bursts, that reveals two co-existing families with different drift rates. We are in the process of improving

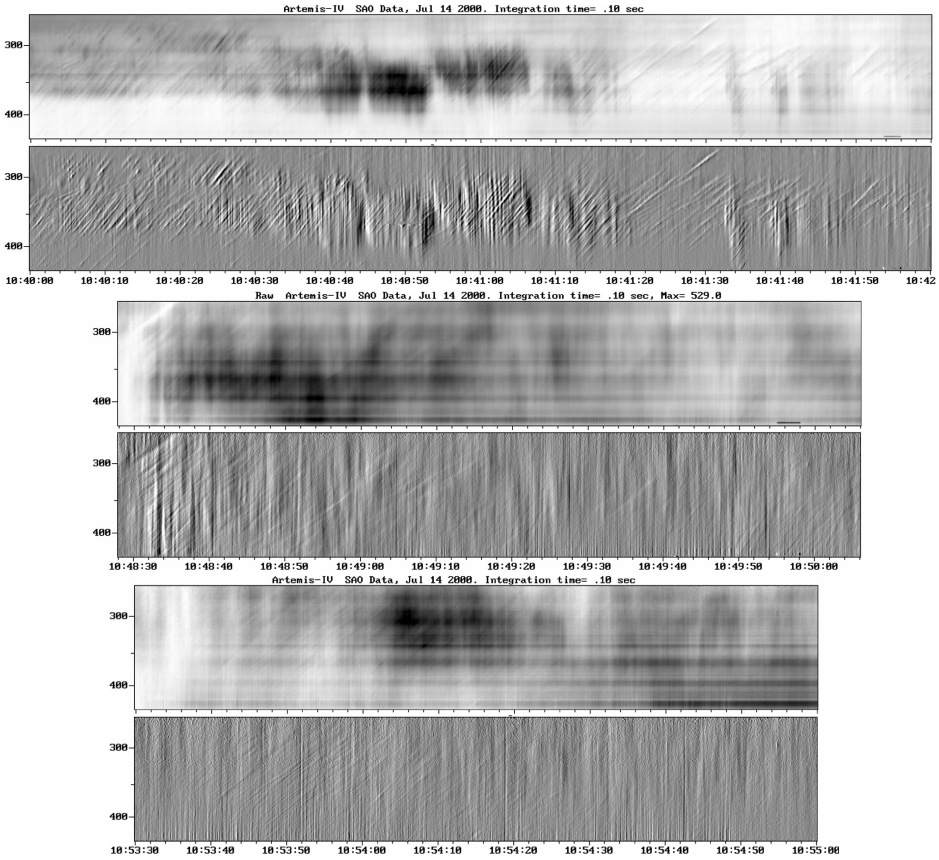

Figure 3: Dynamic spectra of fiber bursts and pulsations (flux and its time derivative) during the late stage of evolution of the event.

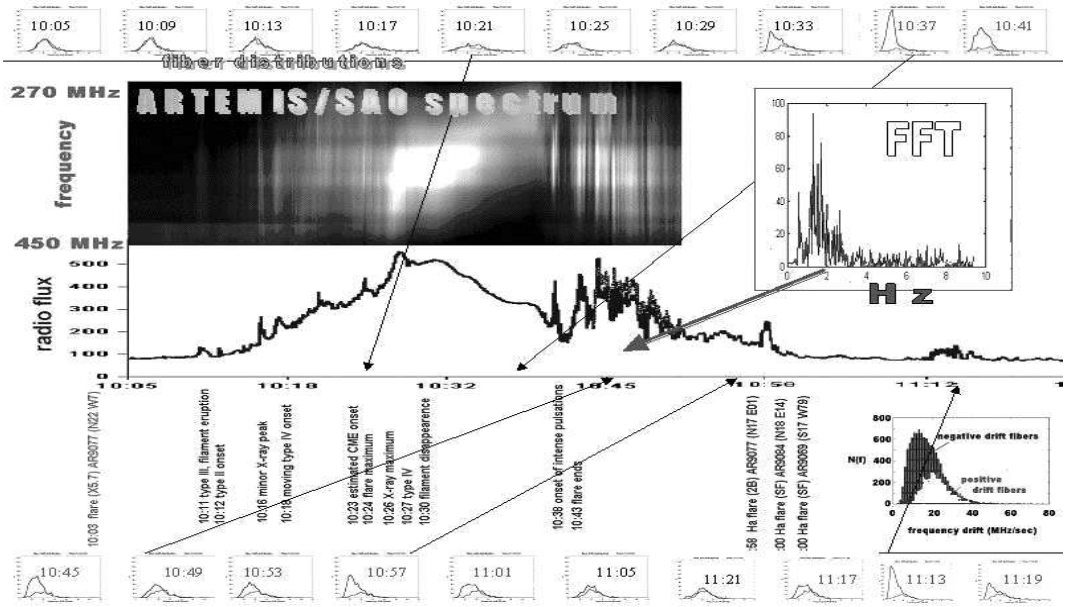

Figure 4: Top and bottom pannels show the evolution of negative and positive drift fibers distributions in frequency. One distribution is presented every four minutes. The distribution of drift rates for all the time period is shown in the lower left panel. The dynamic spectrum of the 14 July 2000 event observed with the ARTEMIS-IV from 270-450MHz (SAO) is presented in the middle. The maximum emission coresponds to the X-ray flare and the begining and evolution of the CME. The radio flux integrated in the range of 270 to 450 MHz from SAO shows also the evolution of the event. A spectrum of the oscillations observed is presented in the upper left panel.

our analysis and we expect to present more thorough results in the near future.

3 Conclusions

The large flare of 14th July 2001 is associated with complex radio emission (impulsive, continua and pulsations) as well as with a halo CME which produced geomagnetic effects. The flare started at 10:03 UT in Ha and soft X-rays. In the time period 10:18 to 10:30 many complex phenomena appeared such as a moving type IV followed by a stationary type IV, a hard X-ray peak and a rapid expansion of the flare eastwards. During the same period energetic electrons were released in the corona, as it is evident by numerous fast drift bursts. Metric emission was also very rich in pulsating structures and fiber bursts, which followed the stationary continuum of one hour duration. Statistical analysis of fiber bursts shows that there are two co-existing families with positive and negative drift rates for most of the time. For three short time periods the fiber distributions become anisotropic, just after some explosive phases of the event. It seems that fibers are associated with the growing phase of the post flare loops seen in TRACE data.

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