THE DISRUPTION OF EUV CORONAL LOOPS FOLLOWING A MASS EJECTION TRANSIENT

E. J. Schmahl
Astronomy Program, University of Maryland
College Park, Maryland

Abstract. A classic filament disruption/coronal transient event ocurred on 10 January 1974. After the prominence liftoff, "gradual" x-rays were recorded by Solrad 9. A white light coronal ejection, interpreted as a loop seen edge-on, followed. During the mass outflow, Hα loops formed at the original site of the prominence. The loops appeared also in EUV spectroheliograms, and rose rapidly before vanishing abruptly. During the disintegration of the loops the apices showed great enhancements and vertical spike structures. The overall behavior of this loop prominence system is compatible with reconnection models.

1. INTRODUCTION

It has been shown that eruptive prominences are the most common precursor of coronal transients (cf. Munro et al, 1979) and that loop prominence systems (LPS), or their X-ray and microwave analogues (cf. MacCombie and Rust, 1979), are the frequent followers of mass ejections. These near-surface phenomena are tracers of coronal magnetic activity and restructuring in the wake of transients.

The 10 January 1974 event, observed in white light, Hα, X-rays, and EUV illustrates the well-known sequence: prominence eruption, flare, transient, LPS.

2. OBSERVATIONS

The first relevant Hα phenomenon was the liftoff of a small prominence at S09E90 near McMath 12702, starting at ∿ 08:50 and fading out at ∿ 09:15. At ∿ 09:40 a 1N flare occurred ∿ 8° S of the prominence. Hα surging was reported and EUV infall was seen later. At ∿ 10:10 Hα LPS became visible at the site of liftoff.

Presumably at this time the white light transient was moving outwards, since at 11:38 the HAO coronagraph photographed coronal material moving at a speed of ∿ 400 km s^{-1} radially above the prominence site (Munro et al 1979, Hildner, 1977). The narrowness and polarization

M. Dryer and E. Tandberg-Hanssen (eds.), Solar and Interplanetary Dynamics, 241-244.

https://doi.org/10.1017/S0074180900067656 Published online by Cambridge University Press

structure of the transient led Munro (1978) to interpret the shape as a loop seen edge-on. Assuming this, the overall geometry of the coronal magnetic field could have considerable shear, since the LPS may lie close ($\lesssim 45°$) to the plane of the sky.

EUV spectroheliograms were first acquired at 09:53 during the 1 N Hα flare. The EUV flare appeared similar in size (∿ 20") and shape (mound) to Hα. The EUV pointing shifted to the site of the prominence where continuous 5 min spectroheliograms showed loops forming from 10:13 on, their size increasing at an initial rate of ∿ 10 km s^{-1} and later at ∿ 40 km s^{-1}. (Such acceleration is unusual for LPS).

While the LPS formed, Solrad-9 recorded soft X-rays which peaked at ∿ 09:50 and declined smoothly to background at ∿ 10:50. (No imaging X-ray telescopes were in operation.) Since the LPS emitted in the EUV coronal MgX line, the X-rays presumably arose in a simmilar volume.

In Hα and EUV "transition zone" lines the loops were co-spatial (to $\lesssim$ 5"). The Hα loops vanished between 10:44 and 10:46. In EUV the loops were disrupting at 10:48. Large spikes appeared at their apices, and enhancements at the tops increased remarkably. Subsequent EUV images in the next orbit show that the low corona returned to the pre-loop conditions.

3. ANALYSIS AND DISCUSSION

MacCombie and Rust (1979) have shown the intimate relation between X-ray and Hα LPS. We therefore assume that the Solrad X-rays are emitted from the same or similar volume as the MgX emission, and determine temperatures, emission measures, and densities (see Table I). The temperature falls from ∿ 6×10^6 to ∿ 4×10^6 K between 09:50 and 10:50, and the emission measure falls from ∿ 2 to 1×10^{48} cm^{-3} during the same interval. These values are similar to that of the 13/14 August 1973 event, whose parameters may be compared in Table I.

The abrupt termination of this loop system after an increase of its apparent velocity seems more consistent with reconnection (e.g. Kopp and Pneuman 1976) than with loop expansion. Reconnection and filling of loops progresses from low heights upward, until the height is reached where the pre-transient magnetic field was open, and then reconnection stops. Free-fall times of order $\lesssim 10^2$ km s^{-1} are sufficient to deplete the highest loops in the observed time of ∿ 2 min (cf. Foukal 1978). The source of mass for the loops is, however, not understood.

The large vertical spike-like enhancements at the apex of the LPS (Fig. 1) during the disruption suggest a relationship to vertical neutral sheets above the highest closed loop in a Kopp and Pneumann helmet streamer. We conjecture that these spikes trace magnetic field lines which open into the solar wind above the helmet.

TABLE I

Coronal Transient and Near-Surface Phenomena

	10 January 1974	13/14 August 1973*
Flare: Hα/X-ray	1F/< CO	1N/C1
Eruptive prominence height:	$\gtrsim$ .05 $R_\odot$	0.18 $R_\odot$
Loop prominence system:	Hα + EUV + X-rays	EUV + X-rays
Max volume (cm^3)**	6 (27)	5 (28)
Height (cm)	4 (9)	1 (10)
X-ray em. meas. (cm^{-3})	1-2 (48)	1.6 (48)
Max temperature (K)	6 (6)	5 (6)
Density x-ray (cm^{-3})	1 (10)	5.5 (9)
Mass source (g)	1 (14)	4.9 (14)
Apparent velocity (km s^{-1})	10→40	1→0.5
Mass upflow required (km s^{-1})	35-150	$\sim$ 3
K. E. of upflow (erg)	1 (28)	> 2 (25
Radiative energy (erg)	2 (29)	$\sim$ 1 (30)
Lifetime (hr)	$\sim$ 1	> 33
Radio events	none	Type II
Coronal Transient*: speed (km s^{-1})	400	$\sim$ 175
mass (g)	1 (15)	2 (15)
P.E.+ K.E.(erg)	1.6 (30)	2.3 (30)

*Data from MacCombie and Rust (1979), Hildner (1978).
**Assumes x-ray volume equals that of Mg X emission.

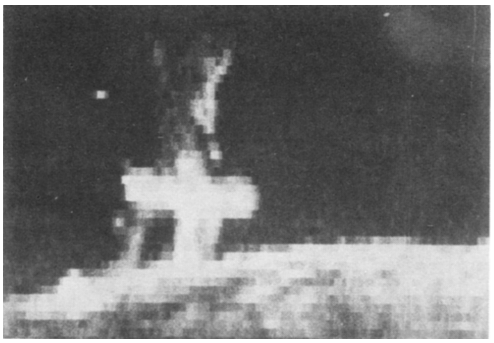

Figure 1.

OIV λ554 spectroheliogram at 10:48 U.T. The image size is 3 x 5 arc min.

REFERENCES

Foukal, P.: 1978, *Astrophys. J.* 223, pp. 1046-1057.
Hildner, E.: 1977, in "*Study of Travelling Interplanetary Phenomena*" pp.3-21 (eds. M. Shea et al.) Reidel, Dordrecht-Holland.
Kopp, R. A. and Pneuman, G. W.: 1976, *Solar Phys*. 50, p. 85.
MacCombie, W. J. and Rust, D. M.: 1979, *Solar Phys*. 61, 69.
Munro, R. H.: 1978, *Bull. Am. Astron. Soc.*, 9 (abstract).
Munro, R. H., Gosling, J. T., Hildner, E., MacQueen, R. M., Poland, A.I., and Ross, C. L.: 1979, *Solar Phys*. 61, pp. 201-215.

https://doi.org/10.1017/S0074180900067656 Published online by Cambridge University Press

DISCUSSION

Moore: Why did you entitle this paper "The Disruption of EUV Coronal Loops..."?

Schmahl: The "disruption" refers to the disappearance of the EUV loops, which are formed (in Kopp and Pneuman's model) by the reconnection of earlier loops disrupted at the time of the mass ejection.

Webb: Do you see any evidence for a temperature gradient in this event? (By this I mean a difference in the height of the loops in different transition zone lines?)

Schmahl: The "transition zone" ($5 \times 10^4 \lesssim T \lesssim 5 \times 10^5$K) line emission is apparently co-spatial with the Hα loop. The coronal emission in the MgX line ($T \sim 1.5 \times 10^6$K) is complicated by the presence of stationary, intervening coronal structures, but the MgX loop emission is certainly compatible with the distribution in X-rays, which appear slightly above the cooler loops.

Gaizauskas: You drew attention to large spiky features in an EUV spectroheliogram for this event which had no apparent counterpart in Hα. This absence may be due to lack of resolution in the filtergrams. When observed at high spatial resolution, large active regions on the limb often show fine spiky features extending more or less radially to coronal heights.

Schmahl: It is my impression that most Hα loop prominences are smooth at the top, although I have seen small "nubbins" at the apex in one case. I would be very interested in seeing examples of the Hα spiky structures that you mention.

https://doi.org/10.1017/S0074180900067656 Published online by Cambridge University Press