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Metre Wavelength Solar Radio Bursts with Periodic Modulation

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Abstract

Observations of solar radio bursts in the frequency range 125–150 MHz are described. It is found that their properties are consistent with those observed for similar bursts in the 30–55 MHz range, except that all, rather than just a small proportion, showed periodic intensity maxima or fringes in the frequency–time plane. Fringe separation Δf was found to change with frequency between 30 and 150 MHz according to $\Delta f \propto f^{1\cdot 48}$, a result inconsistent with Faraday rotation as the cause of the fringes.

Introduction

Observations of fine structure solar radio bursts in the 30–55 MHz frequency range have been reported (McConnell 1980, 1981; McConnell and Ellis 1981) which showed periodic intensity modulation in the frequency–time plane. The bursts are characterized by narrow bandwidth ($\sim$100 kHz), a time duration at a single frequency of $\sim$50 ms, and a frequency–time slope of $\sim$2 MHz s^{-1}. For a small proportion of the bursts (a few per cent) the intensity is observed to vary quasi-sinusoidally with the frequency interval between successive maxima of $\sim$100 kHz. One of the suggested explanations of the modulation has been Faraday rotation of an initially linearly polarized signal in the solar corona (McConnell and Ellis 1981). In this case, it may be shown simply that for the frequency interval between the maxima we have $\Delta f \propto f^3$. The observations reported previously were made over a frequency range too small (30–55 MHz) to establish the actual variation of Δf with frequency with sufficient accuracy. In this paper new observations in the frequency range 125–150 MHz of the bursts of this type are reported and, taken together with the 30–55 MHz observations, show that Faraday rotation is unlikely to be the cause of the fringes.

Observations

The antenna used in the observations was the 170 m $\times$ 85 m Llanherne array which is capable of true broadband operation over the frequency range 30–150 MHz (Ferris *et al.* 1981). That is, the signals over the whole frequency range are simultaneously available at the antenna terminals. It was used as a transit instrument and hence was available for solar observations only for about 20 min each day.

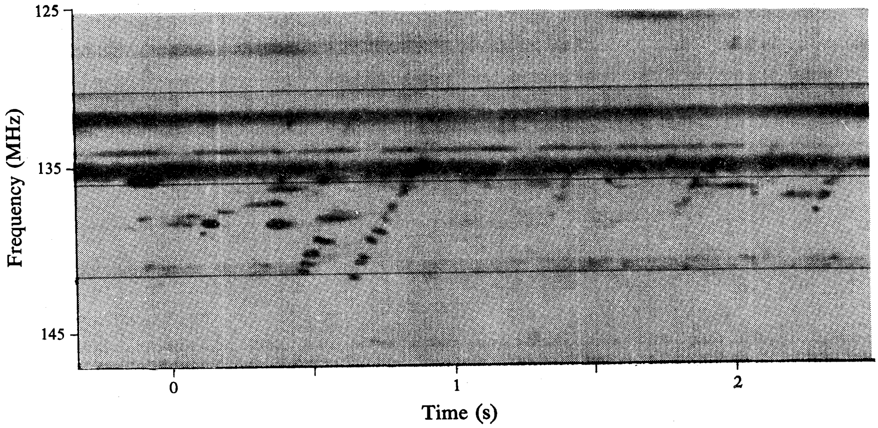

Fig. 1. Example of dynamic spectra of solar bursts showing periodic modulation.

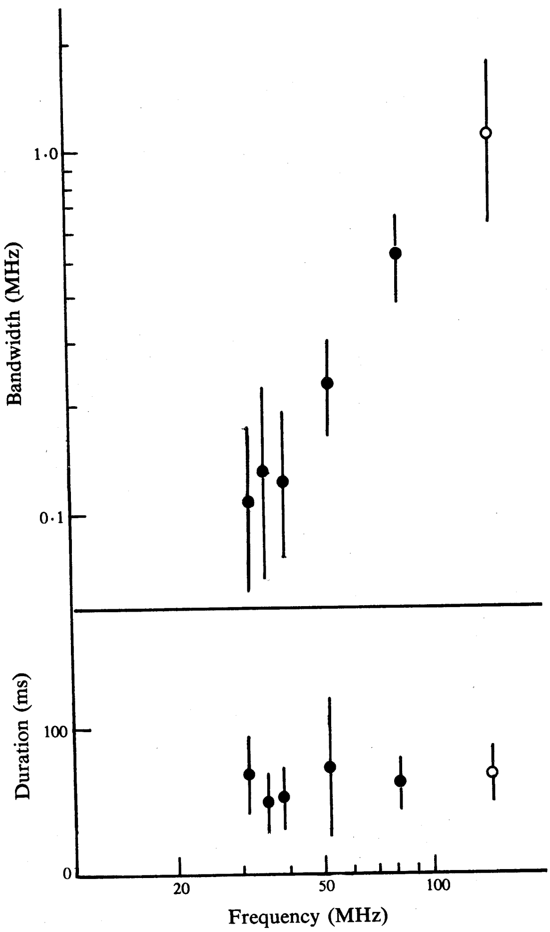

Fig. 2. Distribution of bandwidth and duration of the bursts with frequency: solid circles, McConnell (1981); open circles, present work.

The signals in the 125–150·6 MHz range were analysed on-line with a 256-channel spectrum analyser, with channels of bandwidth of 100 kHz. This instrument samples the whole spectrum every 600 μs. In addition, the output signals are passed through a dynamic gain controller which, from instructions contained in a microprocessor, adjusts the gain in successive channels every 2·5 μs. The gain of the whole system is hence adjusted continually over the whole spectrum to eliminate gain-frequency variations, produced by the antenna system, the transmission lines and the receiver, without degrading the time resolution of 600 μs. The output of the spectrum analyser is recorded on video tape and the spectrum subsequently reconstituted in the playback system and recorded on 35 mm film.

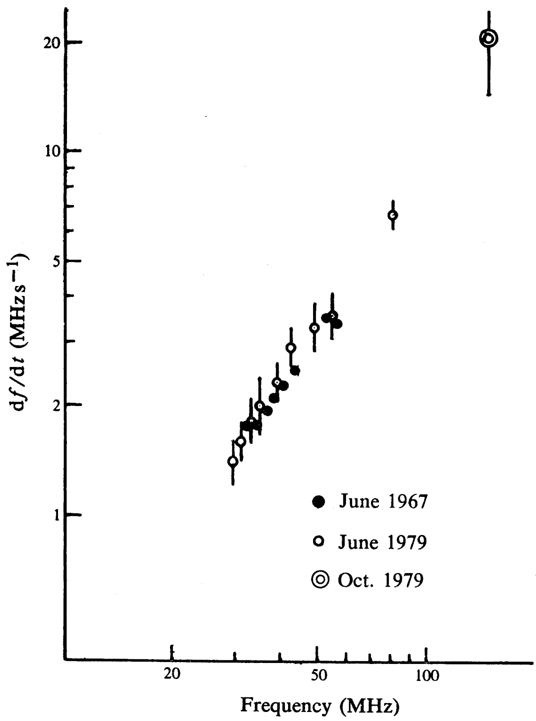

Fig. 3. Variation of drift rate with frequency for the bursts observed near 140 MHz and at lower frequencies in June 1967 (Ellis 1969) and June 1979 (McConnell 1981).

Observations were made in October and November 1979, and transient solar bursts of the S type were recorded on 12 and 13 October. Examples of their spectra are shown in Fig. 1. Approximately 100 such bursts were recorded in a total time of 10 min. Unlike the similar bursts recorded near 40 MHz by McConnell and Ellis (1981), where only a few per cent showed periodic structure, all the bursts in the 125–150 MHz range had periodic intensity variations. Fig. 2 shows the bandwidth and the duration at a single frequency of the bursts and, for comparison, the values observed by McConnell (1981) for frequencies less than 80 MHz. The frequency drift rate was $20 \cdot 4 \pm 6 \cdot 2$ MHz s^{-1}. Fig. 3 shows the drift rate df/dt for the bursts observed near 140 MHz, and those seen at lower frequencies in 1967 (Ellis 1969) and in 1979 (McConnell 1981). It can be seen that there was remarkably little change in the drift rates between the two sets of observations in the 30–40 MHz band. The properties of the bursts near 140 MHz are consistent with those which might be expected from extrapolation from the lower frequencies.

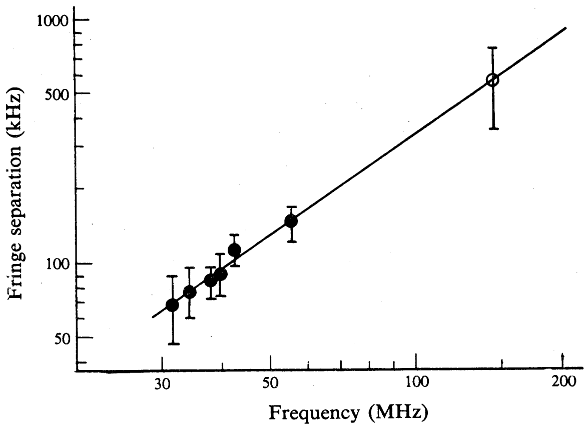

Fig. 4. Variation of fringe separation with frequency: solid circles, McConnell (1981); open circle, present work.

The change in the fringe separation, that is, the frequency interval between successive maxima, is shown for the different observations in Fig. 4. The fringe separation Δf is found to increase with frequency at the rate $\Delta f \propto f^{1\cdot 48}$. An explanation of the fringes based on Faraday rotation hence appears unlikely.

Acknowledgment

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