SOURCE STRUCTURE IN METRE-WAVE TYPE V SOLAR BURSTS

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Abstract (*Astrophys. Letters*). The type V burst has been defined as a wideband continuum which sometimes appears for a minute or so following a type III burst (Wild *et al.*, 1959b). It is now generally accepted that type III bursts arise from plasma waves set up by electrons escaping with velocity $\sim c/3$ along open magnetic field lines (Wild *et al.*, 1959a; Stewart, 1965); the most widely accepted explanation of type V continua is that they arise from plasma waves set up by electrons of similar velocity which have become trapped in a coronal magnetic loop (Weiss and Stewart, 1975). On this hypothesis the plasma waves are set up by two opposing electron streams in the trapping region, and from this consideration Zheleznyakov and Zaitsev (1968) have concluded that type V emission should be predominantly at the second harmonic of the local plasma frequency. In this paper we describe and discuss some two-dimensional observations of source positions of type III–V events which were obtained at 80 MHz on the Culgoora radioheliograph.

The 14 type III–V events summarized in Table I, associated with 14 different solar active regions, were observed at 80 MHz with the radioheliograph during the period 1968 May to 1969 December. All 14 events were listed as type III–V in the Radiophysics spectrum catalogue, but only 3 had classic III–V spectra resembling that in Figure 1(a). The remainder graded down to bursts only a little more diffuse than a normal type III or *U* burst. However, the sensitivity of the heliograph is greater than that of the spectrograph, and in some of these less definite events a second heliograph source, which we believe to be type V, was recorded. The less definite events are listed separately in the second line of Table I.

TABLE I

Displacement of type V from type III source position – based on 14 events observed during the period 1968 May to 1969 December

Spectrograph appearance	Number of events			
	Outward	Tangential	None	Inward
Classic III, V	3	0	0	0
Diffuse III or *U*	4	2	5	0

Gordon Newkirk, Jr. (ed.), Coronal Disturbances, 235–238.

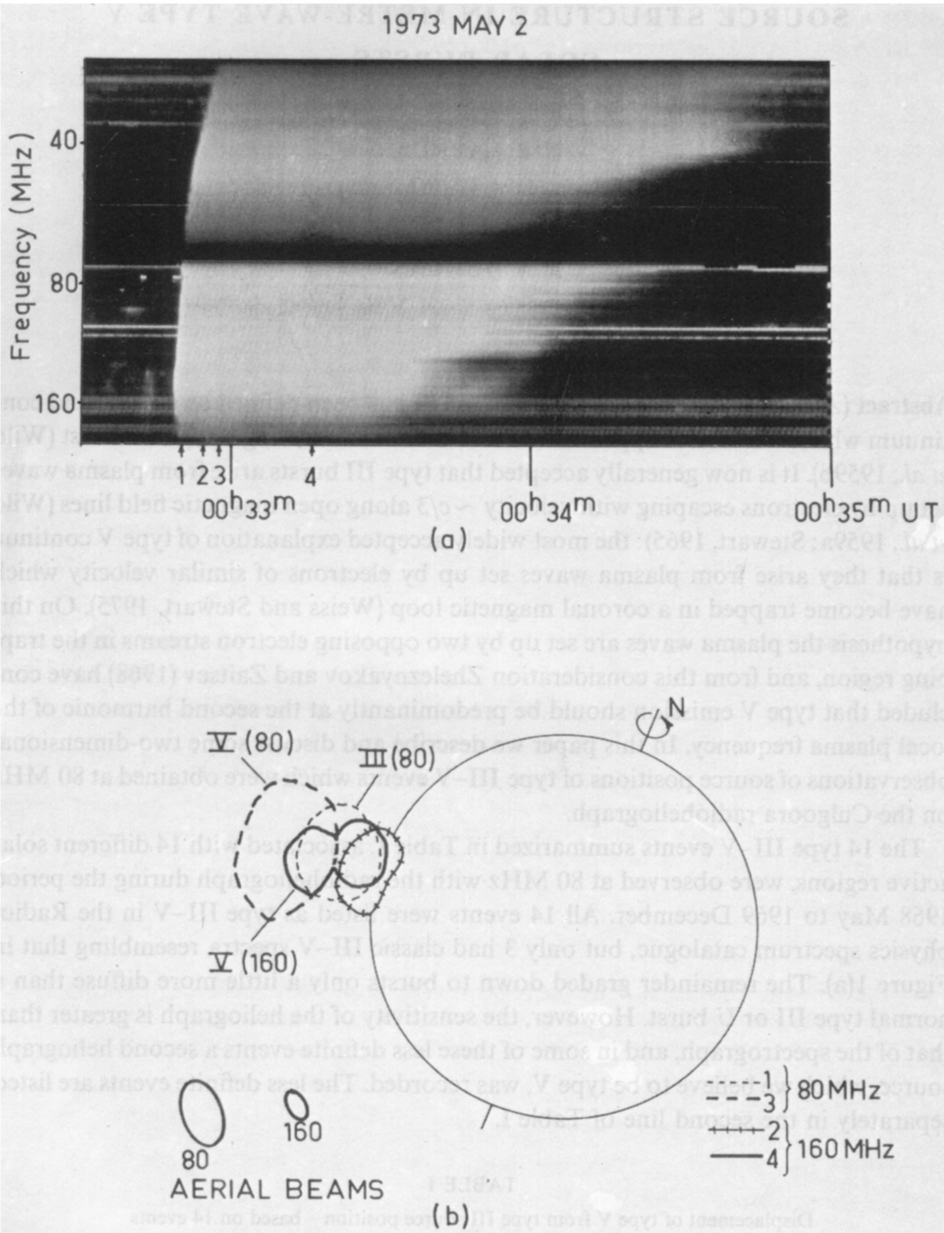

Fig. 1. Type III–V burst, 1973 May 2.
(a) Spectrum. (b) Source positions at 80 and 160 MHz at times indicated.

The angular size of the type V source was usually similar to that of the type III – about 6′ to half maximum intensity at 80 MHz. With the exception of a single event, the degree of circular polarization of both sources was low – less than 10%.

The most interesting characteristic of the radioheliograms is the frequent displacement of the type V from the type III source position. This displacement was always either tangential or radially outward; in no case was the type V source closer to the disk centre than the type III source (Table I). Figure 1 is a more recent example of a type III–V event, with radioheliograms at both 80 and 160 MHz. At 80 MHz both the type III and the type V source components were recorded, and the outward displacement of the type V from the type III source position is clearly seen. The dispersion of type V height with frequency is also evident (Figure 1b).

The complete absence of inward displacements seems to rule out the possibility of explaining the observed outward displacements (Table I) in terms of tangential displacements and accidents of perspective. It therefore seems necessary to explain them in terms of emission and propagation.

At first sight the outward displacements might seem explicable in terms of type III emission at the fundamental plasma frequency, and Zheleznyakov and Zaitsev's (1968) suggestion of type V emission at the second harmonic of the plasma frequency. This simple explanation, however, conflicts with other evidence. Stewart (1972) has observed the fundamental and second harmonic of individual type III bursts almost to coincide in position, and Steinberg *et al.* (1971) and Riddle (1972) have explained this effect in terms of coronal refraction and scattering. These results make the question of emission at the fundamental or second harmonic irrelevant to a discussion of apparent source heights. Thus, if we retain the belief that type V emission arises through a plasma wave mechanism, if we accept Stewart's (1972) observations and their explanation, and if we suppose that the propagation characteristics of type V emission resemble those of type III emission, it becomes necessary to postulate that in the type V source region the coronal plasma density is enhanced.

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COMMENTS

Smith: In the case assumed by Zheleznyakov and Zaitsev of two counter streaming electron streams, plasma waves will be generated very effectively. In this case, the fundamental will be produced more effectively than the harmonic because it is produced by induced scattering which is effectively a much more non-linear process than for the second harmonic. This would explain the outward displacement of the type V burst when combined with results of scattering calculations.

Sturrock: If only 10 out of 14 cases show that type V is a greater height than the type III source, this seems hardly significant statistically.

Duncan: We have now twice as many cases.

Sturrock: It seems that the relative heights, if real, could be understood if the coronal density is higher in the closed field regions than in the open field regions.

Uchida: It seems that the trailing edge of your type V is quite irregular. Is it real?

Labrum: Yes.

Melrose: In connection with the suggestion that the type V sources might appear higher than second harmonic type III's because of preferential backward emission of the latter, I would like to point out that the theories predicting backward emission are outdated. Smerd, Wild, and Sheridan (1962, *Australian J. Phys.* **12**, 369) assumed coalescence of plasma waves generated by the stream with thermal plasma waves, but this leads only to thermal emission. Zheleznyakov and Zaitsev (1970, *Soviet Astron. AJ* **16**, 67) assumed that scattered plasma waves coalesce with the initial plasma waves, but they ignored the decrease in wave number which accompanies the scattering of plasma waves. Coalescence of plasma waves with larger and smaller wave numbers leads to preferential emission in the direction of the larger wave number. Which is the forward direction?

Rosenberg: How can you reconcile both type *U* and type V bursts as being due to particles trapped in a closed magnetic field bottle? I would then expect a *U* followed by a V or something like that.

Newkirk: The rarity of type *U* bursts and the fact that type III and V's are often associated may be due to the configuration of the ambient magnetic field. We have calculated the fates of the energetic particles emitted above some 46 major flares. About 30% escape the Sun directly, 70% go into mirroring orbits (type V?), and only 0.2% impact the chromosphere at the conjugate point. These latter particles might be identified with *U* bursts.