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Analysis of the 9th November 1990 flare

Anita Joshi & Wahab Uddin, *U. P. State Observatory, Manora Peak, Naini Tal 263 129, India.*
e-mail: anita@upso.ernet.in   wahab@upso.ernet.in

Abstract. In this paper we present complete two-dimensional measurements of the observed brightness of the 9th November 1990 $H\alpha$ flare, using a PDS microdensitometer scanner and image processing software MIDAS. The resulting isophotal contour maps, were used to describe morphological-cum-temporal behaviour of the flare and also the kernels of the flare. Correlation of the $H\alpha$ flare with SXR and MW radiations were also studied.

Key words. $H\alpha$ flare—isophotal contour maps—flare kernels.

1. Introduction

In this paper, we present two-dimensional isophotal contour maps made from the analysis of 9th November 1990 flare, with the aid of isodensitometry and image processing of photographic $H\alpha$ observations. We have given salient information about the morphological changes in the flare using the isophotal contour maps. With the help of isophotal contour maps along with three-dimensional (3D) pictures, the location of kernels of the flare have also been investigated. We have also studied the nature of the flare in soft X-ray (SXR) and microwave (MW) radiations, with the help of the limited data available with us.

2. Isophotal contour maps

We have carried out photographic monitoring of 9th November 1990 flare, using 15 cm, f/15 Coudé refractor in conjunction with Daystar $H\alpha$ and Ca II K filters, at Uttar Pradesh State Observatory (UPSO), Naini Tal. The density on the film of the images were digitized, at Indian Institute of Astrophysics (IIA), Bangalore, with the help of a positional densitometer system (PDS) and analysis has been carried out at UPSO (Joshi 1996).

Selected H_α filtergrams of the flare (1N/N06E36, AR 6359B) are shown in Fig. 1. To visualize flare kernels in this figure we have also shown isophotal contour map and 3D (x, y, I) intensity plot at the maximum phase of the flare. The figure shows a question-mark shape filament, before the onset of the flare. The flare erupted from the lower part (towards south) of the filament and from the upper part (towards north) of the filament a dark surge erupted. At the maximum, the flare produced about six minute duration remote chromospheric brightening. Selected $H\alpha$ isophotal contour

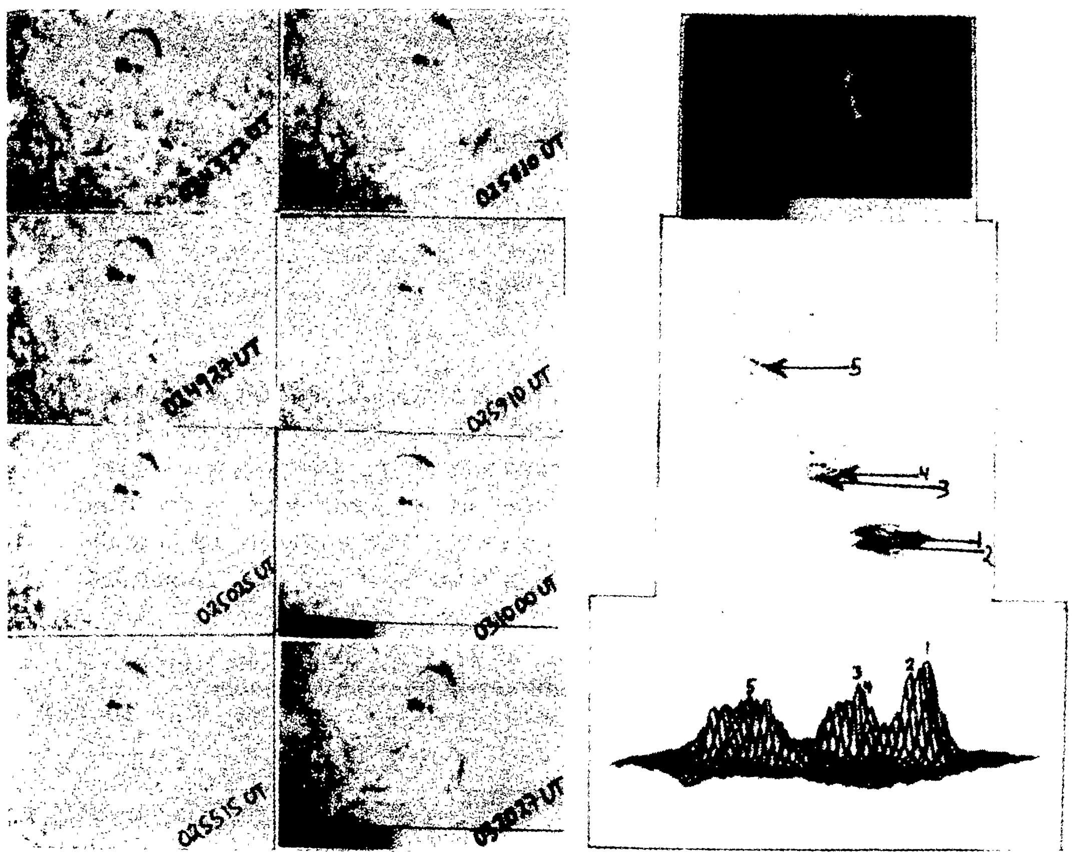

Figure 1. Selected $H\alpha$ filtergrams (left) and isophotal contour map with 3D intensity plot (right) at the maximum phase of the flare.

maps of the flare are given in Fig. 2. The isophotes were set at a chosen intensity ratio between flare intensity (I_f) and background intensity (I_b). In the figure, the first isophote was set at $I_f/I_b = 1.61$ and the increment between two contour levels was 0.29. The flare occurred at 024836 UT in the form of two ribbons. The two flare ribbons were denoted as A and B. During the rise phase of the flare the thickness of the ribbons increased with time till the maximum at 024927 UT. As the ribbons thickness increased, the separation between ribbons decreased and ribbons appeared closest to each other at the flare maximum. After the maximum there was a decline in the flare activity. During the decline the ribbons A and B were noticed to separate speedily, followed by the fragmentation of ribbon A. At 025810 UT again a slight increase in flare activity was noticed which later showed gradual decay of flare activity. To confirm this chronology of event, in Fig. 2 we have also presented intensity and area plots of the flare as a function of time, wherein, intensity is expressed in arbitrary scale and area is in millionths of solar disk. It is clear from the data points (only in decay-phase) that the flare in Ca II K (crosses) shows similar trend as in $H\alpha$, whereas in Ca II K the flare covers a larger area than H_α. There are five bright points among these bright points the two most intense points (number 1 and 2) may be flare kernels (cf. Fig. 1). These two points have intensities 2.45 and 2.38 times of the surrounding flare intensity. Thus, the selection criterion for the flare kernels is the bright points, having intensities 2.4 times of surrounding flare intensity.

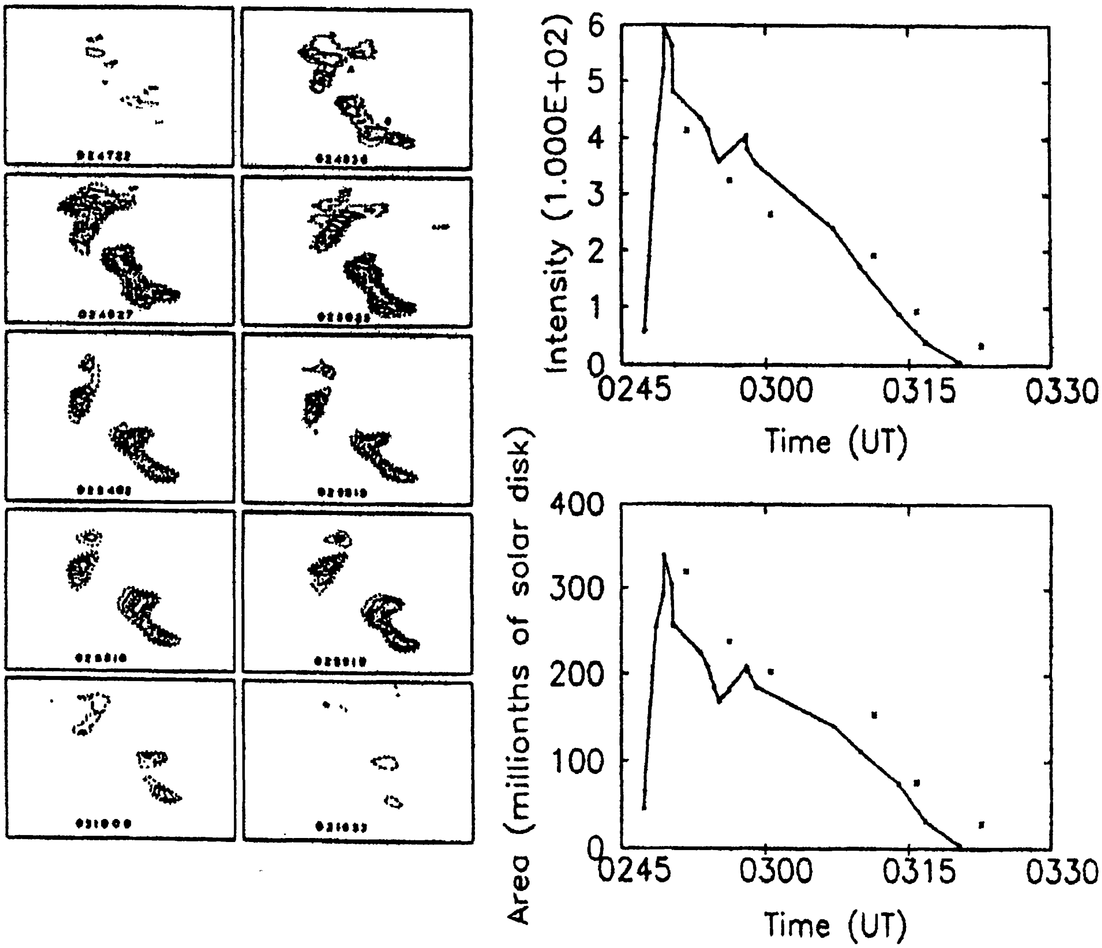

Figure 2. Flare isophotal contour maps and intensity and area time profiles.

3. SXR and MW radiations

The flare associated with radiations in SXR and MW (SGD 1991) GOES SXR time profiles shows a sharp rise to maximum, followed by a gradual decay as in $H\alpha$. The profiles of 1–8 Å and 0.5–4 Å bands show peak fluxes as $6.1 \times 10^{-6}\,\mathrm{W\,m^{-2}}$ and $4.9 \times 10^{-7}\,\mathrm{W\,m^{-2}}$ respectively. The peak value of the flux in 1–8 Å band suggest X-ray importance class C6.1. By using SXR time profiles, we can determine effective temperature (T_{eff}) and emission measure (EM) of SXR emitting source. For determining these quantities, we have followed Thomas *et al.* (1985). The calculated values came out to 0.8×10^7 K and $1.3 \times 10^{49}\,\mathrm{cm^{-3}}$.

The flare associated MW burst recorded in frequencies 410, 610, 1000, 2000, 2840, 3750 and 9400 MHz respectively (SGD 1991, Joshi 1996). From the radio data, we have estimated the values of the magnetic field perpendicular to the electron density ($B_{\perp}$) in gauss, electron energy (E) in MeV and the angular size (ϕ) in arcsec of the MW burst source. For this we followed the method given by Degaonkar *et al.* (1981). The estimated values are 204 gauss, 1.4 MeV and 12.4 arcsec.

4. Results and discussions

The triggering of the flare appeared to be due to filament existing in the vicinity of the active region (Fig. 1). The flare produced remote chromospheric brightening. Isophotal contour maps (Fig. 2) given by us chalk out a detailed scenario of flare. The nature of the evolution of the flare can also be studied very well by time profiles. It is a dynamic two ribbon flare. The flare shows the expanding motion of two flare ribbons with the velocity of separation of 3.75 km s^{-1} during the maximum phase of the flare. The $H\alpha$ classification of the flare corresponds to class 1N (SGD 1991). The area (338 millionths of solar disk) measured by us at the maximum of the flare also corroborate to this class. The isophotal contour maps along with 3D pictures help in visualizing the location of flare kernels, whereas the clear cut detection of flare kernels is only possible in the wings of H_α (Tang 1985).

The flare is also associated with radiations in SXR (C6.1-class) and MW (spiky burst). The estimated values of T_{eff} (0.8×10^7 K) and EM (1.3×10^{49} cm^{-3}) suggest that SXR emission originated in a hot plasma through thermal bremsstrahlung (Kawabata 1960). From the radio data, the calculated values of $B_\perp$, E and ϕ of radio source are 204 gauss, 1.4 MeV and 12.4 arcsec.

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