Bull. Astr. Soc. India (2001) **29**, 241–243

Dynamical properties of flare Loops of 27 November 1996

Wahab Uddin[1] and Lalan Prasad[2]

[1]*State Observatory, Manora Peak, Naini Tal 263129, Uttaranchal, India*
[2]*M.B. Govt. P.G. College Haldwani, Naini Tal 263141, Uttaranchal, India*

Abstract. We observed a post-flare loop system in H_α on the west limb on 27 November 1996 which started earlier than 05:07:20 UT in NOAA active region 7997 (N04, W89). The post-flare loops were associated with long duration x-ray flare of important class B9.0. We study the evolution of post-flare loop system which display complex, fan like structure with multi bright loop tops in H_α as well as in x-ray/ Yohkoh and SOHO observations. This event shows the characteristics of long duration event (LDE). The main aim of this paper is to study the morphological changes of post-flare loops to understand the prolonged post eruption energy release process in decay phase in H_α, x-ray, radio wave and in microwave regions. The results of our investigation has been discussed in the light of existing models.

Key words : Post-flare loops - energy release

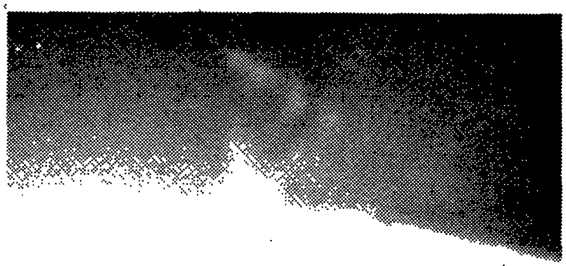
1. Observational Details

In the rising phase of 23rd solar cycle we have observed a huge system of flare loops in H_α on November 27, 1996. The loop system was developed on the west limb in the NOAA active region 7997 which was approaching towards the west limb (N 04, W 89) (Solar Geophysical Data (SGD) 1997). We have a good sequence of observations on November 27, 1996 from 5:00 UT to 6:30 UT, which shows the evolution of flare loops with many bright loop-tops. We study the morphological changes associated with the flare loops (e.g., altitude, relative density, angle of inclination and expansion in the top-bottom width). In the last phase of our observations we also observed a twisted and inclined surge associated with flare loops. The solar flare began at 2048 UT (Nov. 26, 1996), reached maximum at 0032 UT and ended at 0456 UT (Nov. 27, 1996) in the x-ray of class B9.0. The post-flare loops show the fan like structure in H_α as well as in x-ray. Due to the limited space we have given only two selected H_α filtergrams which clearly show the significant changes with surge activities in the later phase in Fig 1.

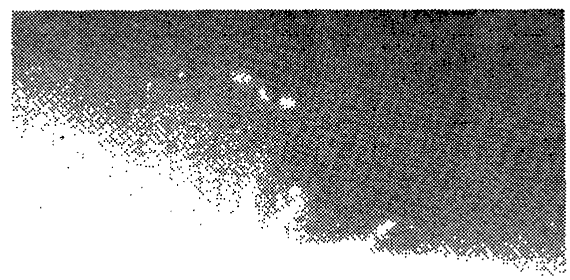
2. Data and Analysis

The flare loops were formed between the flare ribbons during the development of flare and showed the link between the ribbons because the second ribbon is in the line of sight of first ribbon. We can estimate the amount of energy Ec available due to coalescence instability (Tajima et al. 1982). For our calculation we consider the physical parameters loop magnetic field (B) ~ 50 Gauss, loop length (L) ~ 1.3×10^{10} cm and current channel width (a) ~ 4.5×10^{8} cm and got the value of coalescence energy Ec ~ 4.4×10^{30} erg. The thermal energy of flare loop ~ 10^{30} erg estimated by Koshishi et al. 1995. The coalescence energy is evident in the brightness can extend away from the overlapping region along the adjacent parts of the loops.

The post flare loops have a complex structure as they rise above the limb, usually with the appearance of an arcade of loops with enhanced tops. Over a period of many hours, the loop system increases systematically in height, some loops fading while others appear but with a gradual decrease in brightness and the system disappearing after roughly 16 hours after reaching height more than 10^5 km. The post-flare loop systems reveal occasional transient brightenings at localised regions (Smart et al., 1993). In this event we observed five bright knots of varying relative densities at their legs and tops. There is very slight changes in intensity, this result infer that the case of LDE. In a short span of time during gradual evolution we estimated relative densities at foot point and top and at 5:14:6 UT, we got the maximum relative densities at the foot-point and the loop-top.



(a) 05:07:20 UT



(b) 06:10:19 UT

Figure 1. Shows some selected frames of post flare loops in H_α.

The post flare loops showed the blue and red shifts which reflect the upward and downward flow of materials with velocity about 50 km s^{-1}. It is clear that our case is slow rise and slow decline post-flare loops. Therefore, we can say that flare loops occure in a gradual phase of the flare. The material is highly fragmented, becoming less visible as it falls from the top and increasingly visible farther down in the legs. This can be an effect of compression, an effect of a temperature gradient along the legs, or simply because the emission shifts out of the bandpass of the filter because of high velocity of the matter along the line of sight. The intensities in the legs near the foot points are enhanced in H_α by Doppler brightening because of the high velocity (Heinzell and Rompolt, 1987). Individual blobs can be seen to become more elongated as they fall down along the legs, new blobs are formed at the top. Our observations reveal that post-flare loops show conspicuous H_α surge activity at the west limb. A dark surge is found with its bright foot point to be the first manifestation of new magnetic flux. Even during the later stage of post-flare loops the surge is found spouted out from the bottom edge at 05:55:35 UT on the western side of the limb and grown gradually.

3. Results and discussions

The observed flare loop system shows continuous release of energy for many hours. We got the free fall velocity ~ 207 km s^{-1} and thermal coalescence conduction energy ~ 4.4 x 10^{30} erg. The plasma velocities are around free-fall velocities near the top of the loops but are significantly smaller close to their foot points suggesting a decelerating mechanism (Malherbe et al. 1997). We calculated the downward flow with the help of Doppler's shift and its velocity comes to be ~ 20 km s^{-1}. The existence of the well-developed post-flare loop systems in the flares on November 26 and 27, 1996 allows us to suppose that in these flare the acceleration in the delayed phase was also caused by the post-eruption energy. The Kopp-Pneuman model interpretation seems to be the only plausible explanation of the observed growth of loops in the dynamic flare (Svestka, 1989). The structural changes of post-flare loops show the expansion in width near the foot points and on the top reflect the continuous release of magnetic energy.

Finally, we conclude that these flare loops are not associated with major emission in the radio wave, x-ray, micro wave and in H_α. We observed in the H_α brightenings at the low temperature and from YOHKOH and SOHO observations we found that flare loops persist for many hours above the H_α flare loops in high temperature regions. During the post-flare loops type I and III radio bursts also occurred (SGD, 1997). Radio observations provide an important means for understanding the changes in the magnetic field in the post flare loops (Rui-Xiang and Min, 2000).

There are many papers in the literature on the study of post flare loops associated with higher importance class LDE in H_α and in other wavelengths, But the study of lower importance class LDE in H_α and in other wavelengths is rarely reported in the literature. So we suggest that more observations in different wavelengths are required for the good understanding of the events which release energy at slower rate for long durations.

Acknowledgements

Authors are thankful to the anonymous referee for useful comments.

References

Heinzel P., Rompolt B., 1987, Solar Phys. 110, 171

Koshishi H., Fujiki K., Ename S., Nakajima H., Shibasaki K., Irie M., 1995, STEP GBRSC NEWS, 5, 5

Malherbe J.M., Tarbell T., Wiik J.E., Schimieder B., Frank Z., Shine R.A., Driel-Gesztelyi L.V., 1997, Astrophys. J. 482, 535

Rui-xiang S., Min W., 2000, Chin. Astr. Astrophy. 24, 241

Smart R.N., Zhang Z., Smutko M.F., 1993, Sol. Phys. Vol. 148, 139

Solar Geophysical Data: 1997, pt I No. 629 and Pt II No. 633, NOAA, Boulder, Colorado, USA

Svestka Z., 1989, Solar Phys 121, 399

Tajima T., Brunel F., Sakaj J., 1982, Astrophys. J. 258, L45