ON IMPULSIVE AND GRADUAL OPTICAL SOLAR FLARES

A. Bhatnagar, A. Ambastha, R.M. Jain and N. Srivastava
Udaipur Solar Observatory, Udaipur (India)

Abstract: A comparative study of H-alpha intensity and area development of several flares is presented in an attempt to investigate characteristic features of various types of optical solar flares.

I. INTRODUCTION

Intensity-time profiles for X-rays and radio emissions from flares are generally available, but few such studies have been reported in H-alpha or in any other optical wavelength, viz., Dodson et al. (1956), Abramenko et al. (1960) and Dodson and Hedeman (1968). Tallant (1970) had obtained light and area profiles of two flares using video technique. We present in this paper a comparative study of intensity and area curves for six types of flares observed in H-alpha to investigate characteristic features of their development.

II. OBSERVATIONS

From a large collection of H-alpha time-lapse filtergrams taken at Udaipur Solar Observatory, we have selected 17 flares belonging to the following six types: (i) 3 impulsive, (ii) 2 homologous, (iii) 3 gradual, (iv) 2 spotless (v) 3 umbral and (vi) 1 two-ribbon.

A simple digital photometer with an aperture corresponding to an area of about 6"x 8" arc on an enlarged image was used for flare density measurements. These measurements were made on various portions of the flare, or kernels, on sufficiently large number of frames to obtain a time-resolution of 10-60 seconds. The flare areas were measured on an enlarged image scale of about 1" arc per mm using an X-Y digitizer. In figure 1 is given the time profiles of intensity (derived from the density measurements) of flare-kernels in terms of percentage change with respect to the quiet chromosphere alongwith flare areas in terms of millionths of the solar disk of six characteristic types of flares. We note that different flare-kernels of the same flare display variations in their growth and lecay rates.

III. DISCUSSION

(1)IMPULSIVE FLARES: Three flares of (A) 28 March 1980, (B) 10 May 1981 and (C) 28 May 1981 selected in this category distinctly displayed a steep rise in flare intensity while two of them (A and C) showed steep decline too. Interestingly, flare-kernels of event (B) showed gradual decay both in intensity and area. Flare-kernels in (A) and (C) showed a pre-maximum peak - a precursor in the light curve. All these impulsive flares occurred in D, B, and BG active regions. In events (B) and (C), both intensity and area correlated well in time but a delay of 2 minutes between the peak intensity and flare area was noticed in the case of event (A).

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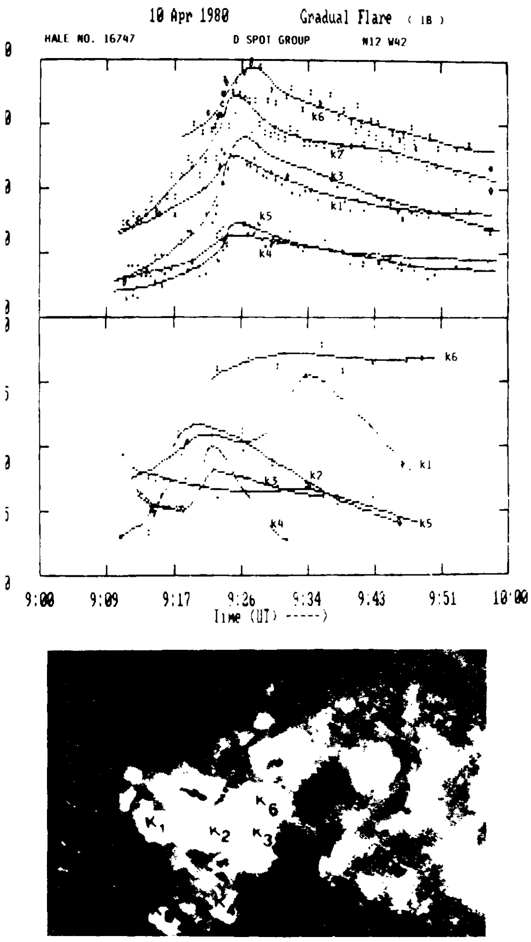
(2)HOMOLOGOUS FLARES: As the name implies, in this case successive flares occur essentially at the same location of an active region. We have attempted to see if the intensity and area profiles too are homologous. Two homologous flares of (A) 9 November 1979 (3 flares), and (B) 17-18 April 1980 (2 flares) were studied. In event (A), flare-kernels in all the three flares displayed similar light and area curves. But in event (B), size and shapes of the flares on the two consecutive days showed some variation, while, slopes of rising and declining phases of all flare-kernels appeared nearly identical. A time lag of around 10 minutes was noticed between some kernels and conspicuous fluctuations in area were observed on 17 April 1980. A double peak in intensity was displayed by kernels of flares of 18 April 1980. From the study of flares (A) and (B), we conclude that homologous flares not only occur in the same location, but also display similar growth and decay rates in intensity and area.

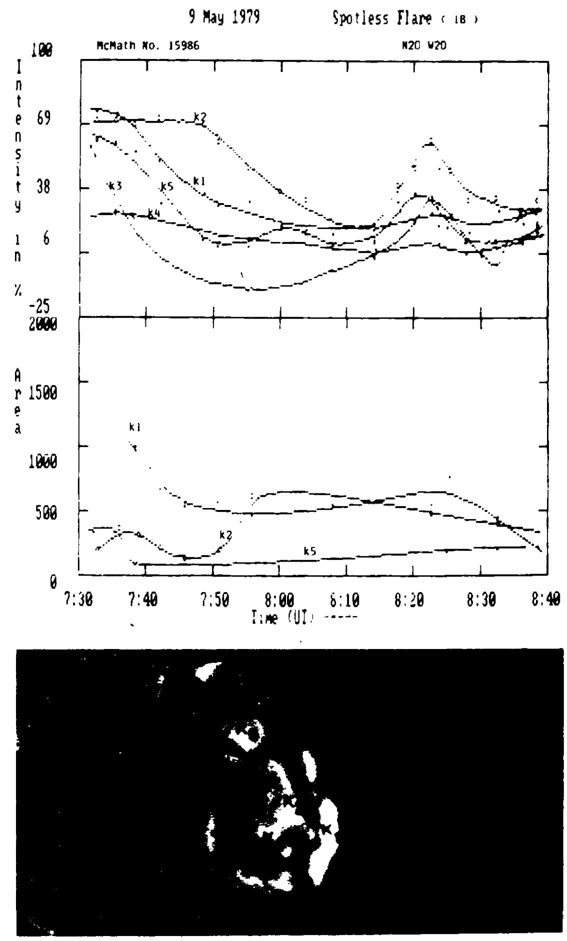
(3)GRADUAL FLARES: Three gradual flares of (A) 10 April 1980, (B) 11 April 1980 and (C) 15 May 1981 were selected. Intensity-time profiles of all kernels of these flares displayed nearly identical behaviour. In the case of event (A), the flare-kernels started brightening up slowly, typical of gradual phase. But about two minutes before the peak, intensity of the kernels displayed sudden rise with a rate as observed in the case of impulsive flares. However, their area curves displayed gradual rise and fall. In the case of events (B) and (C), marked intensity fluctuations were observed for some kernels with a quasi-periodicity of 5-10 minutes. Similar fluctuations were also seen in area-time plots of some flare-kernels.

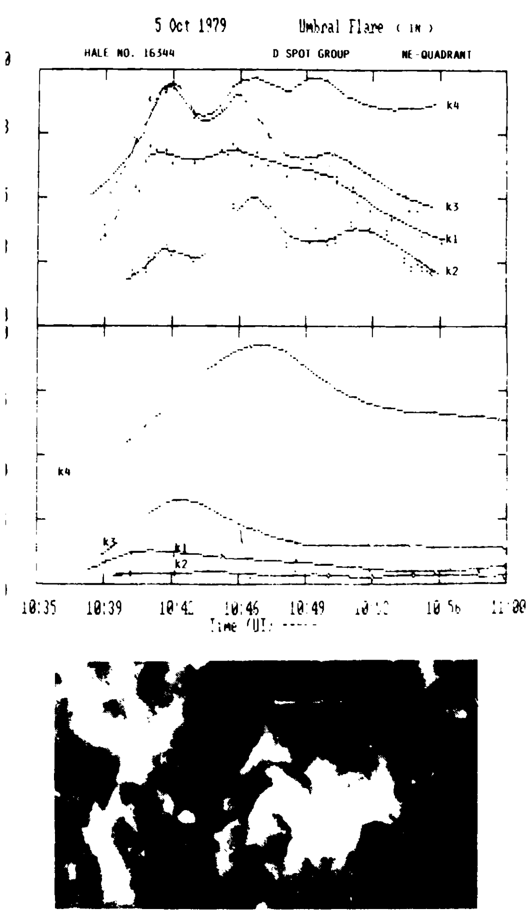
(4)SPOTLESS FLARES: Generally, spotless flares display two-ribbon configuration with a neutral line ($B_{||}$=0) in between. The two spotless flares selected here occurred in old, decaying active regions on (A) 9 May 1979, and (B) 9 December 1980. In both the cases, our observations began near the maximum phase of the flare. Several flare-kernels of event (A) and all kernels of event (B) displayed secondary peak brightness after the main maximum phase. The rate of decay of flare area was observed to be small (dA/dt = - 3.5 millionths of solar disk/minute) for these flares.

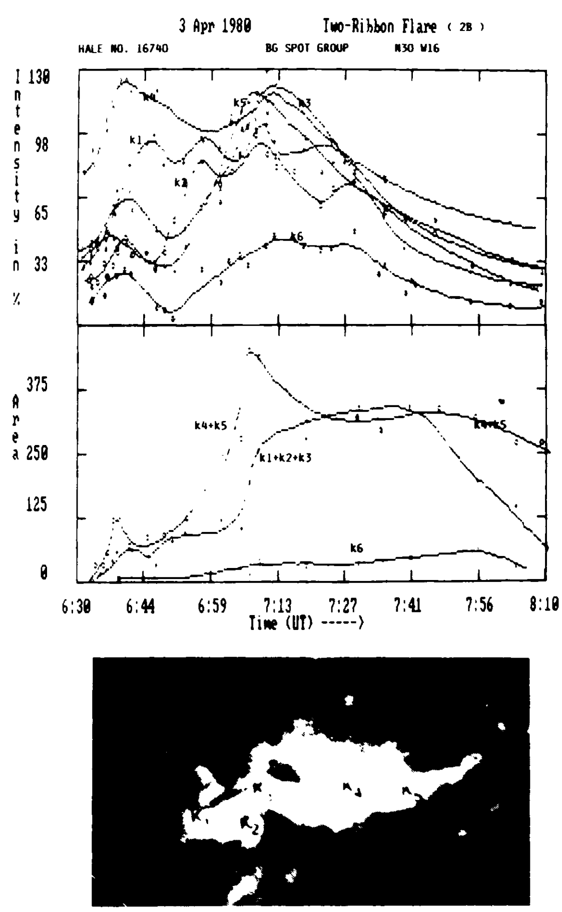
(5)UMBRAL FLARES: Normally even large flares tend to avoid the strong spot umbral magnetic fields. However, sometimes very small subflares have been observed in umbrae or at the umbral-penumbral boundary. Tang (1978) has reported four umbral flares in large dominant p-spots and tiny or non-existent f-spots. She suggested that umbral flares may be in fact two-ribbon flares with one ribbon in the umbra and the other in the nearby plage region. We have selected in the present study, three umbral flares seen as compact, bright flare-kernels. The intensity and area of flare-kernels in the umbrae and outside in the plage region were measured. The most striking feature of the light-curves of these flares is the quasi-periodicity in intensity with periods ranging between 5-10 minutes. Corresponding brightness fluctuations were seen in the plage brightness too which were in phase with the fluctuations of umbral flare kernels.

(6)TWO-RIBBON FLARES: A two-ribbon flare of 3 April 1980 is taken here which occurred in a complex BG active region. Six flare-kernels of this event were considered for measurement. As shown in figure 1, all six flare-kernels displayed quasi-periodic intensity fluctuations and time lag in peak brightness. Slopes of their intensity profiles during the rise and decline of the flare were found almost similar to the gradual flares.









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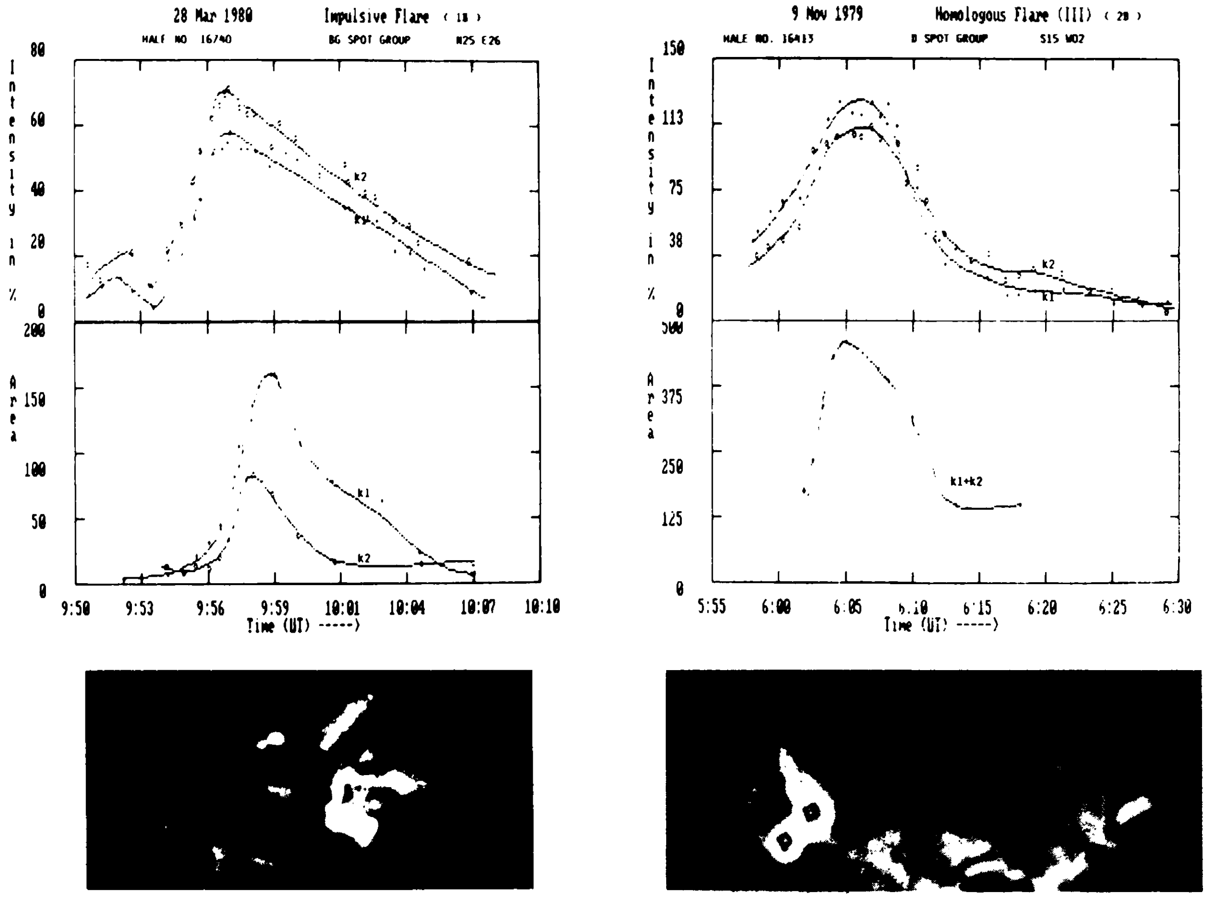

Figure 1: Temporal profiles of intensity and area (in millionths-of-solar disk) of several H-alpha kernels in six representative flares of gradual, spotless, umbral, 2-ribbon, impulsive and homologous types.

IV. CONCLUSION

From the study of the seventeen solar flares of six types, we conclude that there are significant differences in H-alpha intensity and area growth curves of various types of flares. These differences in growth and decay rates in intensity and area appear to be a function of magnetic field configuration and the rate of energy build-up in an active region. In some H-alpha flares, especially the umbral flares, conspicuous quasi-periodic intensity fluctuations were also observed. Further investigations are needed to understand the mechanism for the observed quasi-periodic nature of the umbral flares.

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