HOMOLOGOUS MICROWAVE BURSTS AND ASSOCIATED SOLAR FLARES*

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Abstract. Homologous characteristics of radio bursts at 3000 MHz and associated optical flares are studied. It is found that flares associated with homologous radio bursts are also homologous optically.

1. Introduction

Solar flares originating in the same active region sometimes show the same optical appearance. Ellison *et al.* (1960) termed such events as homologous flares. These occur exactly in the same region with respect to the spot group and show considerable similarities in the structure of the flare filaments as well as in the development of the flare itself. Fokker and Roosen (1961), Fokker (1967) have found several examples of homologous radio events. White and Janssens (1970) have recently reported an example of radio and optical homologous flares occurring nearly 54 h apart and showing detailed similarities both in Hα and at microwave frequencies. In this investigation we report on certain features of homologous radio bursts recorded at Kodaikanal at 3000 MHz and associated optical flares.

2. Criteria for Homology

Homology in optical flares is characterised by similar or even identical appearance of the flare filaments when viewed in the light of Hα, for flares occurring in the same region on successive occasions. Remarkable similarities can be noticed as shown in Figure 1, which shows a number of flares that occurred in the same region. In the radio domain, however, the definition of homology does not appear to be as simple. Fokker (1967) has defined quantitative criteria to determine whether any two bursts are homologous or not. These criteria work out very well when we collect published radio data. In this paper we adopt more subjective criteria while considering the homologous characteristics of two bursts occurring at the same frequency. We shall be guided to a great extent by the similarities in the development of the radio events, their amplitudes and durations as well as association with the same centre of activity.

3. Observations

Figure 2 shows some of the radio bursts recorded during the period May 25, 1967 to

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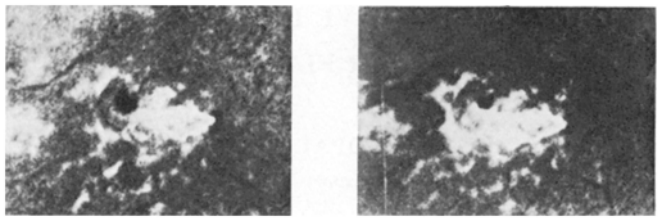

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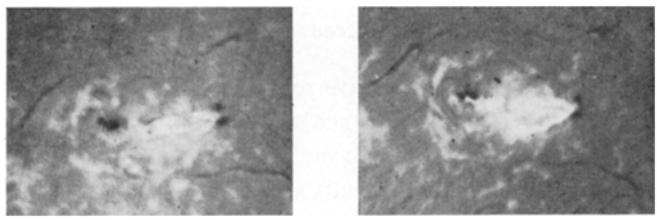

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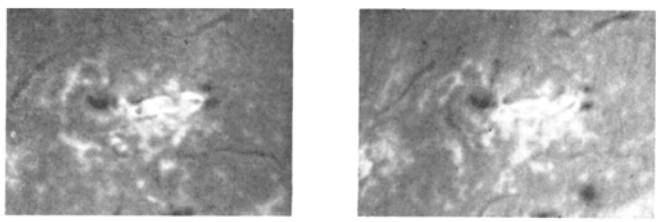

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Fig. 1. Typical examples of homologous optical flares observed in Hα (Top two photographs are reproduced from J. T. Jefferies *et al.*, *Astrophys. J.* **129**, No. 1, 1959 by kind permission of University of Chicago Press).

June 3, 1967 at Kodaikanal at a frequency of 3000 MHz. Also plotted on this diagram is a burst recorded at Sagamore Hill at 2695 MHz on May 21, 1967 (*ESSA Solar Geophysical Data* No. 274). All these bursts, associated with flares occurring in the same region, have striking similarities even though the bursts have occurred at widely separated intervals. It is interesting to see that some of the minor features, such as the peaks marked 'A', are seen in the bursts on different days. Figure 3a shows four bursts associated with flares near the central meridian observed on December 17, 1966.

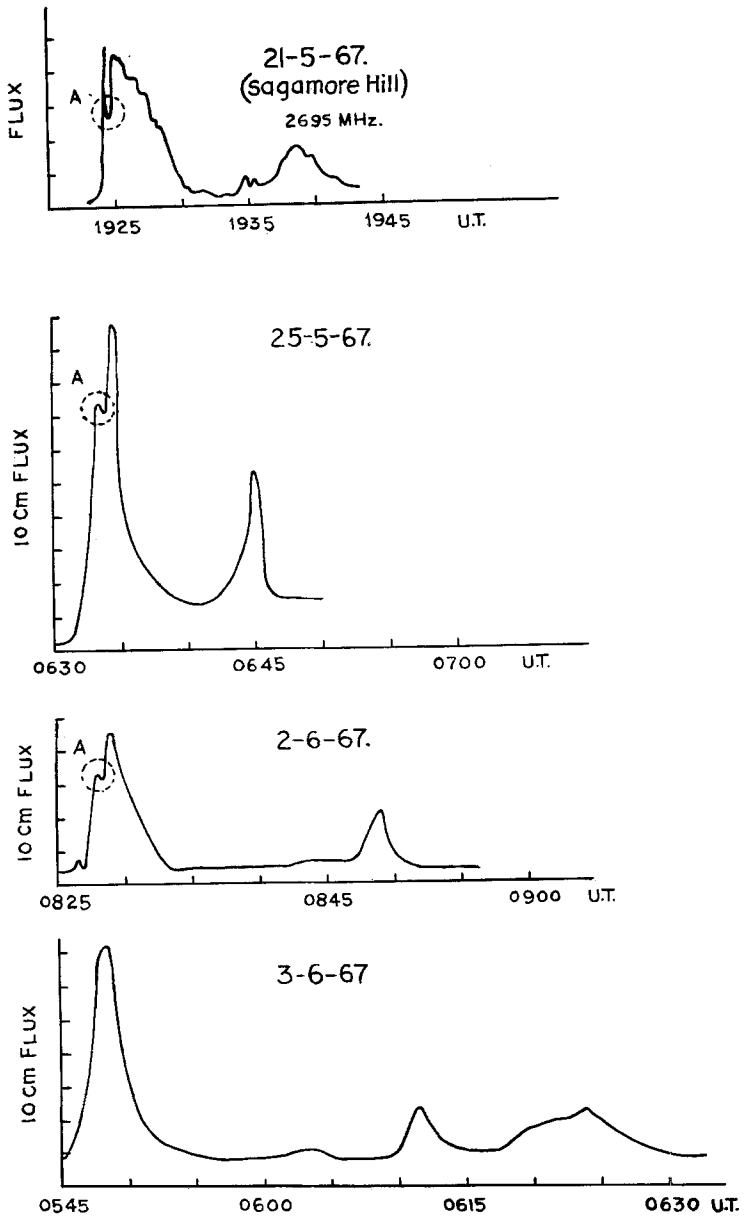

Fig. 2. Series of homologous microwave bursts. Diagram at top was recorded at Sagamore Hill and bottom three were recorded at Kodaikanal.

The top two bursts were recorded at Kodaikanal and the bottom two were recorded at Nera (Fokker, 1967). These bursts have striking similarities and have occurred at an interval of approximately 2^h30^m to 3^h.

It will be of great interest to see if flares which give rise to homologous radio bursts are also optically homologous. Figure 3a shows the Hα filtergrams of three flares

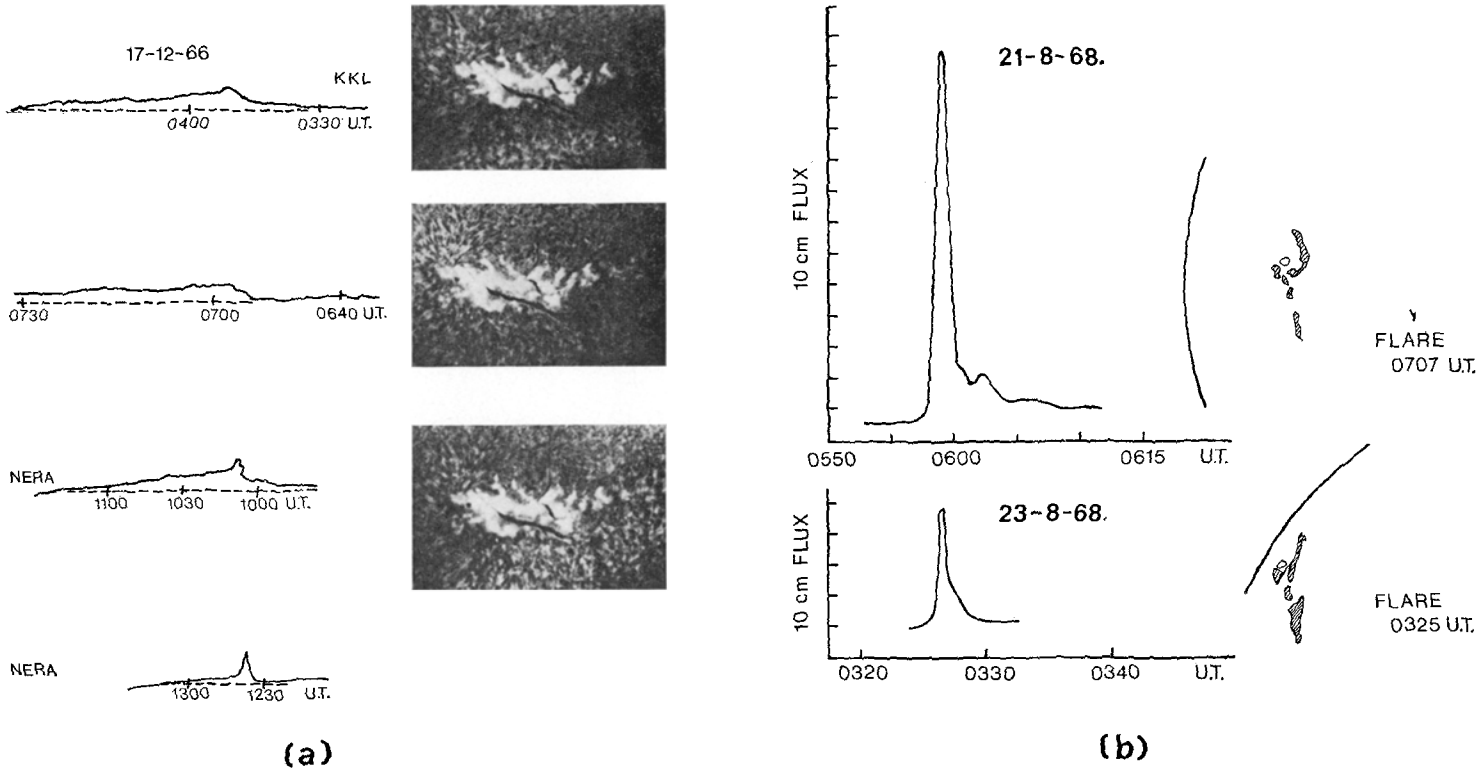

Fig. 3. Homologous microwave bursts and associated optical flares. (The Hα filtergrams in (a) were kindly supplied by Dr. R. G. Giovanelli, Division of Physics, C.S.I.R.O., Sydney, tracings in (b) are from the spectroheliograms taken at Kodaikanal).

which have given rise to the first three radio events. In Figure 3b are shown two bursts occurring on 21 and 23 August 1968 along with drawings of the flare filaments. In both cases the optical flares have similar structures.

Ellison *et al.* (1960) found the flares of 10, 12, 13 April 1959 optically homologous. The available radio data on these events associated with these flares indicate that they are homologous in the radio domain also, when we apply the Fokker (1967) criteria.

4. Discussion

The foregoing observations indicate that solar flares which are optically homologous will also give rise to homologous radio bursts. The converse is also true. This is only to be expected, since according to existing ideas, the radio emission associated with solar flares is caused directly by the movement of the disturbance from the chromospheric levels where the optical flares originate, into the corona from where the radio emission originates at different levels. The occurrence of homologous flares indicate, therefore, that the principal features of the magnetic configurations persist over extended periods of time in the active region. Flares that occur in the same region under identical or similar conditions, give rise to identical optical and radio manifestations. It is generally agreed that the energy released during a flare is due to a sudden conversion of magnetic energy. However, there is evidence (Hansen and Gordon, 1960; Howard and Babcock, 1960; Bappu and Punetha, 1962; Bumba and Howard, 1965) to show that there is no substantial change in the magnetic configurations during the flares as indicated by direct measurement of the magnetic field as well as the facular field orientation and structure on K-spectroheliograms. Even if there is some destruction and change in the magnetic field as envisaged by Severny and some others the conditions should be favourable for an exceedingly rapid recovery and rebuilding of the magnetic configurations along the same lines that prevailed prior to the flare occurrence.

Acknowledgements

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