A DAMPED TRAIN OF REGULAR METRE-WAVE PULSES FROM THE SUN*

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Abstract. The metre-wave observations presented here of a damped train of regular pulses from the Sun appear much simpler than other similar events previously described. The interpretations so far proposed for such phenomena do not adequately explain the asymmetry observed in this case.

1. Introduction

A number of publications (Abrami, 1970, 1972; Rosenberg, 1970, 1972; McLean *et al.*, 1971) have already described the remarkably regular trains of pulses sometimes received from the Sun at metre wavelengths during solar radio outbursts. We wish to present here a particularly striking, recent example of this phenomenon, and to draw attention to the difficulties encountered in the application of existing theories to this event.

2. Observations

On 1972 May 16 the Culgoora radio spectrograph recorded the complex spectrum shown in Figure 1, following a sub-flare (reported start 03^h07^m UT, importance $-$B, coordinates W15°, S16°). This event shows most of the features of a major outburst – a group of type III bursts followed by type V-like continuum, decimetric fast-drift bursts, a microwave burst and a type II burst.

The feature of particular interest here is the series of pulses in the frequency range 200 to 300 MHz, starting at $03^h14^m40^s$ and continuing to about 03^h17^m. In the inset in Figure 1 the part of the spectrum showing the pulses has been reproduced to show more of the weak pulses at the end of the series. Figure 2 is a microphotometer tracing from the original film obtained by scanning parallel to the time axis at a constant frequency of 230 MHz.

From these two figures it can be seen that the envelope of the pulse train starts abruptly and decays gradually. The pulses are essentially simultaneous over a broad range of frequencies. In Figure 3 the times of the maxima and minima are plotted against pulse number to show the extraordinary regularity of the pulse period, 4.28 ± 0.01 s.

Figure 4 shows the profiles of a few individual pulses on an expanded scale to illustrate their asymmetric shape with a slow rise and sudden decay. This asymmetry

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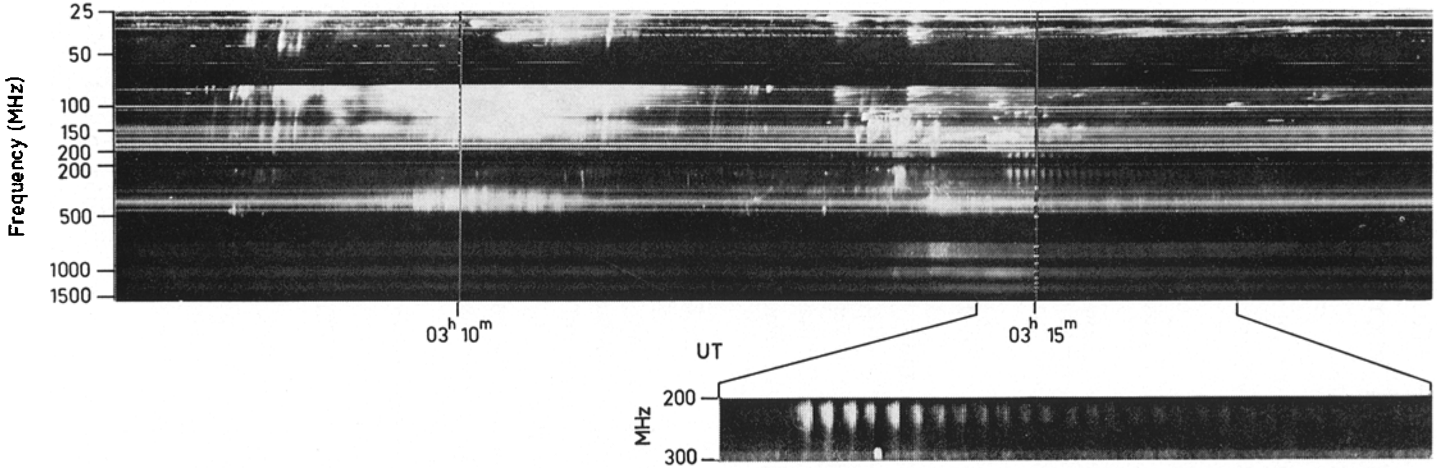

Fig. 1. The dynamic radio spectrum of the event described here. There is a gap in the data between 50 and 75 MHz because the aerial used for that band could not be pointed at the Sun at the time. Because of a slight overlap of the bands swept by separate receivers 200 MHz appears twice on the frequency scale, with more gain in the lower frequency band. The inset at the bottom shows the pulses more clearly.

is also evident in Figure 1. From Figure 4 the rise time is found to be 1.8 times the decay time.

The Culgoora radioheliograph was operating at 160 MHz during this event, which proved to be too low a frequency to record any evidence of pulses.

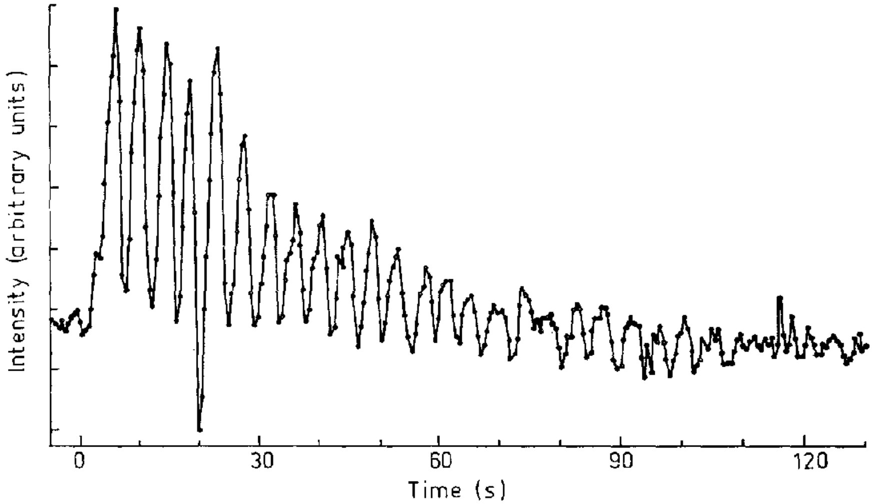

Fig. 2. A microphotometer tracing from the original of the spectrum shown in Figure 1. The scan was made parallel to the time axis at a constant frequency of 230 MHz. The dots indicate the times of the individual scans of the spectrograph. The deep minimum at 20 s is produced by the frequency calibration and time marker visible on the spectrum at 03^h15^m UT.

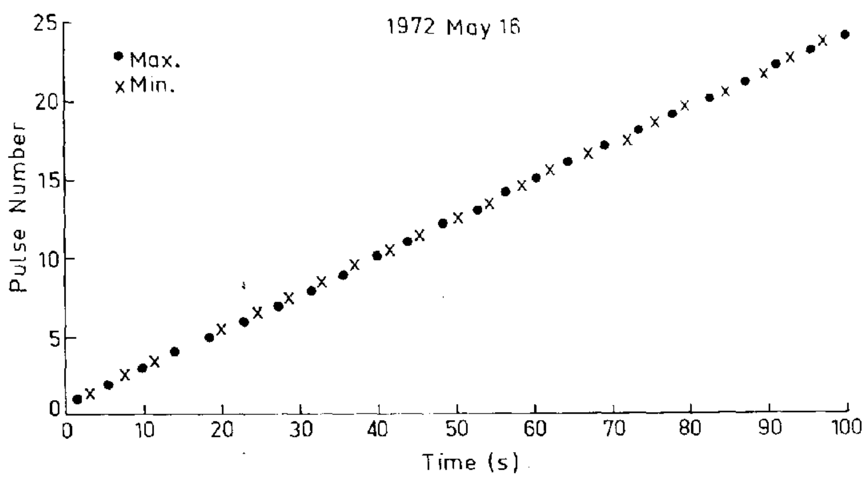

Fig. 3. Plot of the times of individual maxima and minima against pulse number. From the slope of this straight line the pulse period is 4.28 ± 0.01 s.

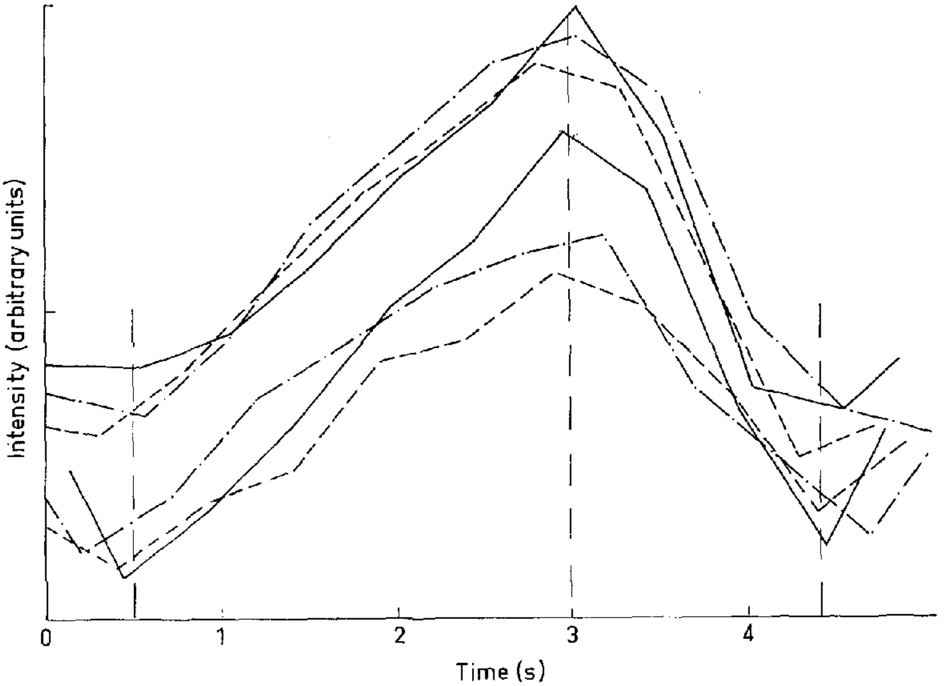

Fig. 4. Individual pulse profiles. Three pulses near the start of the event (top three curves) and three from about half-way through (bottom three curves) are shown. The intensity scale for the latter has been expanded to make them more comparable with the other three.

3. Discussion

The pulsations described above have some characteristics like those of other events described previously (Abrami, 1970, 1972; Rosenberg, 1970, 1972; McLean *et al.*, 1971). However, they differ from other events in two respects: they are much more intense than the associated continuum emission, (if indeed any occurred) and the envelope of the pulses is much simpler, with a sudden start and gradual decay. We suggest this simpler and more regular behaviour may represent a basic pulsating phenomenon which is often complicated by the presence of continuum or other emission.

The most obvious requisite of a theory is an explanation of the sharply defined pulse period. Rosenberg (1970) proposed resonance of transverse magnetohydrodynamic waves in a sharply defined flux tube in the solar corona. Oscillations of the magnetic field modulate the synchrotron emission from subrelativistic electrons, as discussed in more detail by McLean *et al.* (1971).

If the modulation of the magnetic field is due to a standing wave, then the asymmetry of the wave form is hard to understand. Since the emissivity is everywhere a monotonic function of the magnetic field in this theory, the observations must reflect a basic asymmetry in the mode of oscillation. Rosenberg's modes in a cylindrical tube are symmetrical. Moreover, because the periods of these modes are not harmonically related, it is not possible to combine them to form an asymmetric but periodic waveform as observed. We note that asymmetric standing waves could occur if the oscillating region were bounded by plane surfaces. While we feel at present that such a structure is unlikely in the corona it might be worth further investigation. We do not believe that the relatively slow damping observed can seriously modify these arguments.

It is conceivable that the non-linear terms, neglected in Rosenberg's treatment, might lead to the observed asymmetry. We have not been able to explore this possibility.

Abrami (1972) reports both sinusoidal and saw-tooth waveforms. For the saw-tooth waveforms the slow rise and sudden decay reported here are typical.

Abrami (1972) suggested that the saw-tooth waveform might be due to travelling rather than standing waves interacting with some structure in the corona, such as a tube of force. While this is a possible approach to the problem it is incomplete as it stands since it offers no explanation of the periodicity of the pulses. In a possible variant of Abrami's model the travelling waves excite resonant oscillations in the flux tube which defines the frequency, but then the variations would again be symmetric.

We are left with the conclusion that, despite its distinctive characteristics, which invite a simple theory, this event is as yet unexplained.

References

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