DRIFTING PULSATIONS, 3 GHz OSCILLATIONS AND LOOP INTERACTIONS IN THE JUNE 6, 2000 FLARE

M. Karlický[1], H. S. Sawant[2], F. C. R. Fernandes[2], J. R. Cecatto[2], F. Fárník[1], and H. Mészárosová[1]

[1]*Astronomical Institute of the Academy of Sciences of the Czech Republic, CZ-25165 Ondřejov, Czech Republic*
[2]*Instituto Nacional de Pesquisas Espaciaias, INPE, C.P. 515, 12201-970 Sao Jose dos Campos, SP, Brazil*

ABSTRACT

The radio observations of the June 6, 2000 flare reveal two impulsive phases, 15:06-15:40 UT and 16:26-16:40 UT. At the beginning of both these phases, i.e. at 15:06:46-15:07:00 UT and 16:26:34-16:26:42 UT, two drifting pulsation structures (DPS) were observed in the 1.0-1.7 GHz range. Furthermore, during both these phases the quasi-periodic oscillations with periods of 160 and 11 s, respectively, were observed at 3 GHz. The first and main impulsive phase was also characterized by the 2-4.5 GHz broadband pulsations and the continuum, during the second impulsive phase the 2.5-3.5 GHz pulses, consisting of narrow band spikes, were observed. The images obtained with *SOHO*-EIT depict parallel flare loops whilst those from *Yohkoh*-SXT show a bright source located at their top which may originate between them. We have therefore interpreted the high-frequency 3 GHz oscillations as those in this loop system using the current-loop coalescence model. On the other hand, the DPSs are explained as in our previous papers, i.e. as the radio manifestation of the plasmoid ejection.

INTRODUCTION

There are long-duration flares that reveal more than one impulsive phase. Recently, for this type of flares it was found that drifting pulsation structures (DPSs) are observed at the onsets of the impulsive phases (Karlický *et al.* 2001). In the October 5, 1992 flare the DPS occurred during a plasmoid ejection (Kliem *et al.* 2000). On the other hand, there are several observations showing loop interactions (e.g. Šimberová *et al.* 1993). Both these features were observed during the June 6, 2000 flare.

OBSERVATIONS

The June 6, 2000 flare, classified as X2.3, was observed at 15:00-17:00 UT in the active region NOAA AR 9026. A full-halo coronal mass ejection and a type II burst were reported in association with this event. During the June 6, 2000 flare two impulsive phases were observed. Quasi-periodic oscillations with characteristic periods of about 160 s during the first phase and about 11 s during the second one were registered at 3 GHz. During the first phase (15:06-15:40 UT) the 2-4 GHz radio spectrum consists of broadband pulsations and continuum; during the second phase (16:26–16:40 UT) the pulses (2.5-3.3 GHz, duration $\sim$ 5s) consisting of many narrow band spikes were observed. These pulses correspond to quasi-periodic peaks observed at 3 GHz. In the 1.0-1.7 GHz frequency range the radio emission started with a group of type III-like radio bursts at 15:06:10-15:15:06:30 UT and with the DPS at 15:06:46-15:07:00 UT.

During the interval 15:15-15:40 UT, fibers and zebra patterns were observed. Just at the beginning of the second phase at 16:26:34-16:26:42 UT the second DPS was recorded. This flare was also observed by the *Yohkoh*-SXT and the *SOHO*-EIT. Their images, presented in Figure 1, are consistent with an interaction of parallel flare loops explaining the high-frequency 3 GHz oscillations.

INTERPRETATION

The DPSs were observed at the onsets of both impulsive phases as reported earlier for similar events by Karlický *et al.* (2001). The DPSs are therefore interpreted as the radio manifestations of the electrons accelerated in the current sheet during the reconnection process, connected with a plasmoid ejection. Two DPSs indicate two disruptions of the magnetic rope. After these processes, in the loop system (Figure 1) below the current sheet the parallel loops started to interact. At these times the oscillations at 3 GHz were recognized. These facts agree with the Tajima *et al.* (1987) model of interacting loops.

In such a model the observed 3 GHz oscillations are due to the periodic coalescence of current-carrying loops. Their period (Tajima *et al.* 1987) is: $T = 2\pi(-2E)^{-3/2}t_A^{-2}$, where $t_A = \lambda/v_A$, λ is the magnetic field scale length, E is the initial "energy" of the system, and v_A is the Alfvén speed. Assuming roughly that the zebra frequency corresponds to that of the plasma frequency, we estimate the electron density to be $\sim 1 \times 10^{11}$ cm^{-3} and the Alfvén speed $\sim$ 1000 km s^{-1} within the interaction region. Now, for λ = 10000 km, the initial "energy" E of the system is estimated to be $- 2.68 \times 10^{-3}$ s^{-2} in the main impulsive phase, and $- 1.59 \times 10^{-2}$ s^{-2} in the secondary one. The higher value of the initial "energy" E in the first phase means that at this phase a deviation of the loop system from the equilibrium state was greater than in the second phase.

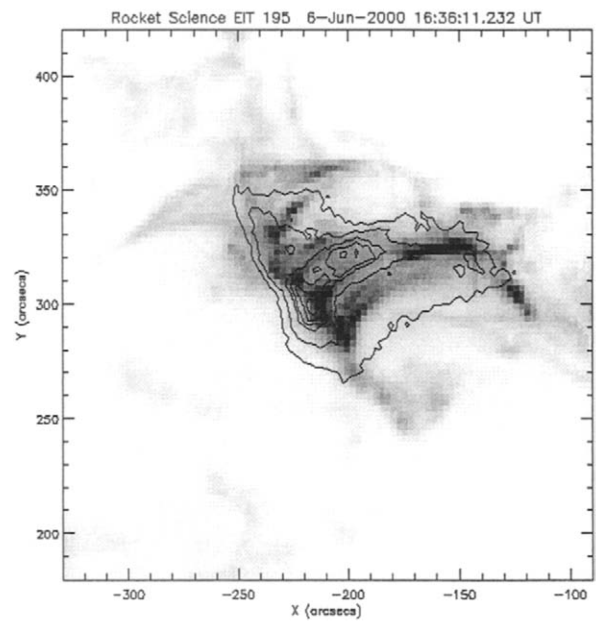

Fig. 1. The *Yohkoh*-SXT image (16:36:41 UT, contours) superimposed on the *SOHO*-EIT image at 16:36:11 UT.

ACKNOWLEDGEMENTS

M. K. thanks FAPESP authorities for supporting his visit to INPE (P.N. 01/00144-5). This work was also supported by the grant S1003006.

REFERENCES

Karlický, M., Y. Yan, Q. Fu, S. Wang, K. Jiřička *et al.*, *Astron. Astrophys.* **369**, 1104 (2001).

Kliem, B., M. Karlický, & A.O. Benz, *Astron. Astrophys.* **360**, 715 (2000).

Šimberová, S., M. Karlický, & Z. Švestka *Solar Phys.* **146**, 343 (1993).

Tajima, T., J. I. Sakai, H. Nakajima, T. Kosugi, F. Brunel *et al.*, *ApJ* **321**, 1031 (1987).