OBSERVATIONS OF SPLIT-BAND HARMONIC TYPE II BURSTS WITH THE CULGOORA RADIOHELIOGRAPH AT 80 AND 160 MHz

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Abstract (*Solar Phys.*) When the Culgoora radioheliograph started operating at both 80 MHz (the initial frequency) and 160 MHz (from May 1972) it became possible for the first time to make simultaneous observations of the fundamental and second harmonic sources in type II bursts. Three such bursts, each having harmonically related split-bands, have been observed so far. The new 80 and 160 MHz heliograph observations are illustrated in Figure 1. Since all three events had split-band structure the results are presented separately for the lower- (l) and upper- (u) frequency components and differences between the source positions in the two components will be highlighted. For the burst of 1973 May 19, which was observed at large zenith angles, calculated corrections for ionospheric refraction – approximately 1′ to 2′ for the 80 MHz sources – have been applied; the remaining two events are presented as observed since the refraction effects are thought to be small.

In the event of July 4 the fundamental bands of both the upper and lower components crossed 80 MHz, and for both components the centroid of the harmonic (at 160 MHz) was closer ($\sim 3'$) to the flare position than was the centroid of the fundamental. In the other two cases the fundamental of only the upper component crossed 80 MHz. In one case (May 19) the harmonic at 160 MHz is again (though only slightly) closer to the flare than 80F; in the other case (July 7) the two positions almost coincide and are close to the flare. Thus, while the results for the event of July 4 are in at least qualitative agreement with ray-tracing computations in refracting and scattering coronal models (Riddle, 1972a, b and private communication) the results for the other events (particularly July 7) appear to be difficult to reconcile with the computations, which show that a fundamental source is always displaced outwards, and a harmonic source inwards, from its true, projected position.

The present observations also add to the previous sample of positions of the fundamental source at 80 MHz and, at a later time, of the second harmonic of the source at 40 MHz. (No fundamentals were recorded at 160 MHz, as all fundamental bands started below 160 MHz.) Again only in the event of July 4 were both l- and u-components observed; in the l-component the second harmonic of 40 MHz is closer to the flare than the fundamental at 80 MHz, but in the u-component the relative positions are reversed. This same reverse sequence, with fundamental closer to the flare than the second harmonic, is very pronounced in the July 7 event, while the two sources nearly coincide on May 19 (in both these last cases only the u-component sources were observed).

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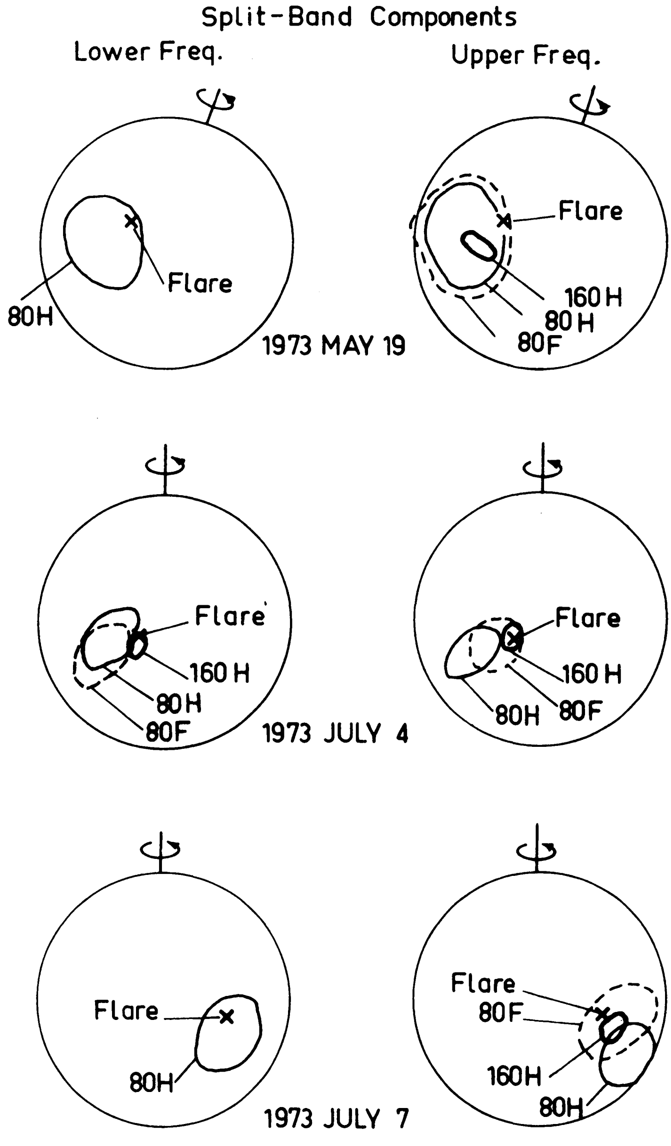

Fig. 1. Half-power contours of the sources of three splitband harmonic type II bursts observed with the Culgoora radioheliograph at 80 and 160 MHz. Full contours apply to harmonic sources and dashed ones to fundamental sources: those labelled 80F and 160H refer to simultaneous observations of the fundamental (at 80 MHz) and the second harmonic (at 160 MHz); the contours labelled 80H refer to 80 MHz observations of the same spectral feature at a later time when the fundamental emission was at 40 MHz.

The results for the *l*-component of July 4 and the *u*-component for May 19 agree with those from previous observations made without identifying split-band components (most were not split-band bursts) and are in qualitative agreement with the computations. The remaining results for the *u*-components of July 4 and 7, both

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showing the 80 MHz fundamental much closer (~3′ to 4′) to the flare than the second harmonic of 40 MHz, do not agree with our previous observations nor with the computed results for sources in a spherical corona or on the axis of a radial streamer. (Warwick (1965) reported one example where the fundamental was closer to the flare than the second harmonic for a non split-band type II burst.)

We note that all cases which appear to be incompatible with ray-tracing computations occur for sources in the *u*-component; a full explanation of these observations would probably require a better understanding of split-banding in type II bursts.

The relative positions of the sources of the two components of a split band – at the same frequency but at slightly different times – can also be deduced from the present observations, and the examples given here increase the number of such observations available by a large factor. As there were no fundamental sources observed at 160 MHz, the only new data on fundamental sources comes from the July 4 event where $(80F)_u$ is closer to the flare than $(80F)_l$, and this is opposite to the result of Dulk (1970). For the harmonic sources we find in all three cases that $(80H)_l$ is closer to the flare than $(80H)_u$; this agrees with Dulk's result but is opposite to one case reported by Labrum (1969). On the other hand, $(160H)_u$ is closer to the flare of July 4 than is $(160H)_l$, which is opposite to the only other comparable result (Dulk (1970) reported one case at 158 MHz). Thus, the small sample available so far suggests that neither the fundamental nor the harmonic bands show systematic relative positions of the lower- and upper-frequency components.

Table I summarizes the positions of the components relative to the flare position.

These, seemingly erratic, observed separations between the *l*- and *u*-components of fundamental and harmonic bands may have an explanation in existing split-band theories (McLean, 1967; Smerd *et al.*, 1974) but meaningful comparisons between theory and observation will require a knowledge of actual coronal densities and disturbance paths for particular events.

Another new and more positive result from the present observations is that the 80 MHz sources are always much larger than the corresponding 160 MHz harmonic source. The difference is much greater than expected from existing scattering calcu-

TABLE I

Projected distance from flare in minutes of arc

Date 1973		Fundamental at 80 MHz	Second harmonic at 160 MHz	Second harmonic at 80 MHz
May 19	*u*	4.3	4	4.3
	l	–	–	3.7
July 4	*u*	2.5	0	5.6
	l	5.3	1.2	3.7
July 7	*u*	1.9	1.9	6.2
	l	–	–	2.5

lations. It is concluded therefore that the harmonic emission volume is much smaller than the simultaneous fundamental emission volume and that the size of the harmonic source increases rapidly with height in the corona.

References

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DISCUSSION

Sturrock: If a type II burst is caused by plasma excitation at a shock front, one would expect radiation at two frequencies originating in the shocked and unshocked gas. Can this be reconciled with the data?

Nelson: This question is the subject of Smerd's contribution later in the Symposium so I'd prefer not to comment at this time.

Smith: Isn't it possible that radiation at the second harmonic is emitted isotropically?

Nelson: For the first event I cannot tell, I have not considered the other two bursts yet from that point of view.

Smith: Are your observations consistent with radiation being produced ahead of and behind the shock to explain the split bands?

Nelson: Yes.