ON THE TRIGGERING OF A SPOTLESS DOUBLE-RIBBON FLARE

R. R. RAUSARIA, S. M. ALEEM, and K. SUNDARA RAMAN

Indian Institute of Astrophysics, Kodaikanal-624 103, India

(Received 22 April, 1992; in revised form 2 June, 1992)

Abstract. We have studied the evolution of the double-ribbon, spotless flare of 21 February, 1992, using Kodaikanal Hα and Kf1 observations. The analysis of the data shows that the Hα filament underwent a large change in shear prior to the day of the onset of the flare. We find considerable rotation of the plage region before the emergence of a small magnetic pore. It is concluded that shear plays an important role in the triggering of a spotless flare.

1. Introduction

Most solar flares occur in well-developed active regions. However, a small number, approximately 7% of all flares, occur in plages with only small or no spots (Dodson and Hedeman, 1970). Spotless flares are a rare but well-observed aspect of solar activity. For flares associated with spots, it is currently believed that the primary source of energy released in these flares is the free energy stored in stressed magnetic fields. The release of this energy occurs in the transition from the sheared configuration to the potential configuration. Contrary to this, spotless flares follow the activation and disappearance of dark Hα filaments (Moore *et al.*, 1979; Moore and LaBonte, 1980). The activation of an Hα filament marks the beginning of the instability in the magnetic field leading to filament eruption. Bruzek (1959) and Rust, Nakagawa, and Neupert (1975) have proposed the appearance of a newly emerging flux region as the cause of the onset of this instability. The propagation of a slow mode wave from another active region has also been proposed as the cause for the triggering of a spotless flare (Švestka, 1976). On the other hand, Moore and LaBonte (1980) find shear as the cause for the onset of a spotless flare. The above discussions show that the nature of the triggering mechanism for the activation and eruption of an Hα filament associated with a spotless flare is still unknown. Therefore, to examine the eruption mechanism, in this paper we report the evolution of a spotless, double-ribbon flare using Hα and Kf1 observations at Kodaikanal. The analysis of the data clearly shows that change in shear one day prior to the day of the flare plays an important role in the triggering of a spotless flare.

2. Observational Data

A daily, white-light photograph of the Sun of diameter 8″ is being taken regularly, using a 6″ refractor at Kodaikanal. Spectroheliograms in Hα are recorded daily using a Littrow mount with a solar image diameter of 60 mm. Ca II K_{232} spectroheliograms of

Solar Physics **141**: 131–141, 1992.

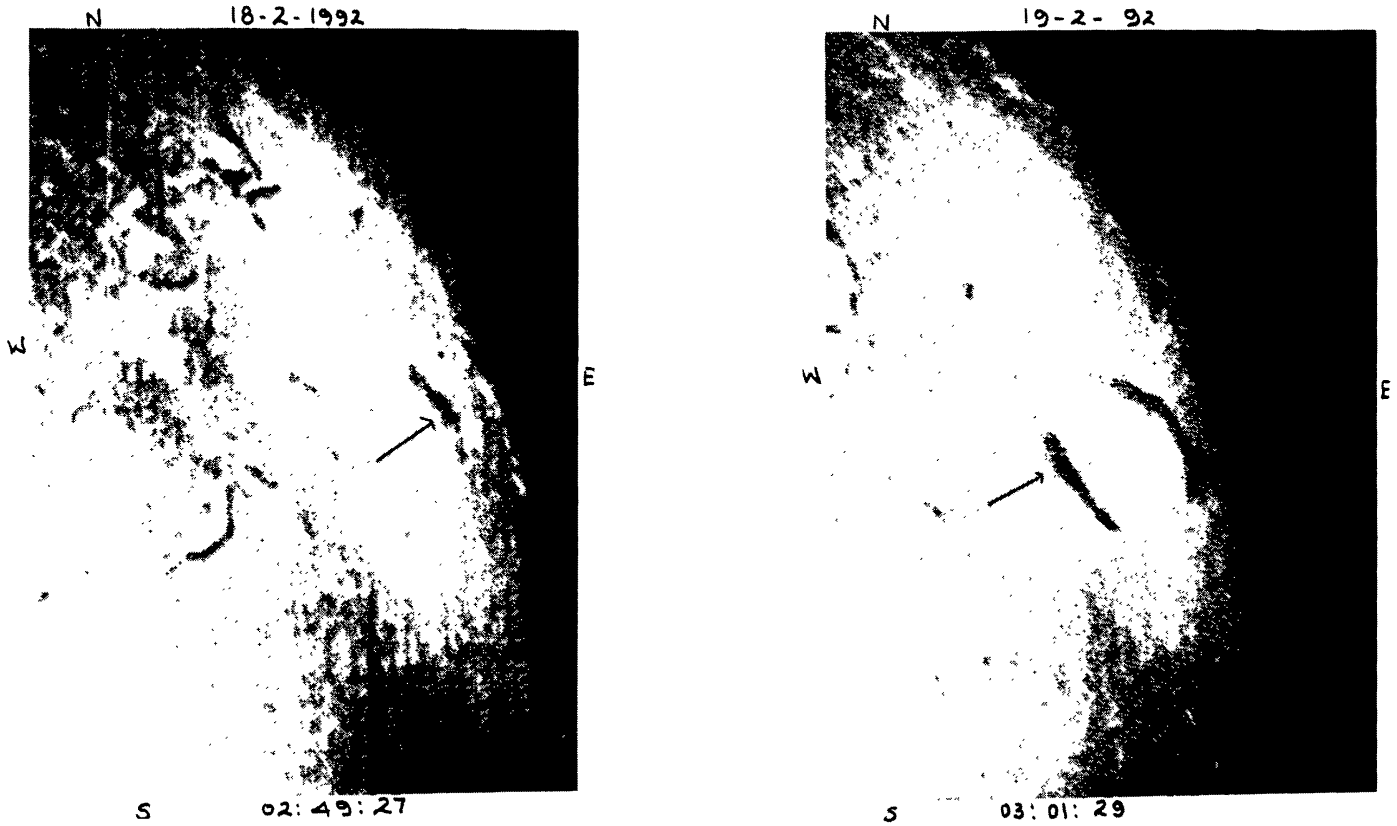

Fig. 1a.

1992SoPh..142..131R

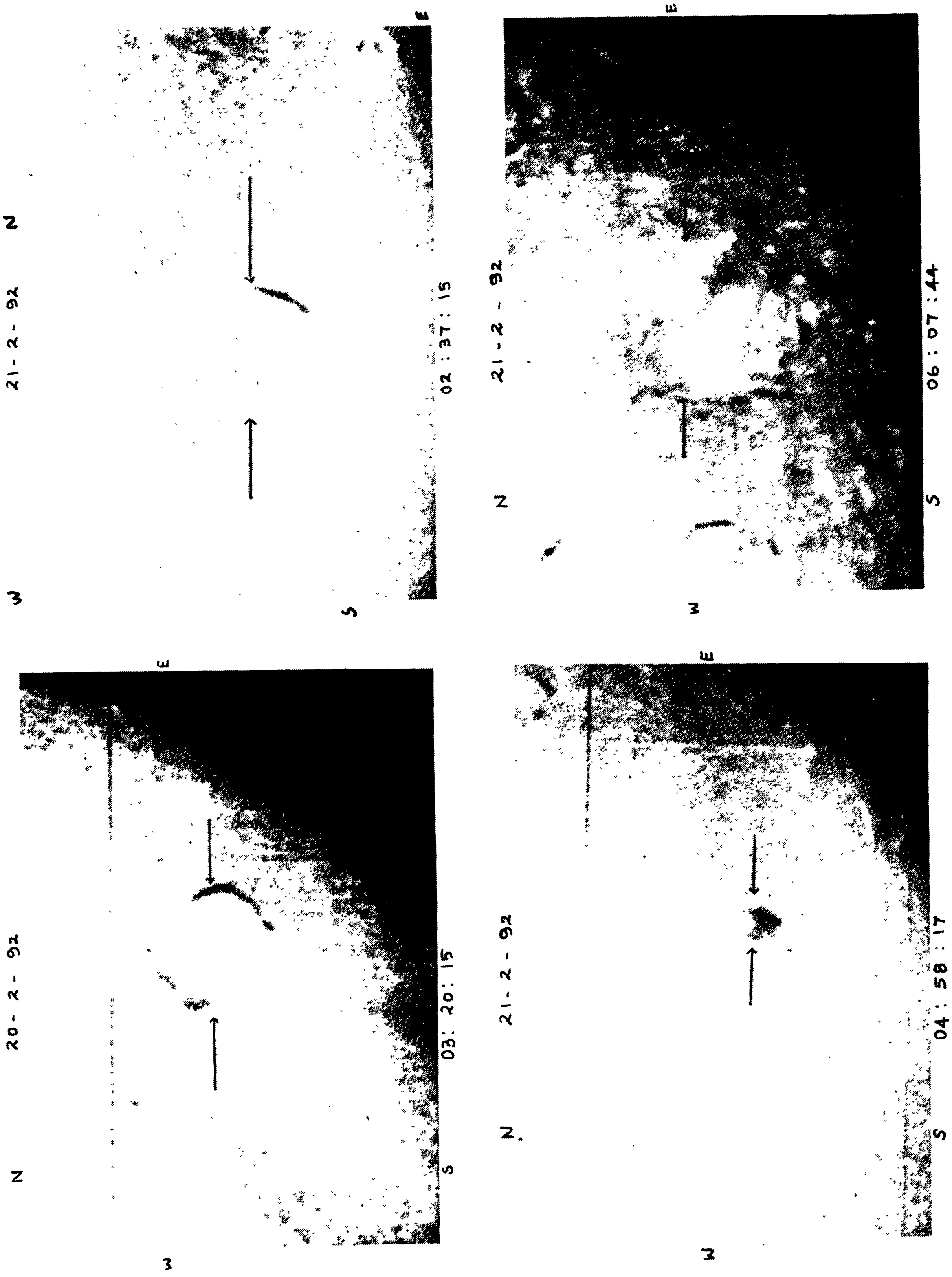

Fig. 1a (cont.)

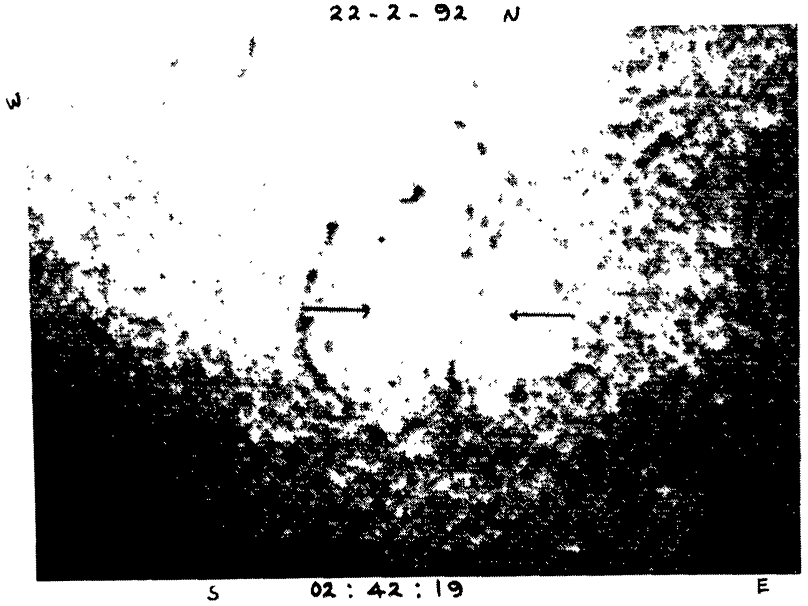

Fig. 1a. Hα spectroheliograms for 18, 19, 20, 21, and 22 February, 1992 showing the evolution of the filament and its subsequent eruption on the flare day. The time of observation is indicated on each frame.

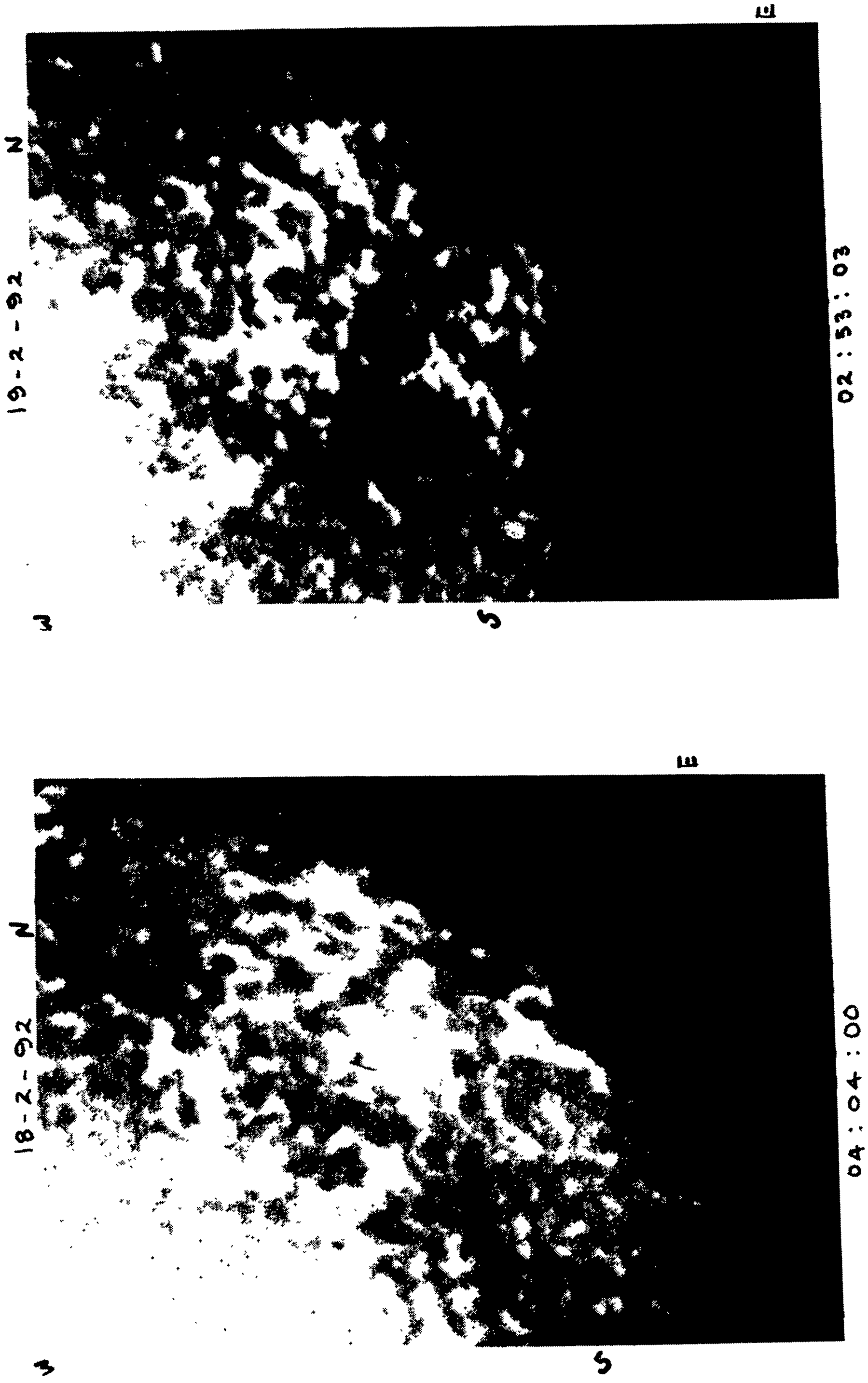

Fig. 1b.

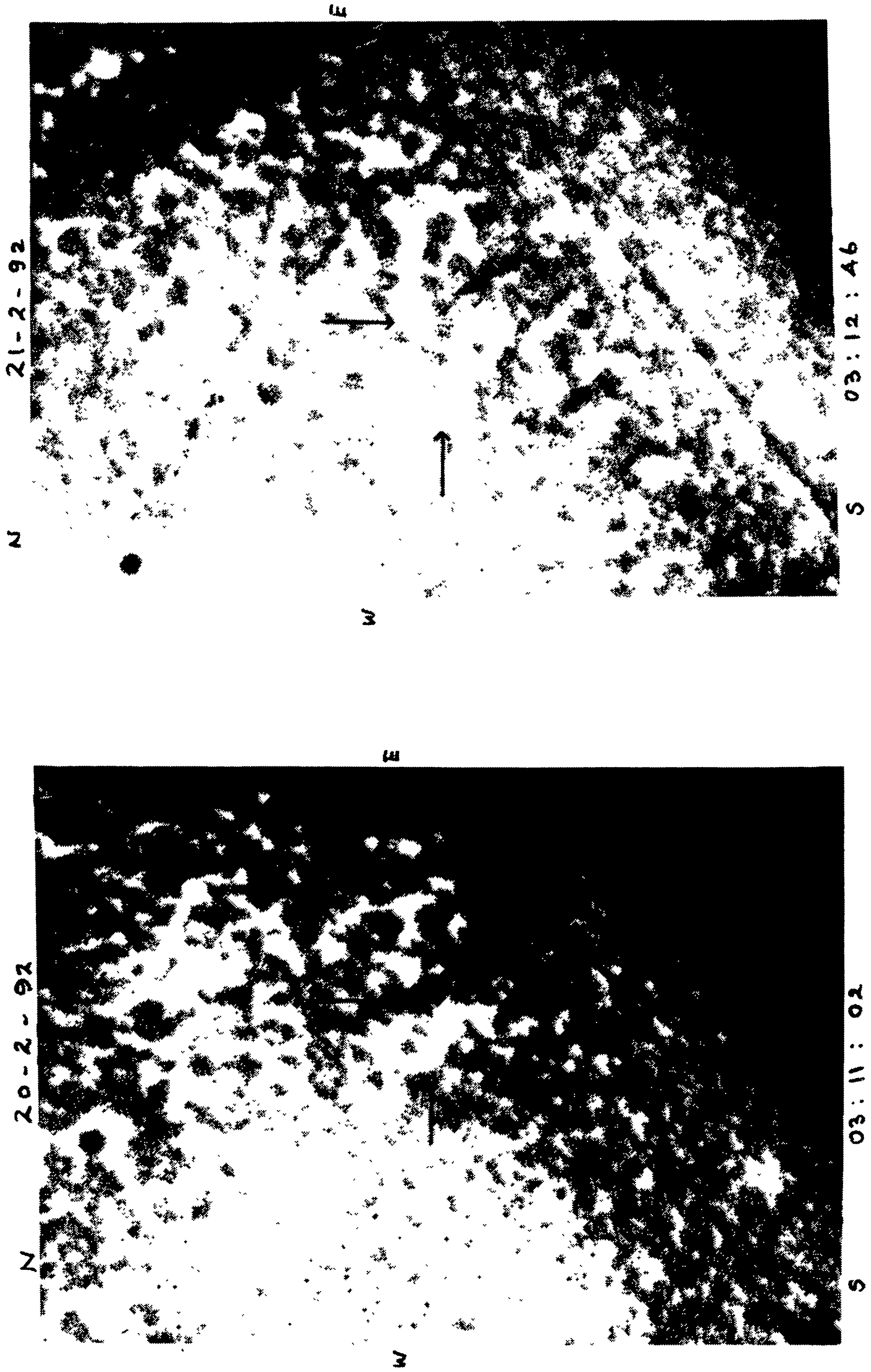

Fig. 1b (cont.)

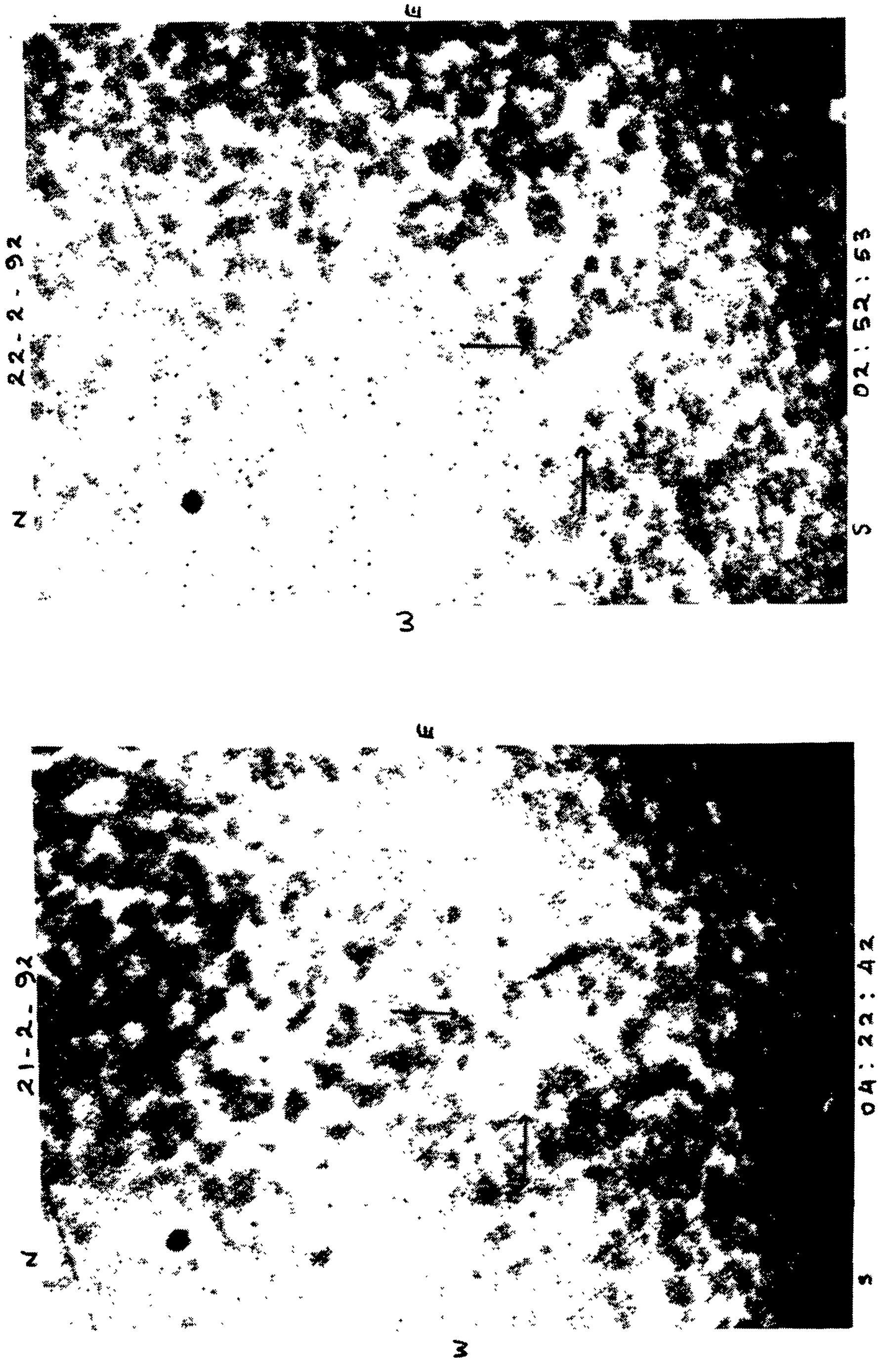

Fig. 1b. Ca II K_{232} spectroheliograms corresponding to Hα spectroheliograms for the days as in Figure 1(a).

1992SoPh..142..131R

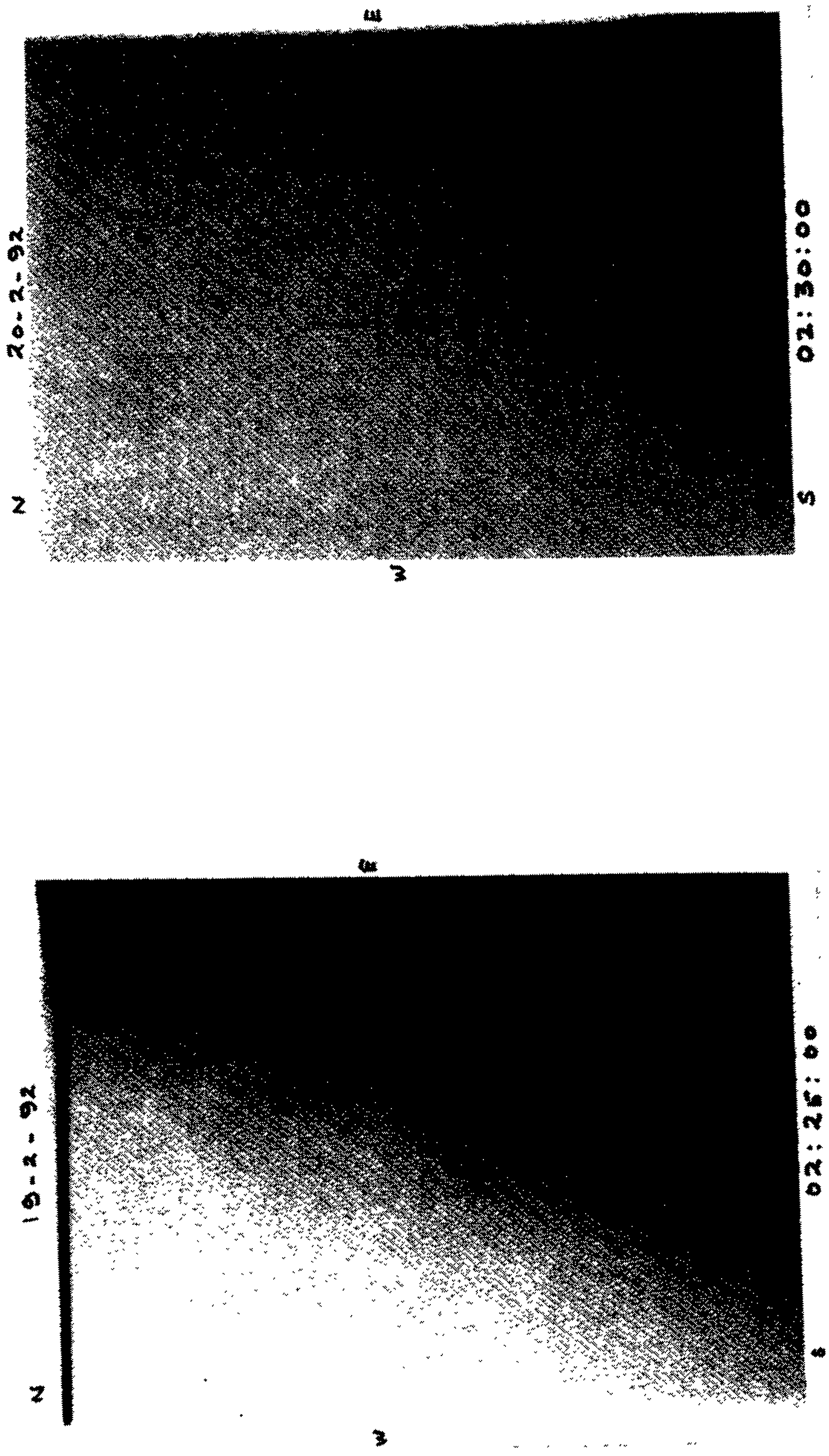

Fig. 1c.

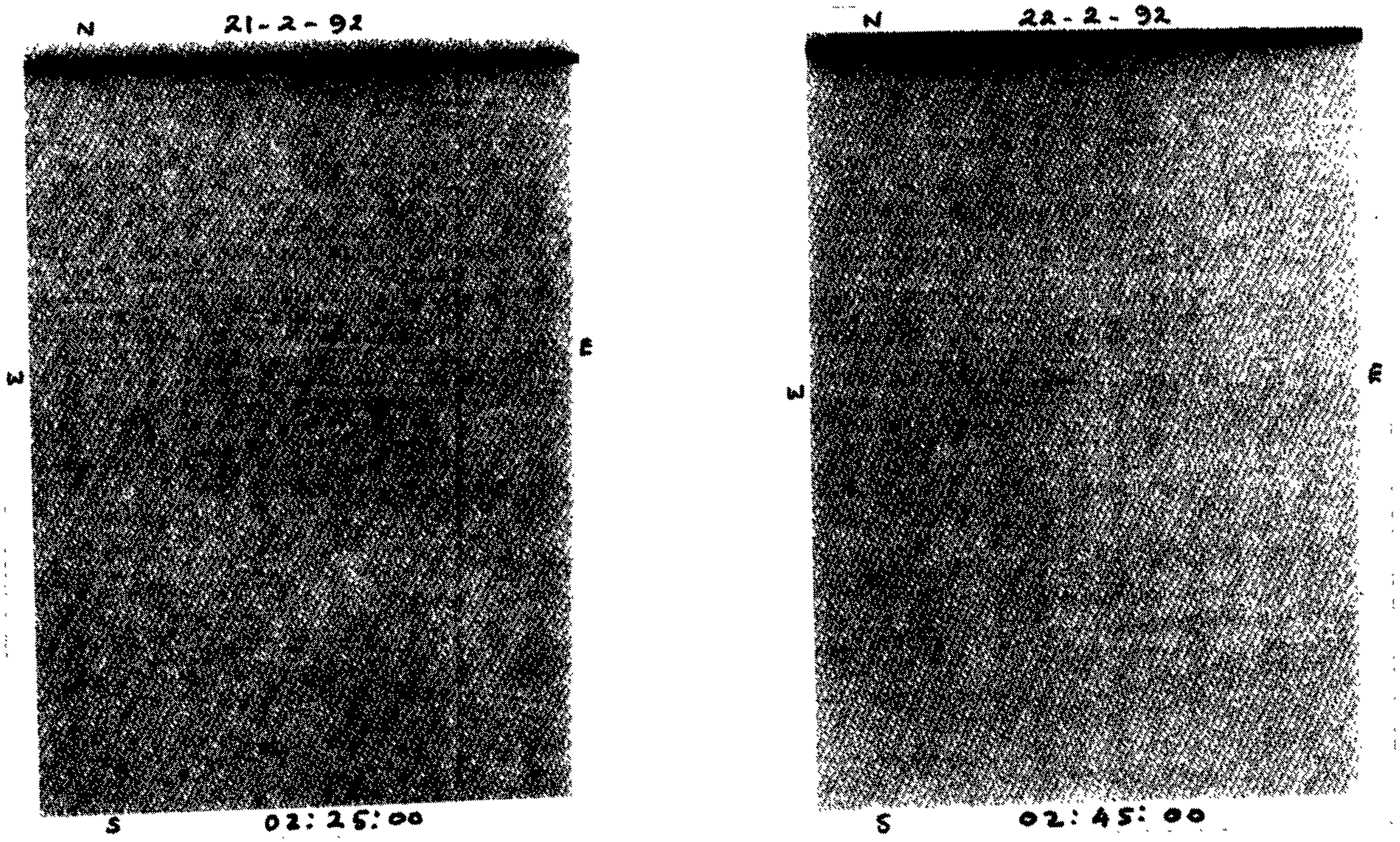

Fig. 1c. Photoheliograms on 19, 20, 21, and 22 February, 1992 showing the appearance and disappearance of a small pore on 20 February, 1992.

1992SoPh..142..131R

the same diameter, 60 mm, are also recorded daily, using prisms. For the present analysis we obtained spectroheliograms every 30 or 60 min.

A circular, dark Hα filament first appeared at the location S 32 E 70 with a smaller plage area on 18 February, 1992. On 19 February, 1992 it moved to the location S 27 E 55. The plage area grew further and broke into two parts. There was a slight change in the orientation of the filament. On 20 February, 1992 the plage area grew still further. The orientation of the plage changed considerably. A small pore appeared at the location S 35 E 35. The orientation of the Hα filament followed the pattern of 19 February, 1992 with an increase in shear. On 21 February, 1992, before the start of observations at 02:37 UT, the small pore had already disappeared. The orientation of the plage area changed further, and the corresponding orientation of the Hα filament also underwent considerable change. At 04:58:17 UT on 21 February, 1992 the filaments started untwisting and developed into a two ribbon flare at 06:07:44 UT. The evolution of the flare and Hα filaments from 18 to 21 February, 1992 are given in Figure 1(a). The Ca II K_{232} Spectroheliograms on different days are reproduced in Figure 1(b) and the photoheliograms in Figure 1(c).

3. Results and Discussions

Vector magnetic field measurements in the photosphere provide direct evidence for the twisted or sheared nature of magnetic loops. In the absence of such measurements, the sheared configuration can be inferred from the Hα filaments, which assume the neutral line position dictated by the sheared magnetic loops. A quantitative measure for the magnetic shear at the photospheric level was proposed by Hagyard *et al.* (1984), from a detailed study of one active region. They defined the degree of shear as the angle in azimuth between the directions of the observed magnetic field and of the potential field.

We have used the argument that the value of the shear can be derived from the Hα dark filament. In the case of an active region the center of gravity of an opposite polarity umbra in a given penumbra forms the reference point with respect to which one can study the change in the orientation of Hα filaments.

However, this is not the case for a spotless flare. Flares are usually associated with plages. As mentioned in Gibson (1973, p. 51), plage corridors or dark lanes between bright plages also delineate the magnetic neutral line. Therefore, we have taken the opposite polarity plage regions as the reference point and have studied the variation of shear angle using dark Hα filaments, from one day to the other, with respect to the center of gravity of the plage regions. We have picked out for each day the Hα and Ca II K_{232} spectroheliograms and photoheliogram. We enlarged the spectroheliogram image (60 mm diameter) and projected it on its photoheliogram mate and aligned them for a perfect match using the (N–S) and (E–W) pole markings. To measure the shear angle, we have chosen the X-axis as the line joining the center of gravity of one plage to the center of gravity of the opposite polarity plage. We have chosen the point of intersection of the neutral line (Hα-filament) and the X-axis as the origin of the coordinate system and the Y-axis to be orthogonal to the X-axis. Now the shear angle γ is the angle between the Y-axis and the neutral line.

TABLE I

Variations of shear angle from 18 to 22 February, 1992

S. No.	Date	Change in the shear angle
1.	18 Feb., 1992	Filament and the plage at the limb
2.	19 Feb., 1992	9°
3.	20 Feb., 1992	20°
4.	21 Feb., 1992	35°
5.	22 Feb., 1992	Filament very weak

The angle of shear obtained by the method described above is given in Table I.

From the table we find that the change in shear angle was considerable on 20 February, 1992 and 21 February, 1992 before the filament broke into a double ribbon.

As mentioned in the introduction, the spotless flare needs a trigger to activate and erupt the filament. In the present observations a small pore did appear on 20 February, 1992 but disappeared quickly before the morning of 21 February, 1992 (Figure 1(c)) whereas the flare occurred on 06:47 UT. The Hα filament shows considerable change in its orientation on 20 and 21 February, 1992 (Figure 1(a)). However, the associated plage region has also undergone considerable change in its orientation (Figure 1(b)) and increase in area. Now there can be two possibilities in which the Hα filament can be activated (i) disappearance of the pore, (ii) change in the shear, which becomes untenable. Since the pore disappeared very quickly and the flare occurred much later (06:47 UT), we feel that the second possibility, a change in shear due to a rotation of the plage, plays a much more important role for the trigger of the spotless flare.

Acknowledgements

We thank R. Selvendran and P. Paramasivam for help in observations and making photographic prints.

References

Bruzek, A.: 1959, *Z. Astrophys.* **31**, 99.

Dodson, H. W. and Hedeman, E. R.: 1970, *Solar Phys.* **13**, 401.

Gibson, E. G.: 1973, *The Quiet Sun*, NASA Scientific and Technical Information Office, Washington, D.C.

Hagyard, M. J., Smith, J. B., Teuber, D., and West, E. A.: 1984, *Solar Phys.* **91**, 115.

Moore, R. L. and LaBonte, B. J.: 1980, in M. Dryer and E. Tandberg-Hansen (eds.), 'Solar and Interplanetary Dynamics', *IAU Symp.* **91**, 207.

Moore, R. L., McKenzie, D. L., Švestka, Z., Widing, K. G. and 12 co-authors: 1979, in P. A. Sturrock (ed.), *Solar Flares*, Proceedings of the Second Skylab Workshop, Colorado Associated University Press, p. 341.

Rust, D. M., Nakagawa, Y., and Neupert, W. M.: 1975, *Solar Phys.* **41**, 397.

Švestka, Z.: 1976, *Solar Flares*, D. Reidel Publ. Co., Dodrecht, Holland.