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Double ribbon flare of 1981 October 19

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Abstract. Photographic observations with a 0.7 Å passband H-alpha Halle filter and morphological description of the double ribbon flare which occurred near Halle plage region 17926 on 1981 October 19 are described. Initially the flare appeared in the shape of the digit 3, but after some time it broke into two parallel strands. The flare was associated with several eruptive centres. From the observed data, we have estimated the separation and the velocity of separation of the two strands. We have also estimated the magnetic field associated with the flare and found it to be 75 and 238 gauss for $n_e = 10^{13}$ cm^{-3} and 10^{14} cm^{-3} respectively.

Key words : double ribbon flare—tearing mode instability

1. Introduction

On 1981 October 19 while monitoring the sun through a 15 cm f/15 refractor and 0.7 Å passband H-alpha Halle filter, we first noticed a flare around 03 14 UT, near Halle plage region 17926. This flare had already started at 03 07 UT (Solar Geophysical Data, 1981 November). The temporal changes in the double ribbon flare were recorded photographically. In the present communication we present an analysis of the observations and morphological changes associated with the double ribbon flare.

2. Observations

The observations comprised of photographs recorded on Kodak SO 115 film using Yashica FRI camera. The exposure time used was 1/250s with the H-alpha filter tuned to line centre. Line drawings were made after enlarging the images nearly 20 times through a spectrum projector. From these line drawings we estimated the separation between the two strands, velocity of separation and the magnetic field associated with the flare.

Examination of the Solar Geophysical Data (1981, 1982) also revealed that associated with the double ribbon flare of 1981 October 19, sudden ionospheric disturbances and radio bursts were recorded at a number of stations between 03 07 UT and 04 15 UT.

3. Morphological description

The double ribbon flare occurred near Halle plage region 17926 at S07 E 27 and it is classified as 2B (Solar Geophysical Data, 1981 November). We measured the area at the brightest phase at 03 18 UT and found it to be nearly 450 millionth of the solar hemisphere which agrees with the above classification.

Visual inspection of the filtergrams (figures 1a, b, c and d) showed the following. At 03 14 UT the flare showed a structure like the digit 3 and the flare area numerous spots (Figure 1a). These spots did not change their positions during the period of flare occurrence. A filament was also present in the flare area. The filament too did not change its shape and position, during the flare. At 03 16 UT the flare showed a double ribbon shape (figure 1b). The lower portion of the digit 3 separated into two branches. At 03 28 UT major portion of flare again appeared to break up into two parts (figure 1c). The lower part of the digit 3 which got fragmented earlier stopped near a spot. This type of behaviour has been noticed earlier (Svestka *et al.* 1961). Figure 1d is the photograph taken by us at 04 04 UT when the flare activity seemed to have subsided.

4. Sudden ionospheric disturbance (SID) and radio bursts associated with the 1981 October 19 flare

Associated with the flare of 1981 October 19 sudden ionospheric disturbances and radio bursts were recorded at a number of stations.

Examination of the Solar Geophysical Data, 1982 January, revealed that various kinds of sudden ionospheric disturbances of importance 3 were recorded at a number of stations which include the observations of SWF, SPA and LF-SPA on 1981 October 19 from 03 07 UT onwards. These SIDs are due to the flare observed near Halle plage region 17926 around 03 07 UT.

Data for x-rays (1–8 Å) supplied by SMS-GOES satellite (Solar Geophysical Data, 1982 April) show that enhanced x-rays between 03 07 UT to 04 15 UT were observed. The maximum value of the x-ray flux for the flare under consideration is 1.5×10^{-2} erg $cm^{-2}s^{-1}$, which is greater than the threshold value 2×10^{-3} erg $cm^{-2}\,s^{-1}$ suggested by Kriplin *et al.* (1962) for SIDs. It confirms that the SIDs reported by a number of stations were due to the double ribbon flare.

Energetic electrons ejected during the flare of 1981 October 19 and radio bursts during the flare were recorded at a number of stations. Associated with the double ribbon flare, solar radio emission spectral data were recorded at Culgoora (Australia). Bandwise observations based on the Solar Geophysical Data, 1982 January, and the radio spectrograms supplied by Prof. K. V. Sheridan are as follows:

Decametre band (8 MHz–24.7 MHz) : Between 02 55 UT to 04 42 UT, during this period a storm-type fiber burst was recorded related to intermittent activity.

Metre band (*25 MHz–74 MHz*) : At 03 18.5 UT, a single fast drift burst (type III) of intensity class 2 was observed. Also, between 03 26 UT to 03 31 UT, a type II burst of intensity class 1 was observed.

Decametre band (*222 MHz–666 MHz*) : Between 03 13 UT to 03 31 UT, a storm-type weak fiber burst of intensity class 1 was observed. Also, at 03 18.5 UT, a single fast drift burst (type III) of intensity class 1 was observed.

According to Zirin (1966), meter and decametre band bursts originate high in the corona.

5. Analysis of observations

The maximum separation between the two strands was measured to be 15×10^3 km. A plot between the separation and time is shown in figure 2. We estimated the velocity with which the separation of the two strands took place. The maximum velocity of separation was found to be 52 km s^{-1}, and with a tendency to decrease fast with time. A graph of the velocity of separation *vs* time is shown in figure 2.

To estimate the magnetic field associated with the double ribbon flare, we assumed that the maximum kinetic energy density involved in the separation of the two strands is equal to the magnetic energy density associated with the flare. We also assumed that the potential energy density and the energy density involved in the expansion of the flare are negligible in comparison to kinetic energy density of the flare. Then

$$\frac{B^2}{8\pi} = \frac{1}{2} \rho V^2_{\max}$$

or

$$B^2 = 4\pi\, n_e m_H V^2_{\max}, \qquad \ldots(1)$$

where n_e is the electron density, m_H the proton mass, $V_{\max}$ the maximum velocity of separation of the two strands, and B the magnetic field of the flare.

According to Svestka (1976), at the maximum phase of all disk flares of importance 1^+ or higher the electron density is always greater than 10^{13} cm^{-3}. Also an analysis of metal lines in flares has led to the limit $10^{13} < n_e < 10^{14}$ cm^{-3} (Letfus 1964).

The magnetic field strength associated with the flare turns out to be 75 gauss for $n_e = 10^{13}$ cm^{-3} and 238 gauss for $n_e = 10^{14}$ cm^{-3} in the flares. For example according to Malville (1979) the observed values of magnetic field in flares were found to range between 100 gauss to 500 gauss.

The production of double ribbon and especially the separating out of lower portion of the digit 3 into two branches can be understood on the basis of tearing mode instability (Bateman 1978).

6. Conclusions

In this paper we have descibed the morphological behaviour of the flare of 1981 October 19. We have measured the separation between the two strands and estimated the velocity of separation and the magnetic field associated with the flare. The estimated magnetic field was found to be 75 and 238 gauss for $n_e = 10^{13}$ cm^{-3} and 10^{14} cm^{-3} respectively.

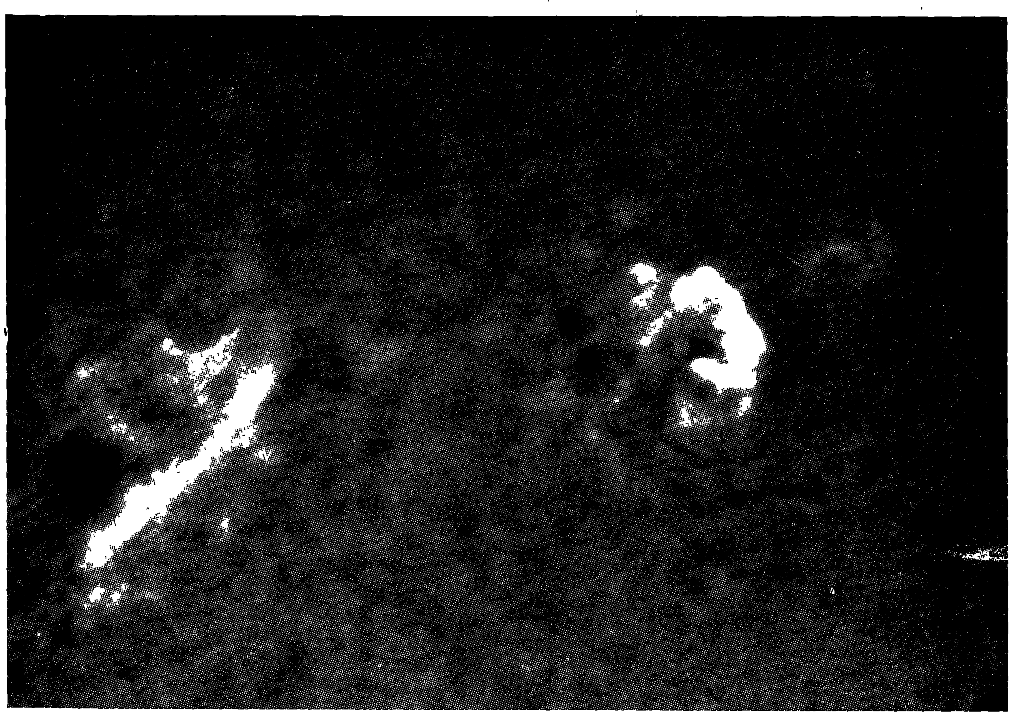
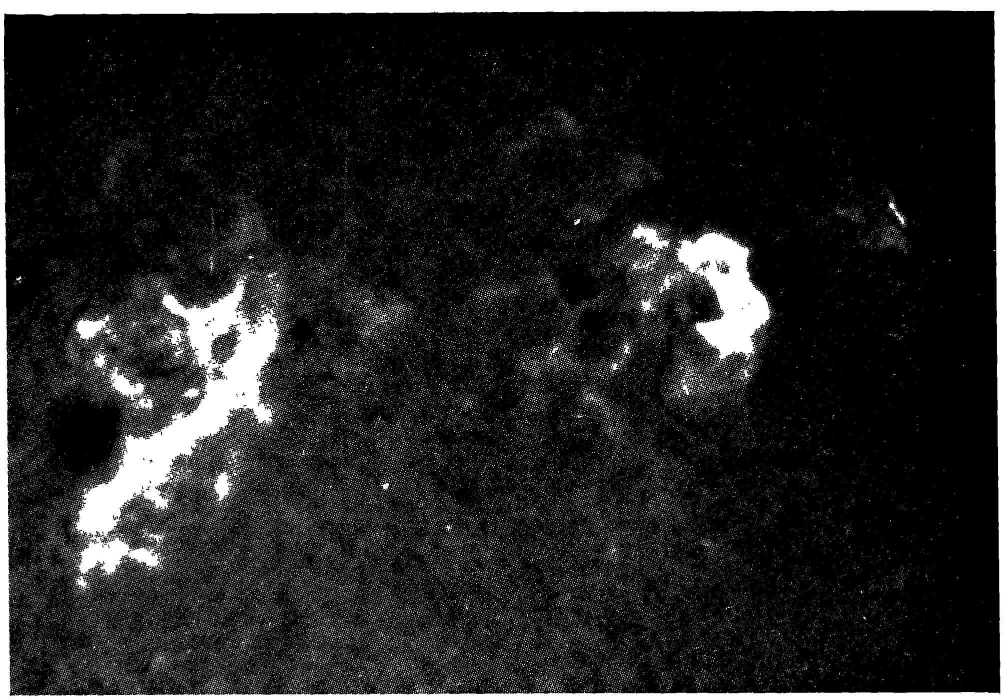


Figure 1a



Figgre 1b

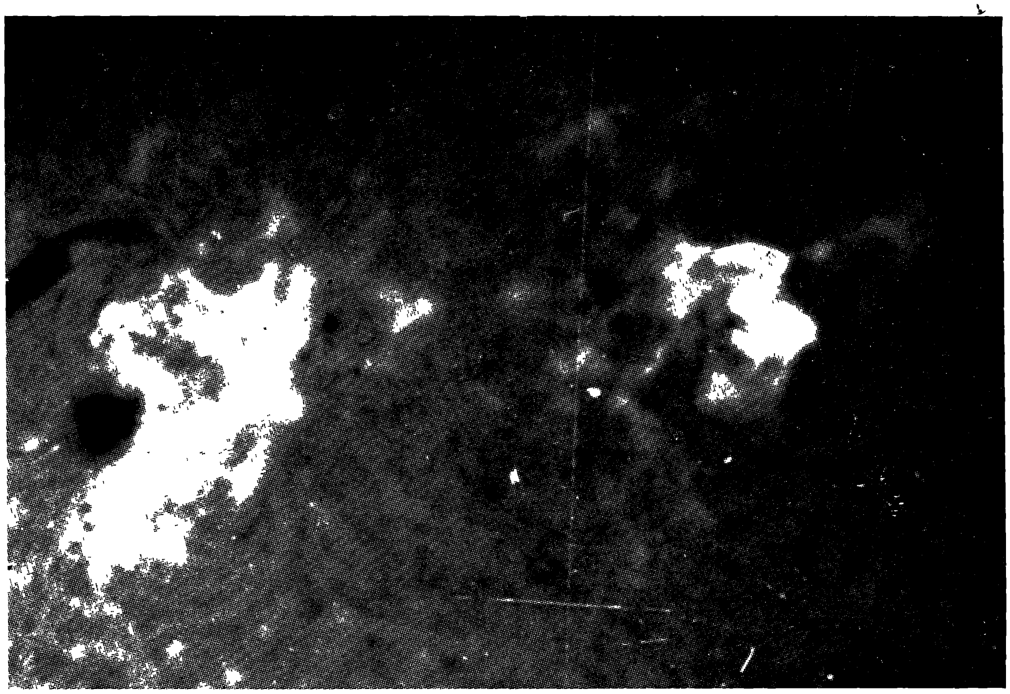


Figure 1c

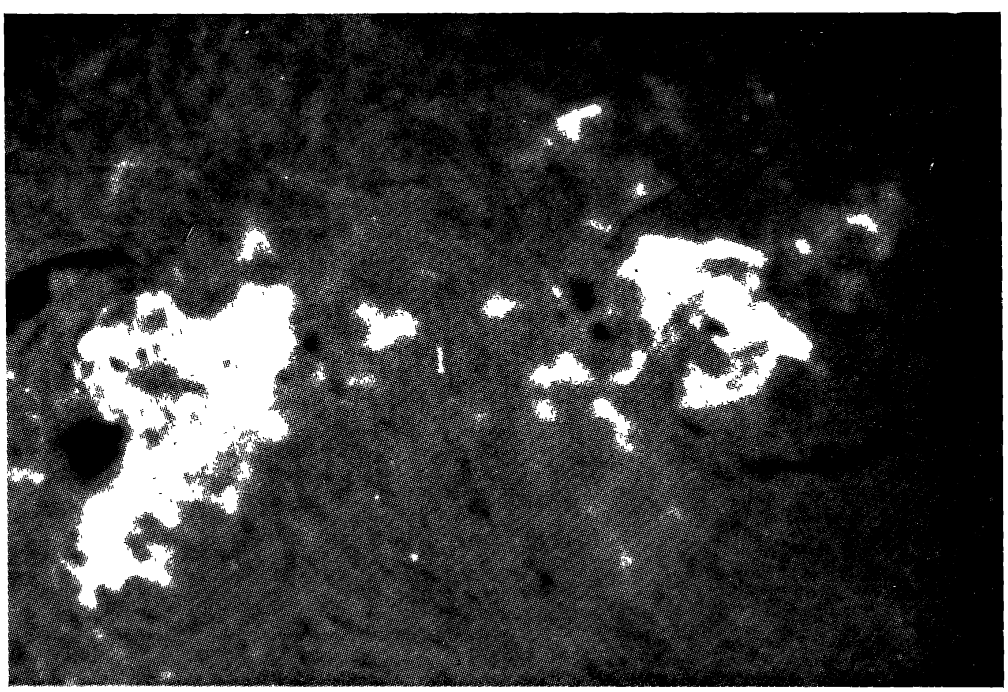


Figure 1d

Figure 1. a, b, c and d are some of the selected filtergrams of the double ribbon flare of 1981 October 19 at different moments.

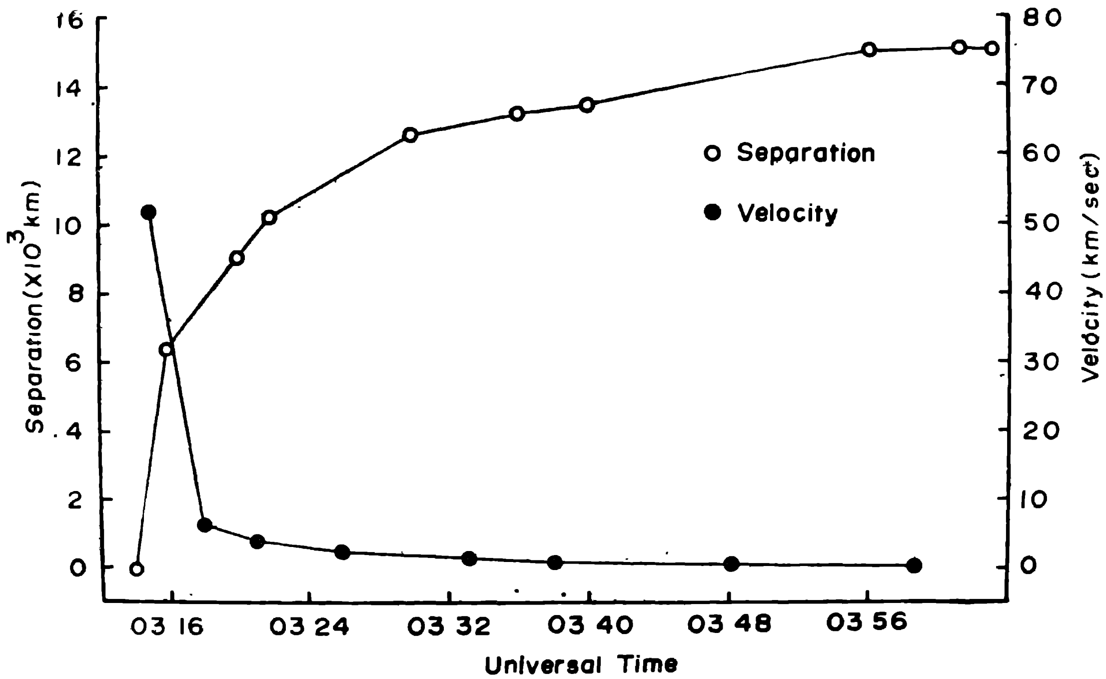


Figure 2. A plot of the separation between the two strands versus time and the velocity of separation versus time.

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