EVAPORATION CAUSES FLARE-RELATED RADIO BURST CONTINUUM DEPRESSIONS

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Abstract. We study the active region NOAA 6718 and the development of a (2N, M3.6) flare in radio and Hz. Due to our knowledge of the magnetic field structure in the active region we are able to associate the different radio flare burst components with the stages in the Hz flare evolution. A discussion of the data in terms of chromospheric flare kernel heating reveals that in the present case the observed flare-related radio burst continuum switch-off is caused by the penetration of hot, ablated gas into the coronal radio source.

1. Introduction

Noise storm depressions are rare but interesting phenomena revealing a special communication between a flaring active region and a pre-existing noise storm continuum source. From the number of occurrences noticed at Tremsdorf Solar Radio Observatory so far we estimate a frequency of about 10–15 more or less well-expressed, flare-related noise storm turnoffs per solar cycle. Their investigation promises insight into the generation of noise storms, the injection, propagation and storage of energetic particles, and the means of communication between the chromosphere and the corona during flares. Figure 1 adds a further typical example to the cases already discussed by Böhme and Krüger (1982) and Aurass, Böhme, and Karlický (1990).

We describe the flaring active region 6718, and study the 10 July, 1991 flare dynamics in all available spectral ranges. A discussion of the data in terms of models of the solar atmosphere above a chromospheric flare kernel in the nonthermal stage of the impulsive flare phase (e.g., de Jager, 1985) yields evidence that in the present case the radio burst continuum switch-off is due to the penetration of hot, evaporated, chromospheric gas into the coronal meter-wave radio source.

The present case is exceptional in several respects:
(a) There is good data coverage in radio, especially there are complete spectra

Fig. 1.  (a) Flux records of the 10 July, 1991 event. Scales are linear but different for the records. Arrows denote the microwave polarization change and the onset of the noise storm continuum depression. The bar marks the onset delay of the depression to lower frequencies. The microwave records are shown in the sensitive regime; the cut-off is at about one-fold the undisturbed Sun. (b) Spectral records of the 10 July, 1991 event in the range 40–800 MHz; first interval (11:59–12:09 UT). Before 12:03 UT, the noise storm is visible between 100 and 170 MHz only. There is no feature in the spectrogram associated with the strong 3 GHz pulse at about 12:01:30 UT (compare Figure 5(a)). (c) Spectral records as in (b); second interval (12:09–12:23 UT) showing the noise storm depression and some noise storm chains within. (d) Spectral records as in (b); third interval (12:35–12:47 UT). The decimetric continuum between 100 and 300 MHz shows typical 'pulsation' fine structures.
Fig. 1b.

of the phenomenon in intensity and polarization due to the data of Trieste, Bern, and Potsdam–Tremsdorf Observatories.

(b) Magnetogram data (Sonnenobservatorium Einsteinturm Potsdam) are available for 9, 11, and 12 July, revealing a sufficiently stable situation that we can use in the following the gross magnetic field structure deduced from the 11th July magnetogram as being representative for one day earlier, too. Further, a complete sequence of Hα and Hα ± 0.5 Å images (Paris-Meudon Observatory) covers the time interval of the radio burst with 1-min time resolution.

(c) Looking at the single-frequency radio records (Figure 1(a)) we note a remarkable coincidence between radio signatures emitted at extremely different coronal height levels (compare the 9.5 GHz microwave record and the meter-wave records, especially between 300 and 100 MHz). The arrow at the 287 MHz record in Figure 1(a) denotes the time interval of flux decay below the preflare noise storm flux level (black area). In the same time interval (arrow at the 9.5 GHz V record, black area) the sense of the degree of circular polarization at the high-frequency end of the observed microwave spectral range is switched from right (R) to left (L). We take this fact as an indication of a relation between an additionally acting microwave source and the duration of the meter wave continuum depression. That gives us the key to understand what happens in the solar corona during a flare-related switch-off of a meter wave radio continuum.

2. Description of AR 6718

On 10 July, 1991 the active region NOAA 6718 (S 22, E 34) is in an advanced state of development. It consists of two large sunspots with an east–west directed axis, and is
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Fig. 1c.

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Fig. 1d.
extended over a distance of about 12 deg. Bipolar subsystems are situated between the two main spots, which is a sign of the often-observed secondary evolution of bipolar spot groups. The subsystem axes are inclined against the main east–west direction. The longitudinal field magnetogram reveals the details of this gross structure (Figure 2).

Fig. 2. Longitudinal field magnetogram of AR 6718. Filaments are indicated (see Figure 3), probable magnetic connections are given schematically. Having the same data for 9 and 12 July, we found the gross structures to be stable so that this magnetogram of 11 July characterizes well the situation one day before. Note: continuous isolines – southern polarity; broken isolines – northern polarity. The small contour to the southeast of the penumbra of \( P_0 \) is caused by projection effects. I, II – filaments, LP – loop prominence, ff – faint features.

The leading spot, \( P_0 \), is of northern polarity. Between \( P_0 \) and the southern polarity \( F_0 \) spot (which has two south polarized flux concentrations \( F_1 \) and \( F_3 \) nearby) there is an extended area of dispersed north polarity flux \( P_1 \) showing several side branches, note especially \( P_3 \). To the south–east of this region there evolves an emerging flux region \((P_2, F_2)\) from 9 to 11 July.

From \( \text{H}\alpha \) pictures taken before and during the flare in NOAA region 6718 (Figures 3(a) and 3(b) shows some of the pictures which are discussed in detail in Section 3) we deduced some chromospheric structure elements of principal importance in the later dynamic flare process:

- A fine filament, I, to the north of \( P_1 \) consisting of two aligned parts (later called IN and IS).
- A larger, also fine, S-shaped filament, II, designating the field inversion line between \( P_1 \) and \( F_0 \). Filament II shows downflow at its southern end.
- A dark feature (probably a loop prominence) LP to the north-west of \( P_0 \). Perhaps this is a remnant of earlier flare activity in active region NOAA 6718.
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Fig. 3. Hα and Hα ± 0.5 Å images obtained at Paris-Meudon Observatory. This is a sample out of a complete set of images with 1-min time resolution. Condensed information is given schematically in Figure 4. The scale is already corrected for the actual central meridian distance of 44 deg. (a) The flare during the isolated northern bright point brightening which is correlated with a strong peak at 3 GHz (top). In the middle, the flare is shown during the onset of the noise storm depression; in the bottom, after the depression. Compare this figure with Figures 4 and 5. (b) The flare during (top) and at the end (bottom) of the late decimetric radio flare activation (compare with Figures 5 and 1(d)).

Already in the preflare phase both filaments I and II are rising which is visible in the blue wing Hα images. In Figure 2, in accordance with the Hα and the magnetographic observations, there are schematically depicted the field lines between regions of different magnetic polarity. For identifying the most probable magnetic connections between flaring regions we have assumed that the two Hα footpoints of a flaring arch must appear almost simultaneously (according to our time resolution). If the flare includes several arches, the flare signature may appear either simultaneously or successively. A careful inspection of the data supports the assumption of at least three different scale sizes:
(a) A large-scale coronal system of field lines between the spots \( P_0 \) and \( F_0 \) \((L_0 > 1.2 \times 10^5 \text{ km})\) touching at least the 300 MHz plasma level in the corona. Only this structure extends into the height range relevant for radio noise storm sources.

(b) Arch-like connections between \( P_3 \) and \( F_3 \), \( P_3 \) and faint features (abbreviated ‘ff’ in Figure 2) to the north of \( P_3 \) and filament II, as well as a strongly sheared arcade connecting \( P_1 \) and the area \( F_1/F_0 \) \((L_1 = L_3 = 8.5–9.7 \times 10^4 \text{ km})\).

(c) The field lines between \( P_2 \) and \( F_2 \) \((L_2 = 1.1 \times 10^4 \text{ km})\).

For the flare process under investigation, the existence of several magnetic subsystems of arcades in different height levels, partly covering each other, as well as the presence of a strongly sheared arcade denote many possible sites of explosive instabilities. The smallest bipolar magnetic feature, \( P_2F_2 \), reveals emerging flux between 9 and 11 July. Further, the subsystem \( P_1F_1/F_0 \) is partly situated underneath the larger system \( P_0F_0 \), the two system axes are strongly inclined against each other (angle = 30 deg); this should lead to current sheet formation between both fields.

Remarkably, the flare starts with an eruptive instability of the small filament, I, which seems to be far away from regions of high magnetic complexity. In GOES-7 X-rays (SGD, 1991) the corresponding burst has a simple fast rise–slow decay time profile of about 4 hours duration. The \( \text{H}_\alpha \) flare grows to a two-ribbon flare around filament II in the highly sheared system \( P_1F_1 \). A permanently high turbulence in the loop prominence LP could be a signature of earlier flare activity in the active region (a 1F flare is reported at 03:08 UT, and a subflare at 06:39 UT).
3. The Flare Dynamics

Quite in accordance with the morphology of the magnetic field patterns described above the dynamics of the 10 July, 1991 flare in AR 6718 (11:58–14:25 UT) is characterized by the interplay of processes in three different parts of the active region. We call them regions ‘A’, ‘B’, and ‘C’ in Figure 4. This figure summarizes the evolution we see in the complete sequence of Hz pictures (e.g., Figure 3); Figure 4(a) presents the time interval 11:58–12:08 UT, Figure 4(b) the interval 12:08–12:22 UT. Further, we use in the

Fig. 4. Sketch of the Meudon Observatory Hz time-series pictures (e.g., Figure 3). Dotted lines – flare ribbons; stippled areas in filaments – rising filament matter; shaded areas – sinking filament matter. (a) 11:59–12:08 UT (the interval before the depression). (b) 12:08–12:30 UT (the interval during and after the depression).
Fig. 5. Some records of Figure 1 with higher time resolution; s.f.u. = solar flux units, 1 s.f.u. = $10^{-22}$ W m$^{-2}$ Hz$^{-1}$. (a) Microwave records of Tremsdorf Observatory. Note the intense 3 GHz impulse at 12:01:30 UT, the impulsive burst with the main maximum at 12:11 UT (9.5 GHz), and the final decimetric activation (12:16–12:45 UT). (b) Intensity and polarization records of Trieste Observatory at 237 MHz; together with the 9.5 GHz Stokes $V$ records of Tremsdorf Observatory. Note also the noise storm chains during the depression and the polarized pulsations at 12:40 UT (see Figure 1(d)).
following description details of the microwave and meter wave radio flux and polarization records (Figure 5) and a presentation of the radio burst polarization development between 237 MHz and 11 400 MHz (Figure 6).

Fig. 6. Polarization records of Trieste Observatory in the range 237–610 MHz; Stokes $V$ records of Bern (3.1, 5.2, 8.4, and 11.8 GHz) and Tremsdorf Observatory (1.47 and 9.5 GHz).
As already reported, the flare starts with the eruption of the filament I far away from areas of high magnetic flux (region ‘A’). The onset of the eruption corresponds with the observation of the first Hα brightening to the north of I (Figure 4(a), ‘B1A’ in region ‘A’), and the fast liftup of the part IN and the slower rise of IS. The same tendency of a preference of rising motions in the northward positioned parts of chromospheric structures will be typical over the whole flare. The flare ribbons around filament II – in the loop systems $P_3$ – bright point ‘B2A’ and $P_1 F_1/F_0$ start brightening (but very faint in the beginning, Figure 4(a), 11:58–12:03 UT). At 12:01 UT the filament IN has disappeared. This stage of the flare yields in radio a faint microwave enhancement (11:58–12:02 UT, Figure 5(a)) and a faint decimetric, L-polarized burst between 300 and 700 MHz, as well as an R-polarized noise storm fluctuation at 237 MHz. Together with the appearance of the second Hα brightening (Figure 4(a), ‘B2A’ in region ‘A’) and the disappearance of IN in region ‘A’, a very strong and narrow band radio spike is superposed between 3.0 and 2.3 GHz (Figure 5(a), the 3 GHz burst at 12:01:30 UT is confirmed by personal communication from A. Benz and A. Tlamanova). This phenomenon is the first intense radio signature of an injection of energetic particles. We argue – the motivation will become clear at the end of this section – that this burst denotes the onset of bursty reconnection between the loop systems $P_1 F_1/F_0$ and $P_0 F_0$. Strangely enough, at that time there is no signature of meter wave type III emission (Figure 1(b), 12:01:30 UT).

The next stage of the flare development is characterized by a stronger radio burst growth in microwaves and meter waves starting at 12:03 UT, accompanied by a compact flare activation in region ‘B’ (near $P_1$ and $P_3$). The polarization records (Figure 6) indicate an R-polarized microwave source and L-polarized flare burst components at 400–600 MHz. Further, we see at lower frequencies during the R-polarized noise storm the onset of a gradual polarization decay at 327 MHz which starts 3 min later at the 237 MHz record. From this time delay a velocity of about 330 km s$^{-1}$ follows, using a two-fold Newkirk streamer density model. We cannot be sure that the polarization effect at 327 MHz has already something to do with the noise storm depression, because we see in the radio spectrum a mixture of noise storm and type IV burst components. The complex appearance of the decimetric and meter wave polarization records, in contrast with the smooth and regular intensity profiles in this stage of the burst, is a rare and remarkable fact. Nevertheless, the present dependence between the polarization decay time and the observing frequency – longer at lower frequencies – is obviously typical for continuum depressions (cf. Figure 5 of Aurass, Böhme, and Karlický, 1990).

At 12:08 UT both ribbons on the sides of filament II (Figures 3(a), 4(b)) enter the main phase of activation. The flare ribbon westward of filament II (region ‘B’) starts to be very bright and highly turbulent. Additionally we note upward movements at the northern end of filament II (a tendency which ceases at this site between 12:10 and 12:20 UT). In the same time (12:08 UT) the microwave burst starts strengthening toward the maximum intensity at 12:11 UT. We conclude that the R-polarized microwave source should be positioned above region ‘B’, which is in agreement with the leading-spot hypothesis and the gyrosynchrotron emission model (cf. Krüger, 1979).
Between 12:08 and 12:12 UT – during the main growth of the microwave emission – a bright, extended part of the northern end of the eastward flare ribbon near filament II (region ‘C’) approaches the spot $F_0$ and touches, therefore, an area of high magnetic flux. At the same time the fluxes of the noise storm and coronal type IV burst components are switched off in the coronal radio source (Figure 1(a), 287 MHz, about 75,000 km above the photosphere). Simultaneously an additional $L$-polarized microwave source grows (Figures 5(a) and 6). We conclude that this new component of the microwave source is situated above region ‘C’ close to the large spot $F_0$ and in contact with the $P_0F_0$ system.

At first glance, the flux records and the radio spectrogram (Figure 1) show the continuum depression in intensity starting at 12:10 UT at 287 MHz and propagating to lower frequencies with the same velocity as was already deduced from the polarization records (330 km s$^{-1}$). The disturbance looks in the spectrogram like a ‘type II burst in absorption’. Only the emission of some noise storm chains (Figures 1(c) and 5(b), denoted by arrows) and the slow decay of the meter-wave polarization degree seen at 237 MHz remain from the lively, fluctuating preflare noise storm source.

At 12:14 UT a facula, which was pre-existing northward of the dark LP, brightens. Starting at 12:16 UT, the region ‘B’ is very turbulent, there is an obvious and unusual change of its shape.

Instead of an increasing distance between the two flare ribbons in ‘B’ and ‘C’, we note a growing westward extension of the western ribbon (Figure 3(b)). Simultaneously, a highly $L$-polarized decimetric radio source starts to be visible at 1.47 GHz (Figures 5(a) and 6). In the $H_\alpha$ data we note a strong downflow of cold matter concentrated to the southern end of the structure LP (Figure 4(b)). At 12:17 UT the meter wave spectrogram (Figure 1(c)) is dark between 40 and 400 MHz (with the exception of the above mentioned noise storm chains).

The radio spectrogram remains completely dark till 12:20 UT. Later a continuum emission is visible between 40 and 70 MHz; some faint drift bursts appear and the noise storm is only barely visible between 100 and 170 MHz (Figure 1b). At 12:20 UT the 8–12 GHz microwave polarization is switched back to $R$; meter wave components reappear first at 287 MHz (Figure 1(a)). The upward movement of matter at the N-end of filament II (region ‘A’) is again evidently visible in $H_\alpha$.

We conclude that from 12:16 till 12:20 UT the main flare activity is redistributed back from region ‘C’ to regions ‘A’ and ‘B’. Evidently the range around $F_3$ did not participate in the flare, but $P_3$ should be connected to the faint flaring features ‘ff’ in region ‘A’ northward of filament II. The smallest loop system $P_2F_2$, denoting emerging magnetic flux between 9 and 11 July, 1991, did not reveal any significant dynamics in $H_\alpha$ during the event. At 12:22:30 UT a type III burst between 130 and 40 MHz is the last bright meter wave component in the spectrum. After a break, a late, characteristic flare activation follows from 12:35 till 12:48 UT. Ranging from 100–300 MHz and 1–2 GHz, this component (Figures 1(d), 4(a), 4(b)) is the latest part of the already mentioned lively fluctuations at 1.47 and 2.0 GHz decimetric emission starting 12:16 UT (Figure 5(a)). It can be interpreted as a signature of the lower efficiency of
flare particle acceleration. Particles are no longer able to reach high magnetic field strength regions at low coronal height levels as necessary for flare burst microwave radiation, but their injection with lower energy is continued. As discussed by Aurass and Kliem (1992) this fine structure rich continuum (pulsations between 100 and 300 MHz, Figure 1(d)) is a signature of a late flare current sheet activation due to the current interruption in the inductively coupled flare circuit.

Remarkably, the western Hα flare ribbon (region ‘B’, Figures 3(b) and 4(b)) reaches the high magnetic field region of the spot $P_0$ during the final decimetric activation. The corresponding large outer span of the Hα flare ribbons independently confirms two facts:

- Definitely, there is a coupling between the loop systems $P_0 F_0$ and $P_1 F_1/F_0$ during the flare.
- The flaring current sheet was rising during the dynamic flare evolution at least from $L_1/2$ (45 000 km) to $L_0/2$ (60 000 km).

We have seen the westward expansion of the western flare ribbon during the decimeter radio burst component between 12:16 and 12:45 UT (Figures 1(d) and 5), say, during 30 min. It follows a current sheet rise velocity of 8.3 km s$^{-1}$; from the chromospheric flare ribbon expansion we estimate a post flare loop footpoint speed of about 30 km s$^{-1}$.

4. Discussion

The problem of flare-related radio burst continuum depressions has already been discussed without a clear identification of the proper nature of the exciting agent (Böhme and Krüger, 1982). Most probable seemed to be the quasi-transversal diffusion of suprathermal particles (from the same particle source supplying the microwave burst) into the large-scale magnetic structures containing the noise storm (and/or coronal flare burst) continuum sources (Aurass, Böhme, and Karlický, 1990). In the present paper we investigate a flare event in an active region without a magnetic ‘Delta-configuration’ (Kuenzel, 1960) but with a magnetic field which is structured into several magnetic subsystems (Figure 2). The flare produces a strong microwave burst, decimeter and meter wave flare burst components, and a noise storm continuum depression of a pre-existing storm source (Figure 1). We can follow the time development of the chromospheric flare by a sequence of Hα images in the center and the wings of the line. Because of the well-known magnetic field configuration of AR 6718 it is easy to follow the time sequence of the flare stages in the different components of the radio spectrum. We find evidence for a close touch between the loop system $P_1 F_1/F_0$ containing strong microwave burst components of the flare and the loop system $P_0 F_0$ connecting the flaring region with the preflare noise storm continuum source high in the corona (see the L-polarized source at 11.4 and 9.5 GHz in Figure 6, and region ‘C’ in Figure 4(b)).

Unfortunately there are no direct meter wave imaging data of the noise storm source (K. L. Klein, personal communication). Thirty-seven GHz maps are available from 09:25 till 10:14 UT (S. Urpo, personal communication) but are of no relevance to our problem. Fortunately, the excellent coverage of the event with radio polarization data
over a broad spectral range, the sequence of Hα images, and the knowledge of the
magnetogram of active region 6718 are sufficient for conclusive reasoning. Let us give
some details:

We argue that the loop system $P_0 F_0$ (Figure 2) is connected with the noise storm
source region. The ordinary-mode noise-storm radio continuum emission should be
$L$-polarized in the present situation when related to the magnetic polarity of the leading
spot (cf. Kružger, 1979). We see a $R$-polarized noise storm (Figures 5(b), 6) according
to the strongest magnetic field in the active region, i.e., the large following spot $F_0$
(Figure 2). Comparable behaviour is reported by Zlobec, Koren, and Messerotti
(1983) and White, Thejappa, and Kundu (1992). In our example, this means that the
interaction flare-noise storm comes out plausibly due to the occupation of the spot $F_0$
by the eastern flare ribbon of filament II, region 'C' in Figure 4(b). We have shown this
essential phase of the development of the flare in the Hα pictures (Figure 3(a)), remember
also the $L$-polarized microwave burst component in Figure 6.

What happens there becomes clear, adopting some well-established observational
facts about flare kernel heating and ablation in the impulsive phase (e.g., de Jager, 1985).
The 10–20 keV electrons, accelerated in the primary flare energy release region and
precipitating into the chromosphere, cause a strong heating of the chromospheric matter
which evaporates. It leaves behind a chromospheric hole at the bottom of which Hα light
is emitted. The heated gas ($5 \times 10^7$ K) streams out convectively with a velocity of
150–400 km s$^{-1}$. Because of the high temperature, a nonthermal aspect of the evapo-
rated matter is predicted (tall electrons with energies $> 15$ keV should escape; de Jager,
1985). We conclude from the strong growth of the microwave emission and the Hα
activity in region 'C' between 12:10–12:20 UT (cf. Figures 4(b), 5(a), and 6) that this
development fits well with our data.

We give in Figure 7 a schematic picture of the chain of processes invoked. We believe
that due to the approach of the flare ribbon to the $F_0$-spot (region 'C' in Figure 4(b))
the evaporating chromospheric matter is partly able to fill the loop system $P_0 F_0$ and thus
to reach the coronal noise storm source. The uplift velocity of 330 km s$^{-1}$ guessed from
radio data is well within the speed range of coronal mass motions. The passage of dense
matter through the noise storm source explains the intensity switch-off by quenching or
screening the radio emission and the 'type II burst in absorption'. The penetrating
matter should have at least a density of $1.3 \times 10^9$ cm$^{-3}$, corresponding to the 300 MHz
fundamental plasma frequency level. The noise storm chains mentioned already,
observed during the depression, have the same drift rate as the depression onset itself,
thus also confirming the presence of directed motions.

The microwave spectrum (Figure 8) reaches a maximum at or below 3 GHz. Further,
it shows approximately at 12:10 UT and later a tendency to flatten continuously till the
end of the event. Independently from the fact that the spectra shown in Figure 8 consist
of a superposition of several unresolved sources, this is – in agreement with usual models
– a signature of very low magnetic fields in the source, pointing towards emission from
very high and certainly not chromospheric loops. The flattening is an argument for a
density enhancement also in the microwave source which can shift the flat spectral peak

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Fig. 7. Scheme of the approach of the Hα flare ribbon (the bottom of the flare kernel in de Jager's (1985) terminology) to the region of high magnetic flux at spot $F_0$. The penetration of ablated hot gas in the loop system containing the noise storm source is shown in three time steps. Fine arrows denote run-away electrons running ahead of the hot gas cloud and firstly inducing an enhancement of the radio source (see Figure 9). The thick arrow designates the cloud movement with (in our example) 330 km s$^{-1}$. In the third stage the noise storm emission is switched off.

Fig. 8. The time evolution of the spectrum of the microwave burst according to the Bern Observatory data.
towards higher frequencies. The density increase may be due to penetration of evaporated matter, too, or by invasion of cold prominence matter (see the downward motion at the southern end of filament II in Figure 4(b)).

![Figure 9](image.png)

Fig. 9. Colour-coded radio intensity spectrogram together with an enlarged part of the sensitive Tremsdorf Observatory 9.5 GHz record (thick black line, from Figure 5(a)) showing the proper onset of the noise-storm continuum depression. At 12:08 UT we observe a definite continuum enhancement between 100 and 170 MHz, probably caused by penetrating, run-away electrons from the flare kernel in region C (Figure 4). Below 100 MHz, we recognize a lot of type III bursts after this time. Between 12:10 and 12:13 UT, the figure shows the onset of the 'type II burst in absorption', completely visible in Figure 1(c).

The picture described is further consolidated by Figure 9, showing a colour-coded intensity spectrogram (Voigt, 1982; Paschke, 1990) of the 40–800 MHz range of the radio burst. We note two facts:

- The strong growth of the microwave burst (for simplicity at 9.5 GHz drawn as a black line in the spectrogram) leads from its very beginning to an 'erosion' of the high-frequency edge of the continuum (Figure 9, 12:07:30–12:10:30 UT around 300 MHz); this means three minutes before the arrival of the slowly moving evaporated matter at the 300 MHz level. Three minutes are about the time necessary for a 330 km s\(^{-1}\) disturbance to pass the distance from the photosphere up to this height level.

- Simultaneously the continuum is enhanced (red colour in the 100–170 MHz spectrum) and type III drift bursts become visible at greater heights (40–90 MHz).

This effect can be due to energetic particles either directly leaving the energy release region or escaping from the evaporated, hot chromospheric gas. If the second is true, our data confirm the nonthermal aspect predicted for evaporated chromospheric matter (e.g., de Jager, 1985).
Already earlier discussions of flare related radio continuum depressions (Böhme and Krüger, 1982; Aurass, Böhme, and Karlický, 1990) noticed hints for the combined action of fast, particle-determined signal speeds and of Alfvénic signal velocities during this phenomenon. The proposed mechanism (Figure 7) explains the presence of both signatures of fast (by runaway electrons) as well as slow (by mass motions) communication between the chromospheric and the coronal height levels emanating from the same source.

Another hypothesis to explain the depression, at least in the present case, is to assume blast wave action, e.g., caused by the initial eruption of filament I. The mentioned tendency of filament II as well as the loop prominence LP to be inclined towards the south (as if lifted due to the action of a disturbance coming from I) could support this idea. But then the ‘type II burst in absorption’ due to a disturbance of 330 km s\(^{-1}\) remains unclear, which should be able to produce a faint type II burst, at least. Note that we had in no one other case of depressions any hint of a type II burst before (Böhme and Krüger, 1982; Aurass, Böhme, and Karlický, 1990).

5. Conclusion

The filling of the loops containing the noise storm source by heated chromospheric flare kernel gas and by energetic particles escaping from this hot cloud, respectively, is well in accordance with the data and explains consistently the observed radio features. Further, this idea elucidates naturally the relative rareness of such a kind of continuum switch-off, because the necessary close spatial contact between chromospheric flare kernels and coronal noise storm loop footpoints seldom happens.

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