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Transient activity in the loop prominence system of a flare active region

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Abstract. Solar limb observations of the activity in a loop prominence system associated with an active region were obtained on 1984 February 2. The activity was observed for a total duration of over seven hours of which the maximum phase lasted for about an hour. From a series of Ca II K prominence spectroheliograms taken during this phase, the individul loops appear to experience a sequence of activity; the brightening of kernel, brightening of portions of the loop, motion of the enhanced brightenings along the legs of the loop and a diffuse appearance of the loop at the end phase. The details of these phenomena and other associated activity are described.

Key words : loop prominence—pre-flare activity—sun

1. Introduction

Filamentary structure, knots and helical structures are common in active prominences. Transient activity such as the oscillation of prominences in flare active regions have been observed by a few investigators (Strauss *et al.* 1980; Malville & Schindler 1981; Vrsnak 1984). The reported duration of these transients is in the range of 1–2 hr before or after a significant flare in the active region. It is known that flare associated active loop prominences are rare phenomena (Kleczek 1965; Engvold *et al.* 1978). We report here our observations of the interesting features in a loop prominence system associated with a flare active region.

2. Observation and results

The observations were obtained at Kodaikanal on 1984 February 2 using a solar image of 60 mm diameter giving a resolution of 31 arcsec mm^{-1}. Ca II K spectroheliogram sequences of the loop prominence system, H_α disc spectroheliograms and H_α visual spectrohelioscope observations were obtained for the transient activity.

A group of four small sunspots of area $2\frac{1}{2}$ square degrees on the visible hemisphere seen on 1984 January 22, developed into a large group of area 32 square degrees by January 31. This NOAA/USAF region No. 4398 is reported to have given 11 subflares during February 1–3 (Solar Geophysical Data 1984); of these, the strongest reported subflare was on February 2 at N16 and W88 :

H_α(SN) and X-ray (C, 5.4)	:	09 : 49 to 10 : 01 UT (Max. at 09 : 51 UT)
Radio (III G)	:	09 : 53 to 09 : 55 UT
Sudden ionospheric disturbance (SWF, SPA and SES)	:	09 : 50 to 10 : 20 UT

We observed the activity from 02 : 17 to 09 : 18 UT and 10 : 22 to 10 : 42 UT, in the loop prominence system associated with this active region.

Activity in loop prominence system

The loop prominence system was slightly active with the brightening of a few kernels at the top of the loops around 02 : 17 UT. It is reported in the Solar Geophysical Data (1984) that an H_α surge occurred in this region between 02 : 30 and 04 : 24 UT. In our K_{232} spectroheliogram at 04 : 48 UT, three bright kernels could be seen. At 05 : 32 UT, bright kernels and enhanced brightening in portions of the loops were seen. This activity in the prominence system continued and reached a maximum phase approximately between 07 : 00 and 08 : 00 UT, when all the identifiable (about 17) loops experienced the brightenings. By 09 : 18 UT, the activity had declined and the loops appeared diffuse. We do not have further observations until after the reported SN flare with minimum in H_α at 09 : 51 UT (Solar Geophysical Data 1984), Our spectroheliogram sections between 10 : 22 and 10 : 42 UT show that only 2 to 4 loops could be seen with very slight indications of the activity.

Activity in individual loops

We carefully examined our K_{232} spectroheliogram plates for frame to frame changes in the sequences, with a view to studying the progress of activity in the individual and the neighbouring loops. We find that the following typical sequence of events occurs as illustrated in figure 1 :

(a) The kernel, at the top of an apparent loop, brightens. For the loop illustrated, the kernel had brightened earlier at 05 : 32 UT.

(b) The brightening of the kernel extends slightly along the loop and towards the limb (figures la and lb). The loop becomes identifiable and a few small brightenings are seen along the legs (figure 1c).

This appears to be an interesting phase of the activity as seen in the case of the loop to the right of the illustrated loop, in figures le and lf. No bright kernel is seen but a portion of the loop near the limb brightens and in the subsequent frames, many small brightenings appear along this adjacent loop.

(c) The bright projection from the kernel extends to about 0.5 to 0.7 times the height of the loop. A portion of this brightening separates and moves down

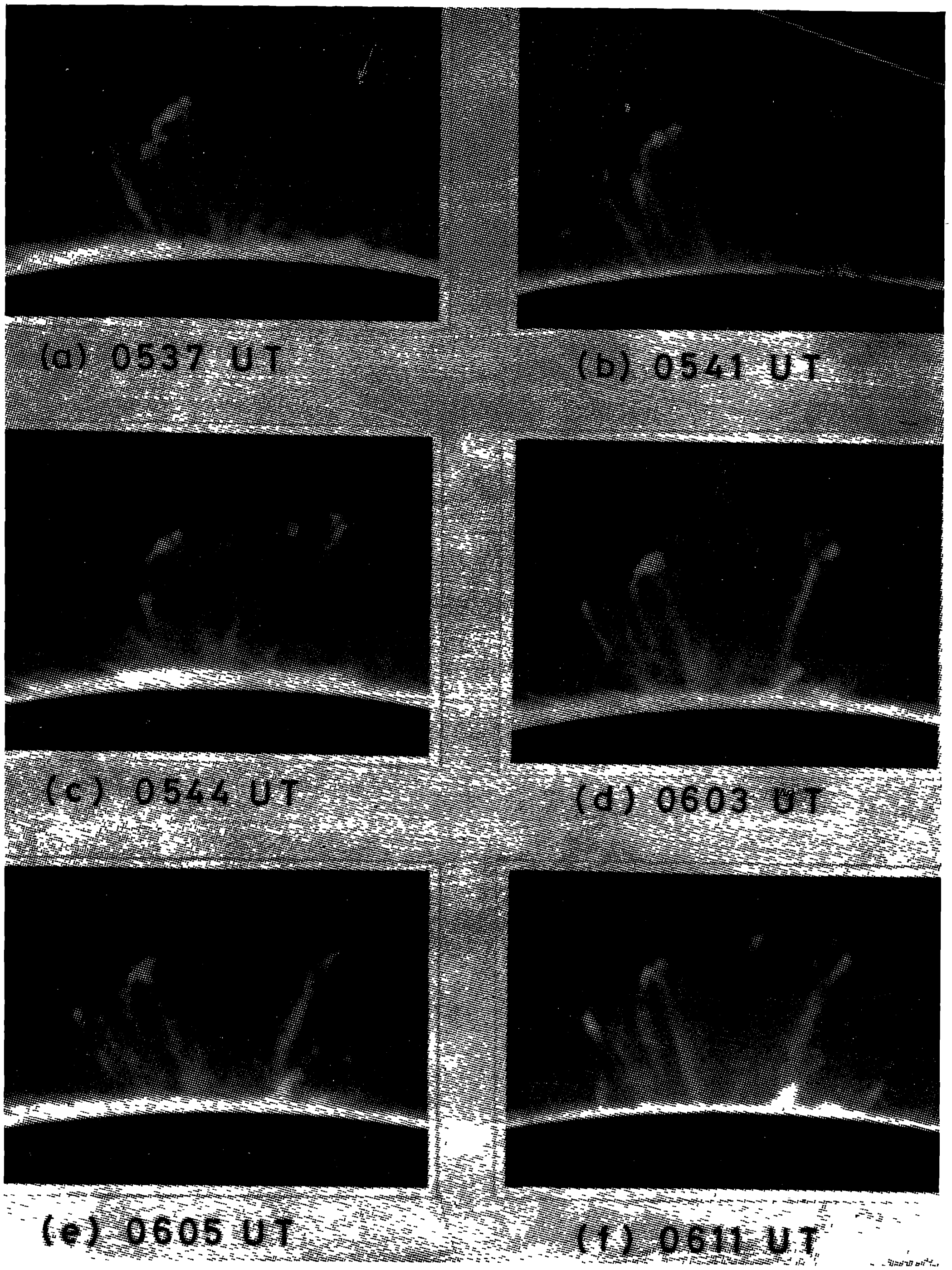

Figure 1. Illustration of the observed transient activity in the loop is indicated with an arrow in (a). The maximum height of the kernel is about 100,000 km above the visible solar limb. Rest of the loops are seen in different phases of their activity.

the leg, with an acceleration of 0.275 ± 0.02 km s^{-2}, which agrees well with the value of acceleration due to gravity on sun. This activity has a duration of 5 to 8 minutes.

(d) A bright projection from the limb is seen at the foot of the active loop, pointing along a leg of the neighbouring loop which was barely noticeable earlier. This feature was observed for the loop illustrated, and from our observations of other active loops, it is not certain whether this occurs in all the active loops.

(e) When the brightenings subside, the loop appears to be quiet (figure 1f). Such loops often exhibit relative brightenings descending along the legs with a velocity and acceleration similar to the brightenings described in (c) above.

3. Discussion

The activity in an individual loop appears to have a sequence starting with the brightening of kernel followed, in many cases, by the appearence of enhanced brightenings in the loop legs. After about 35 ± 5 min, enhanced brightenings are seen moving down the loop legs for a duration of 5 to 8 min. A typical case is that of the active loop illustrated in figure 1, between 0603 and 0611 UT. Details of this phase of activity have already been described in section 2.2 above. As the brightenings disappear, the loop becomes diffuse and steadily becomes fainter. The total duration of this activity in a loop is about 40 ± 5 min. It is difficult to decipher as to how long a loop remains diffuse after the activity, and also whether the entire activity repeats itself in the same loop or not.

Most of the above activity observed in the loop prominence system is in the flare build up phase. The apparent arcade of loop was probably almost perpendicular to the line of sight and hence we could observe the activity in a large number of the loops. Unfortunately, we do not have observations of the occurrence of the subflare itself.

H_α emitting material is known to stream down both the loop legs in post-flare loops at roughly the free fall speed of about 100 km s^{-1} (Bruzek 1964; Poleto and Kopp 1984). The infall of mass in filament legs is observed in H_α for the preflare phase in filament eruptions (Van Hoven *et al.* 1980). Some of the Ca II K observations of loop prominences indicate (a) braided structure in the build up phase of a subflare (Gaizauskas 1978), (b) free fall of emission features towards chromosphere at supersonic velocities (Albregtsen & Engvold 1978), and (c) a Doppler velocity range of −55 to 35 km s^{-1} in the legs (Engvold *et al.* 1978). Our observations provide evidence for free fall under gravity, of the Ca II K emitting material in the loop legs, during the preflare activity.

Twisted rope like structures have been observed in some active loops (Pant 1984). It may be noticed in figure 1e that the loop illustrated appears to have a zig-zag pattern in the bright portion. We find that this pattern is parallel to the direction of the scanning slit and it is not seen in all the brightenings. Hence the possibility of instrumental or guiding distortion cannot be ruled out. If such a structure does exist, however, it would need confirmation through filtergrams in future observations of such activity.

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References

Albregtsen, F. & Engvold, O (1978) in *IAU Coll. No.* 44, p. 246.
Bruzek, A. (1964) *Ap. J.* **140**, 746.
Engvold, O., Jensen, E. & Andersen, B. N. (1978) *IAU Coll. No.* 44, p. 237.
Gaizauskas, V. (1978) *IAU Coll. No.* 44, p. 272.
Kleczek, J. (1964) in *AAS-NASA symp. on the physics of solar flares* (ed : W. H. Hess), NASA SP–50.
Malville, J. M. & Schindler, M. (1981) *Solar Phys.* **70** 115.
Pant, P. (1984) *Bull. Astr. Soc. India*, **12**, 252.
Poleto, G. and Kopp, R. A. (1984) *Mem. Soc. Astr. It.* **55**, 773.
Solar Geophysical Data (1984) *Boulder* : *NOAA*, 475A, 476A and 480B.
Strauss, F. M., Kaufmann, P. & Opher, R. (1980) *Solar Phys.* **67**, 83.
Van Hoven, G. *et al.* (1980) in *Solar Flares* (ed. : P. A. Sturrock), Columbia Associated Univ. Press.
Vrsnak, B. (1984) *Solar Phys.* **94**, 289.