# Hα FLARE OF 14 MARCH, 1984 – EVIDENCE FOR RECONNECTION?

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**Abstract.** Kodaikanal Hα monochromatic and white-light observations are used to study the circular flare of 14 March, 1984. We report here the dynamic activity of the Hα filament, which attained a severe twist before erupting as a 4B flare. We feel that the relative motion between the emerging spot field and its neighbouring field is responsible for the field line reconnection, which triggered the flare.

## 1. Introduction

It is of great interest to look for the physical processes in individual flares, as we do not have any comprehensive or general theory of flares. However, in the case of active solar regions, it is plausible to accept the fact that the surplus energy released at the time of a flare is derived from the gradually stored energy from the surrounding magnetic fields. But observational evidence does not point to any drastic change in the magnetic field at the time of a flare. The emerging magnetic flux at the photospheric level may bring in shear to the field lines (Rust, Nakagawa, and Neupert, 1975). Zirin and Tanaka (1973), Tanaka and Nakagawa (1973), and Neidig (1979) reported the relaxation of shears near the zero lines of magnetic fields prior to flares. Therefore it is concluded that the excess energy released during a flare is drawn out of the magnetic energy stored in twisted or sheared magnetic loops (Martens and Kuin, 1989).

In this paper we have studied the case of the 4B flare of 14 March, 1984 wherein the opposite polarity field lines are pushed together in a region close to the newly emerged field at the photosphere. This, in turn, develops shear and starts reconnection, and it is argued that out of various processes, field line reconnection is responsible for the onset of the flare. We believe that the reconnection which is happening at the photospheric level is marked by the dynamic activity of the filament in a region at the photosphere–chromosphere interface.

## 2. Results and Discussions

Generally flares occur in complex magnetic regions where a high field gradient exists, and also where the magnetic polarity of the area is reversed. The plasma motions in the solar atmosphere lead to the complexity of the magnetic field. Information on the change of magnetic fields in such complex regions may be

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inferred by continuous monitoring of the Hα filaments. Hagyard *et al.* (1984) observed a large degree of shear in the magnetic field configuraton near the area of flare activity. As the flare sites are in the region around the magnetic neutral line, variations in the orientation of field lines in a neutral line may indicate the presence of reconnection, the direct evidence of which is difficult to obtain. Thus we have used the argument that the Hα dark filament, which assumes the position of the neutral line, is dictated by the sheared nature of the magnetic loops. Hence, we have measured the change in the Hα filament direction from one day to the next with respect to the sunspot positions in the same active region, and adopted the following data reduction procedure. We enlarged the spectroheliogram image and projected it onto the photographic print of its photoheliogram mate and aligned them for a perfect match using the (N–S) and (E–W) pole markings. We then sketched the position of the Hα filament on the photoheliogram print. We chose the $X$-axis as the line joining the centre of gravity of one sunspot to the centre of gravity of the other spot group. It has been possible to define the centre of gravity of the sunspots precisley in the case which we have studied. We chose the point of intersection of the Hα filament and the $X$-axis as the origin of the coordinate system and the $Y$-axis to be orthogonal to the $X$-axis. The angle '$\gamma$' between the $Y$-axis and the Hα filament is given as a measure of flare activity. The methodology of our measurement is explained in detail in our earlier paper (Rausaria *et al.*, 1993). Spectroheliograms in Hα and white-light photoheliograms taken at Kodaikanal from 11 to 15 March, 1984 are used in this study and are given in Figures 1 and 2.

A plage elongation, which is representative of close active regions in the east–west direction across the centre of the solar disc, is seen in the spectroheliogram of 11 March, 1984. The following events resulted in a flare on 14 March, 1984 at 02:37:31 UT.

### 2.1. 11 March, 1984

It is well known that the plage distribution is closely correlated with the magnetic field at the photosphere. The plage regions marked as P1 and P2 at the location S15 W16 and S09 E03 (Figure 1(i)) became centres of activity in the next couple of days. The photoheliogram (Figure 2(i)) shows the presence of a spot, S1, at S15 W17, but no spots are found near the region S09 E03.

### 2.2. 12 March, 1984

A new spot group, S2, emerged in the form of pores in the location S08 W08 (Figure 2(ii)) in the close vicinity of the plage region P2 (Figure 1(ii)), in accordance with the fact that the chromospheric plage begins to form much earlier than the appearance of the sunspot. The location of the spot S1 is S15 W30. A feeble Hα filament F as shown in Figure 1(ii) appears close to P2. The alignment of the Hα filament is perfect with the neutral line (Švestka, 1981), and here it is present outside the active region P2, between P1 and P2. Hence, it appears in this case that

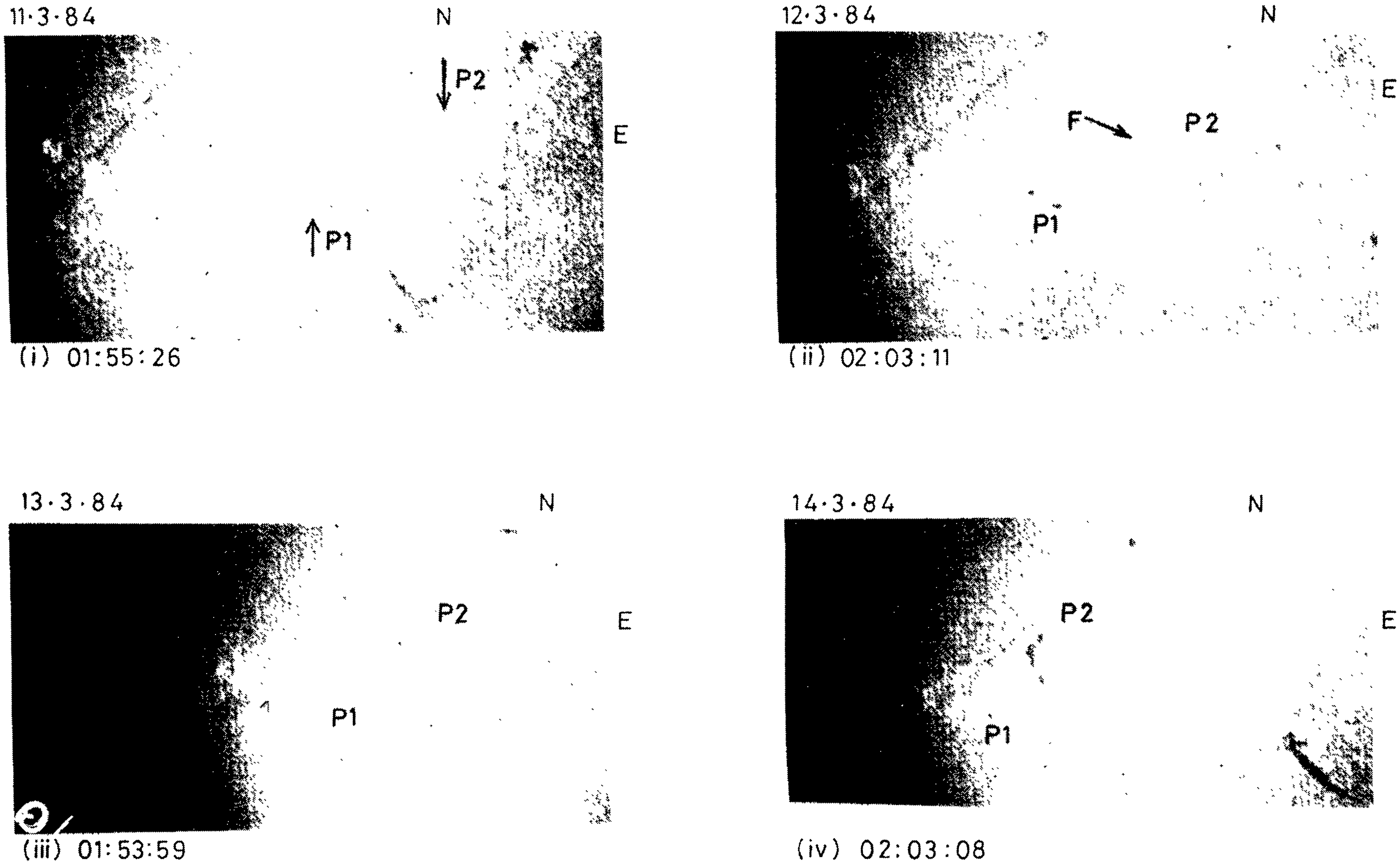


Fig. 1(i–viii). Hα spectroheliograms for 11 to 15 March, 1984 showing the evolution of the filament and its subsequent eruption as a flare on 14 March, 1984.

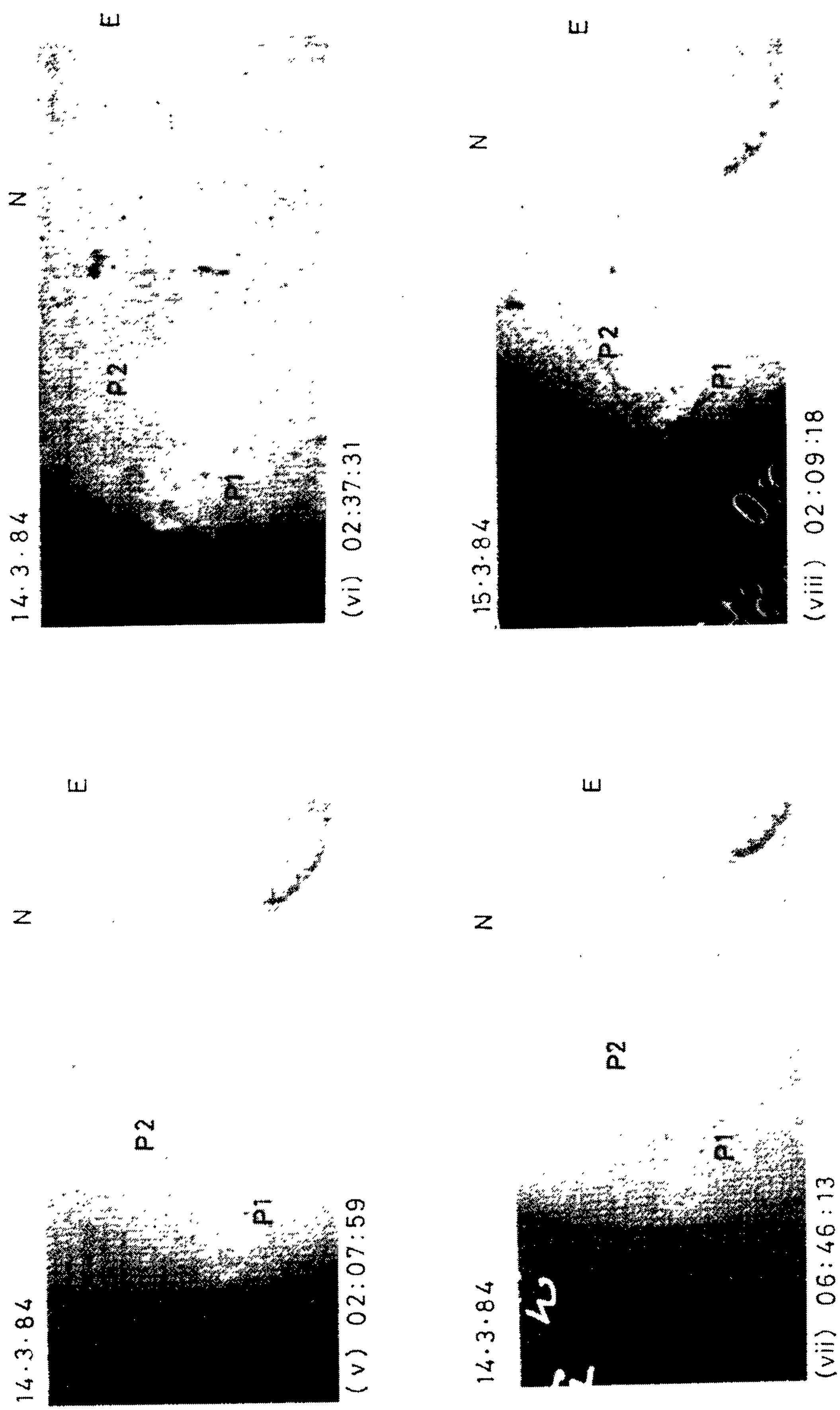


Fig. 1 (continued).

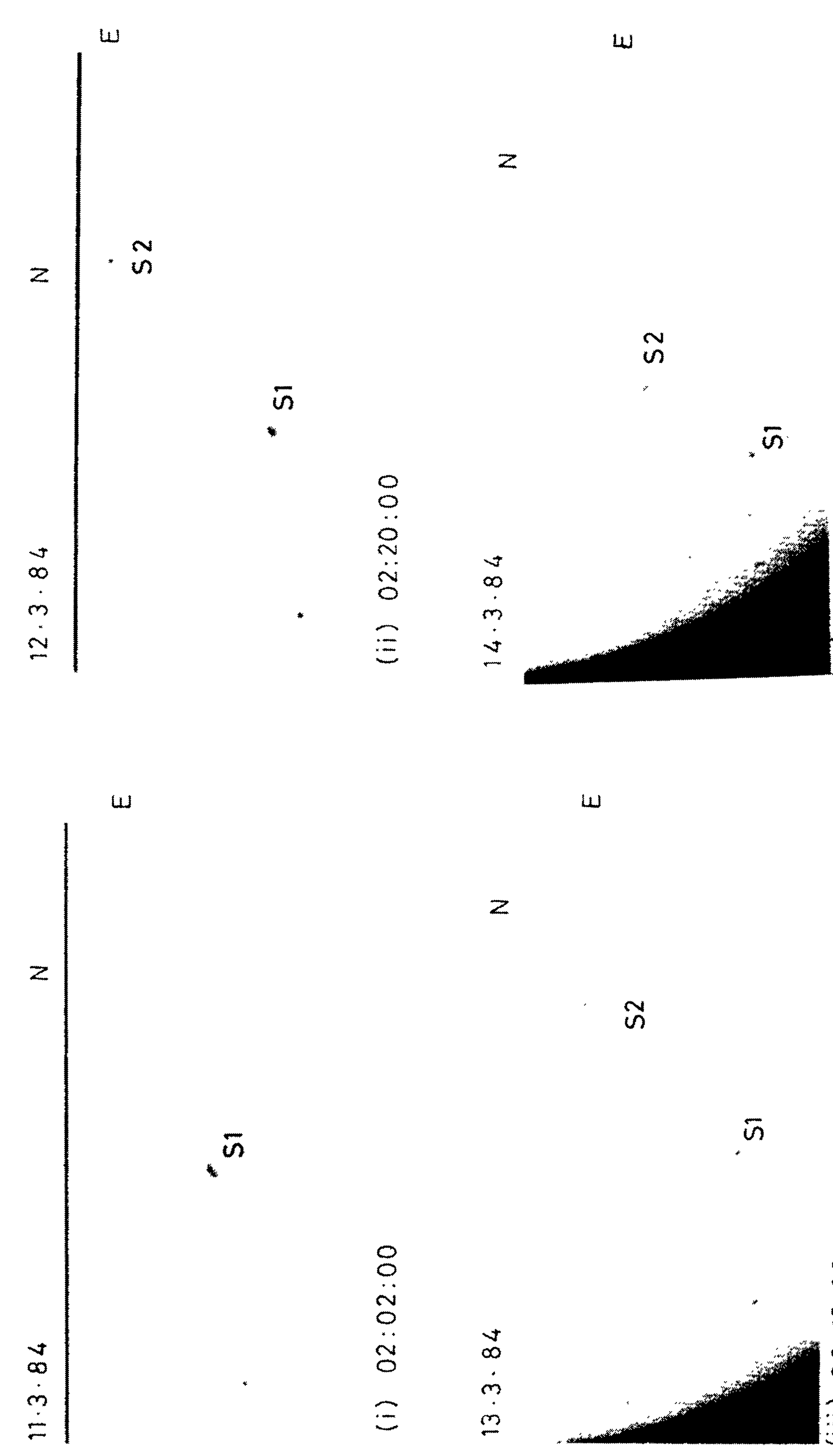


Fig. 2(i–vi). White-light photoheliograms of the corresponding regions for 11 to 15 March, 1984. The development of the newly emerged spot group S2 is shown from 12 March, 1984.

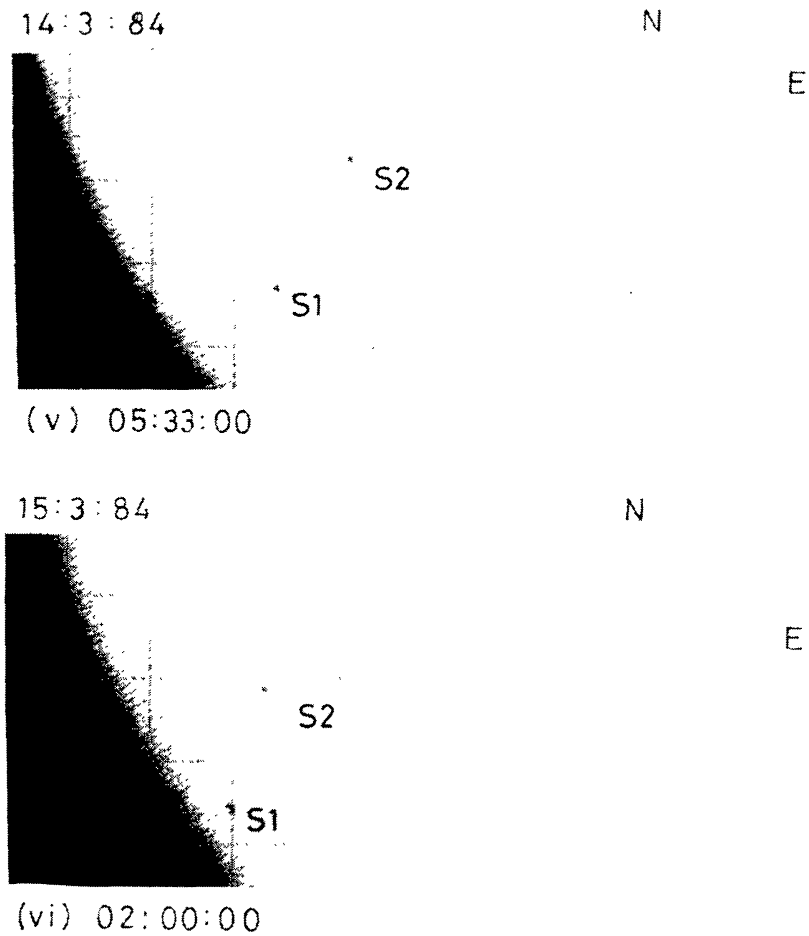


Fig. 2 (continued).

emerging flux alone is not responsible for the filament formation and suggests that the emerging field, S2, is under the influence of the spot field, S1. As the filament is very weak, it is difficult to measure the angle '$\gamma$'.

### 2.3. 13 March, 1984

The newly emerged spot group S2 has grown. The location of S1 and S2 are S14 W44 and S08 W24, respectively. The white-light photoheliogram (Figure 2(iii)) shows both the growth of spot group S2 and its relative motion with respect to spot S1, when compared with the photoheliogram of the previous day, 12 March, 1984 (Figure 2(ii)). It is conspicuous that the emerging flux in the region S2 initiates relative motion between the spot groups S1 and S2. The H$\alpha$ filament is very well marked and positioned closer to the plage P2 in a region between P1 and P2 (Figure 1(iii)).

### 2.4. 14 March, 1984

The spot group S2 has grown further. The relative and rotational movements of the spot groups S1 and S2 are well observed at 02:20:00 UT (Figure 2(iv)), when compared with the previous day 13 March, 1984 (Figure 2(iii)). The respective location of S1 and S2 are S14 W58 and S10 W40. The positions of the sunspot groups S1 and S2 from 12 to 14 March, 1984 lie almost in the centre of the disc. Hence, we feel that the conversion to the heliographic coordinates will not alter the centre of gravity of the spot groups S1 and S2. The difference between the centre of gravity of the spot groups S1 and S2 is 22 deg (12 March), 20 deg (13 March), and 18 deg (14 March), respectively. We believe that the strong emerging magnetic flux in the region S2 plays an important role in compressing and pushing it closer to S1 by a drift of 2 deg on each day. This has strengthened the interaction between the fields S2 and S1 and is observed in the form of filament acceleration at 02:03:08 UT and 02:07:59 UT (Figures 1(iv) and 1(v)). The filament structure becomes much more pronounced, and it attains a semi-circular shape. Also the filament is positioned in a region slightly away from the emerging magnetic field of the preceding spot of S2, in a region between S2 and S1. Hence, we feel that the growth of the filament is due to the interaction of the growing magnetic field of S2 with its neighbouring field S1.

The photospheric plasma motion, such as the relative and rotational motions of sunspots S1 and S2, brought non-potentiality into the magnetic field. In the process, the magnetic field at the chromospheric level in the filament was strongly sheared across the zero line of magnetic field. As a result, the H$\alpha$ filament underwent a severe twist, became untenable and started unwinding itself, erupting into a spectacular circular flare of importance 4B, almost covering the entire region P2 in the location S10 W40 at 02:37:31 UT (Figure 1(vi)). At the time of the flare, this region is blown off and the reference point cannot be identified for measuring '$\gamma$'. Finally, in the post-flare phase at 06:46:13 UT (Figure 1(vii)), the ribbon loops are seen drifting away from each other. The filament acceleration declines, and the angle '$\gamma$' nearly relaxes to its orignal value.

### 2.5. 15 March, 1984

The filament has left its signature in the form of some faint fragments which are seen between the plage regions P1 and P2 (Figure 1(viii)). The values of '$\gamma$' are shown in Table I as a measure of flare activity.

## 3. Summary

Priest and Heyvaerts (1974) outlined a model in which plasma instability could start where the emergent flux interacts with the overlying fields, and as a result, H$\alpha$ pictures might show evidence for reconnection. In this case, we feel that emerging flux is not the only condition for the flare onset. The event suggests that the emerging magnetic flux compresses the overlying field (S2) which, in turn, initiates its interaction with the neighbouring field (S1), and it is observed in the form of a growing H$\alpha$ filament close to the emerging field in a region between these

TABLE I
Change in the orientation of the Hα filament as a measure of flare activity

| Sl. No. | Date | Time (UT) | $\gamma$ (°) |
|---|---|---|---|
| 1 | 12 March, 1984 | 02:03:11 | Filament very weak |
| 2 | 13 March, 1984 | 01:53:59 | 15 |
| 3 | 14 March, 1984 | 02:03:08 | 26 |
| 4 | 14 March, 1984 | 02:07:59 | 33 |
| 5 | 14 March, 1984 | 06:46:63 | 15 |

two fields. When the emerging field (S2) and the existing field (S1) are brought together due to their relative motion, reconnection of field lines takes place in the neutral plane and the flare is triggered. The filament activation and its subsequent eruption as a flare are well observed in Hα, whereas the reconnection of field lines takes place in a region around the magnetic neutral line at the photospheric level. As the Hα filament is supposed to be on the neutral line, we feel that the reconnection is indicated by the dynamic activity of the filament at the chromospheric level. It is further confirmed by the eruption of the Hα filament, as this suggests that the flare has derived its energy from the magnetic field in or near the filament, the region which is identical with the position of the zero line of magnetic field. The change in the orientation of the Hα filament is reported here as a measure of flare activity. We believe that the observations presented in this paper are representative of field line reconnection, and after the flare is over, the field lines regain their original position.

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