TYPE IIIb RADIO BURSTS: 80 MHz SOURCE POSITION AND THEORETICAL MODEL*

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Abstract. We present Culgoora spectrograph and radioheliograph observations as well as a model of type IIIb bursts; the latter are defined as chains of striae of slow or no frequency drift, the chain as a whole drifting like a normal type III burst.

The 80 MHz source positions are studied for a group of IIIb bursts, a IIIb precursor and harmonic pairs of 1:2 frequency ratio. It is found that the IIIb position may vary in a IIIb group. No significant difference was found between the source positions of a IIIb precursor and the following III burst. For one event we found that the fundamental IIIb burst showed a high degree of circular polarization (~46%), while its second harmonic, a normal type III burst, was unpolarized.

We suggest that the main cause for the striae in type IIIb bursts is the existence of filamentary, density irregularities along the path of the electron stream. The denser filaments initially reduce the value of the density gradient along the electrons' path and thereby enhance their emissions over a small range of plasma frequencies. If the radio emission from the filaments dominates the emission from the ambient rarified plasma, striae appear in the spectrum and a type IIIb burst results. This condition is more easily satisfied at the fundamental frequency and for electron streams of relatively high density.

1. Introduction

Type IIIb bursts may be defined as chains of striae of slow or no frequency drift, each chain as a whole drifting in the frequency-time plane like a normal type III burst. They occur in storms or, less frequently, in isolation and sometimes appear as precursors to type III bursts (de la Noë and Boischot, 1972). They are commonly observed below 60 MHz (Ellis and McCulloch, 1967).

In the present paper we report a number of cases where type IIIb bursts identified in Culgoora spectra were observed at 80 MHz with the Culgoora radioheliograph. Some samples are reproduced in Figures 1 to 5. We have found a number of cases of harmonic pairs with frequency ratio about 1:2 where the fundamental is of type IIIb and the second harmonic of normal type III – see, for example, Figure 3a. We have also found two cases where both the fundamental and the harmonic are of type IIIb, as shown in Figures 4a and 5a.

The purpose of the present paper is

(1) to determine the source position of type IIIb bursts relative to those of associated type III bursts;

(2) to present a theoretical model for the origin of type IIIb bursts.

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2. Observations

We present here position observations of three different types of IIIb bursts at 80 MHz; (a) IIIb group; (b) IIIb precursor; (c) IIIb fundamental-harmonic pair.

The number of IIIb bursts whose source positions were available at 80 MHz is too small to present any statistics on source positions.

2.1. Type IIIb group

Several IIIb bursts can be seen in Figure 1a. The bursts studied in this paper are those indicated by arrows in the figure; 1971 August $24^d01^h31^m12\overset{s}{.}5$, $26\overset{s}{.}5$ and $28\overset{s}{.}5$. They occurred late during a 1N flare in McMath region No. 11482 (Figure 1b, lower). The sources of these bursts at 80 MHz are shown in Figure 1b, upper. Computer contours at half the maximum beam brightness temperature for the right-handed circular polarization are plotted. The hatched patterns show the source of a bipolar type I storm at 80 MHz. A comparison between the source positions of the first two type IIIb's and another at $01^h31^m21\overset{s}{.}5$ (not shown in Figure 1b) indicates that there is some scatter in the position of these bursts. On the other hand, comparison between the two adjacent IIIb bursts at $01^h31^m26\overset{s}{.}5$ and $28\overset{s}{.}5$ (dashed and dotted curves in Figure 1b) shows a dramatic change in source position and size. The positions of type III bursts between $01^h32^m32\overset{s}{.}5$ and $35\overset{s}{.}5$ (dot-dash curve in Figure 1b) may give a clue to this problem. These type III bursts seem to be associated with another McMath region, No. 11480, which showed very slight Hα activity at the time. Bearing this in mind and also examin-

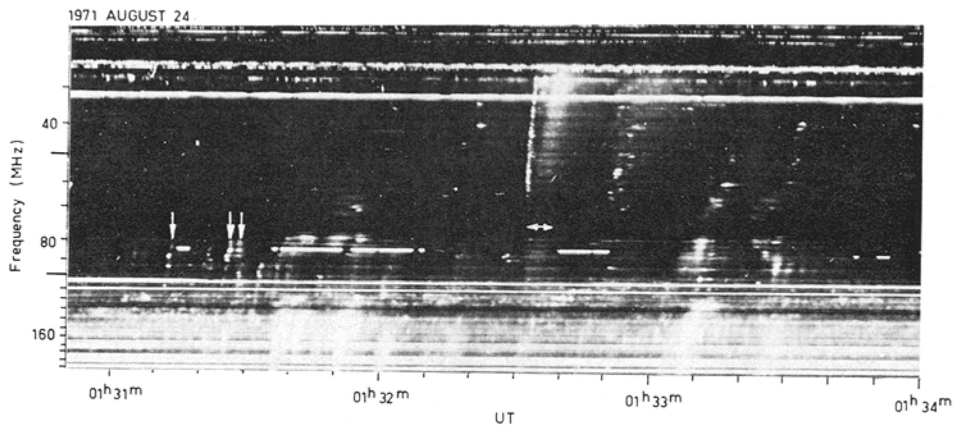

Fig. 1a.

Fig. 1. Group of type IIIb and type III bursts on 1971 August 24. (a) The dynamic spectrum. (b) *Top:* Contours of the radio sources at half the maximum beam brightness. Solid contour: Type IIIb at 80 MHz, $01^h31^m12\overset{s}{.}5$, unpolarized. Dashed contour: Type IIIb at 80 MHz, $01^h31^m26\overset{s}{.}5$, unpolarized. Dotted contour: Type IIIb at 80 MHz, $01^h31^m28\overset{s}{.}5$, unpolarized. Dot-dash contour: Type III at 80 MHz, $01^h32^m35\overset{s}{.}5$, polarization 14% RH. Circularly polarized noise storm sources at 80 MHz ($01^h31^m29\overset{s}{.}5$) are shown by hatched pattern. *Bottom:* Ca plage map at 12^h55^m UT observed at McMath-Hulbert Observatory (*Solar-Geophysical Data*).

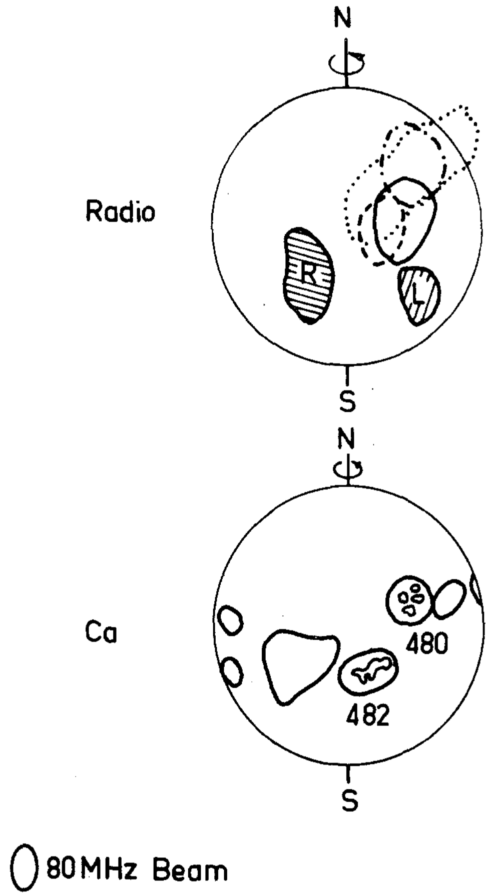

Fig. 1b.

ing the coronal magnetic field maps of the day, we can suppose that the two regions 11482 and 11480 are probably magnetically connected.

The IIIb bursts in the present group are almost unpolarized. The polarization of type III bursts between $32^{s}.5$ and $35^{s}.5$ showed varying degrees of up to 33% right-handed circular polarization.

2.2. Type IIIb precursor

Several type III–V bursts occurred on 1973 June 28 around $23^{h}27^{m}$ UT; only one of them was preceded by a precursor type IIIb, as shown in Figure 2a. In the period 1970 July 15 to August 16 de la Noë and Boischot (1972) found from statistical analysis of a sample of IIIb and III bursts in a frequency range of 20 to 80 MHz that 27% of normal type III bursts were preceded by IIIb precursors. Type IIIb precursors are usually richer in striae than isolated IIIb bursts. In some cases the group of striae is so dense as to become indistinguishable (de la Noë and Boischot, 1972). We find that the precursor may appear as a single burst (Figure 1a), or multiple bursts (Figure 2a), or may be complex, as seen in the event of 1973 July 4 (Figure 3b), where the striae from a number of IIIb's appear to join together. The duration of striae of IIIb precursors is shorter than that of isolated IIIb bursts and also shorter than the duration of the associated type III bursts. De la Noë and Boischot (1972) found the duration of striae of IIIb bursts apparently independent of frequency.

Whether type IIIb precursors are the fundamental components of harmonic type III (Stewart, 1974a) or not (de la Noë and Boischot, 1972) remains an open question. If however the following type III burst does not show on the spectrum in the same frequency range as the IIIb burst, and if also their frequency ratio is about 2 to 1 (Figure 3a), such a pair is designated as a harmonic pair in the present paper and will be treated separately in the next subsection.

The 80 MHz source position of the precursor IIIb and the following III are shown in Figure 2b. Comparison between the contours at $23^h27^m46^s$ (solid contour) and 48^s

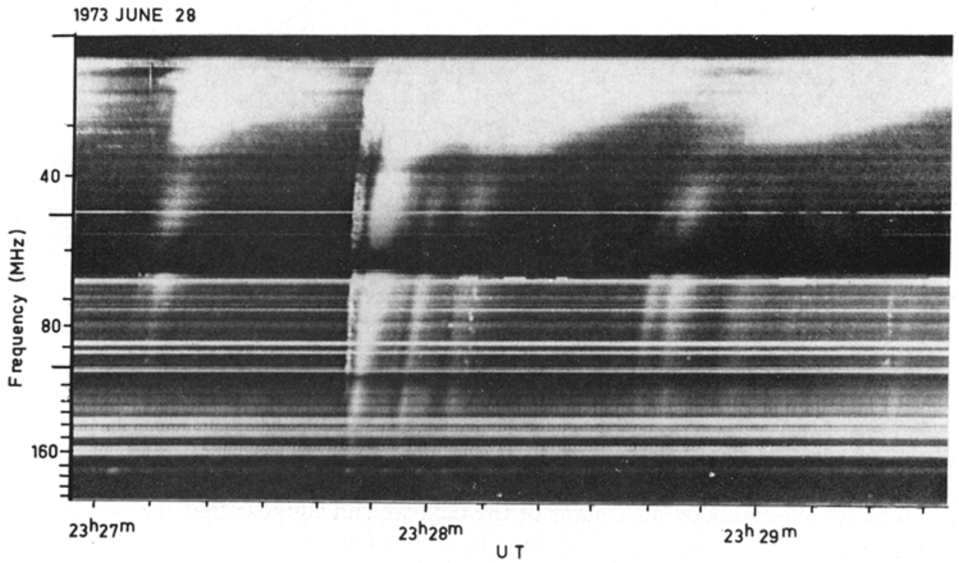

Fig. 2a.

Fig. 2. Type IIIb burst as a precursor of type III–V burst on 1973 June 28. (a) The dynamic spectrum. (b) *Top:* Contours of the radio sources in left-handed circular polarization at $2^{-1.5} \approx 0.35$ times the maximum beam brightness. Burst near $23^h27^m48^s$. Solid contour: Type IIIb precursor at 80 MHz, $23^h27^m46^s$, polarization 4% LH. Dot-dash contour: Transition between type IIIb and type III at 80 MHz, $23^h27^m47^s$, polarization 15% LH. Dotted contour: Type III burst at 80 MHz, $23^h27^m48^s$, polarization 5% RH. Hatched pattern: Type III burst at 160 MHz, $23^h27^m49^s$, polarization ~ 0%. *Bottom:* Ca plage map at 15^h00^m UT observed at McMath-Hulbert Observatory (*Solar-Geophysical Data*). (c) Contours of the radio sources of both the fundamental and the second harmonic in a IIIb–III harmonic pair at $2^{-1.5}$ times the maximum beam brightness. Burst near $23^h29^m25^s$. Solid and dot-dash contours: 80 MHz right-handed and left-handed circular polarization respectively of type IIIb fundamental at $23^h29^m24\overset{s}{.}0$, polarization 46% LH. Dotted contour: 160 MHz right-handed and left-handed circular polarization of type III second harmonic at $23^h29^m25\overset{s}{.}0$, polarization ~ 0%. Hatched and solid contours: 160 MHz right-handed and left-handed circular polarization respectively of a continuing type I storm.

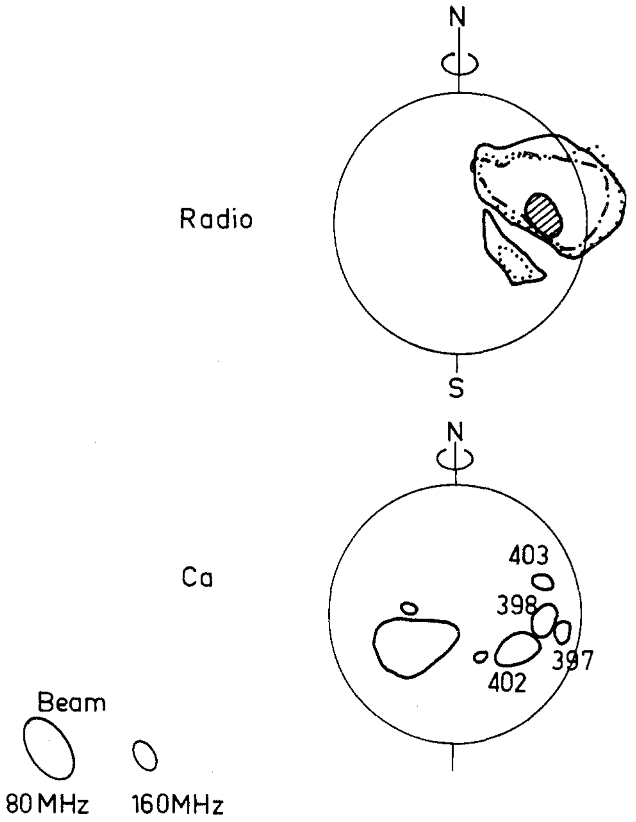
N
Radio
S
N
Ca
403
398
397
402
Beam
80 MHz
160 MHz

Fig. 2b.

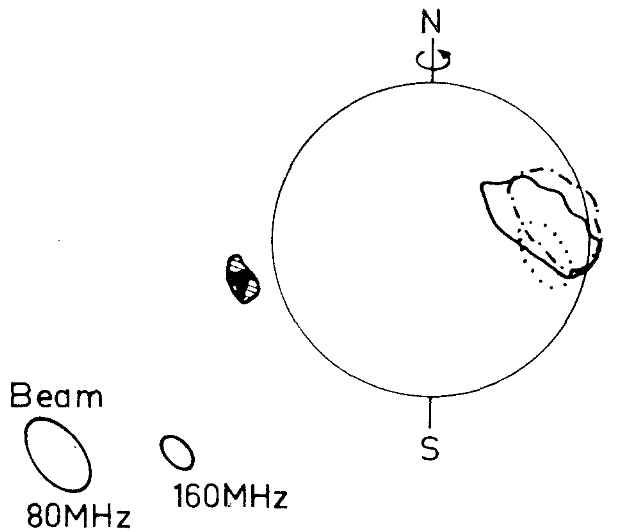
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Fig. 2c.

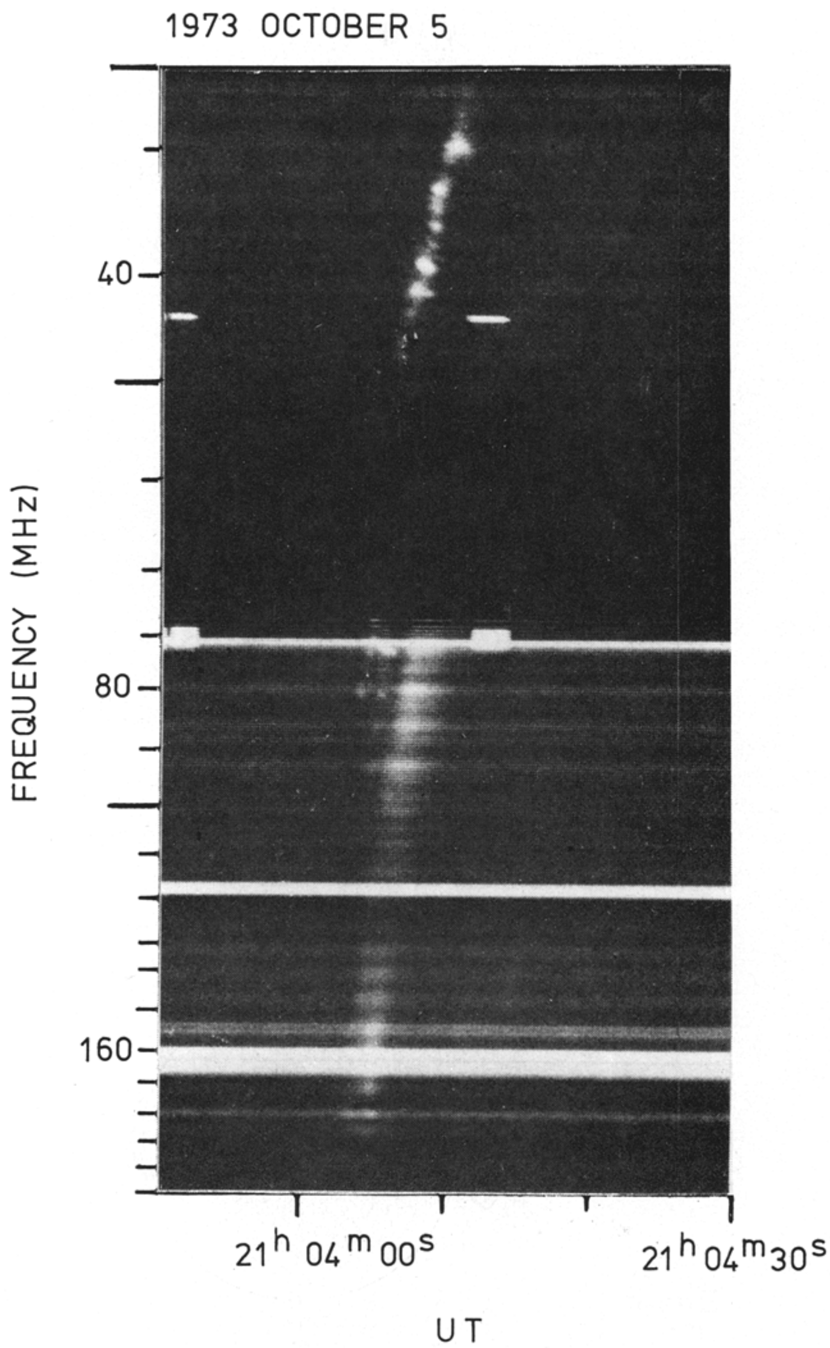

Fig. 3a.

Fig. 3. (a) A harmonic pair of type IIIb-III bursts on 1973 October 5. Only the fundamental emission shows clear striae. (The apparent striae in the second harmonic emission are mainly attributed to the instrumental gain variation with frequency.) (b) Type IIIb burst as a precursor or the fundamental of a type III burst on 1973 July 4.

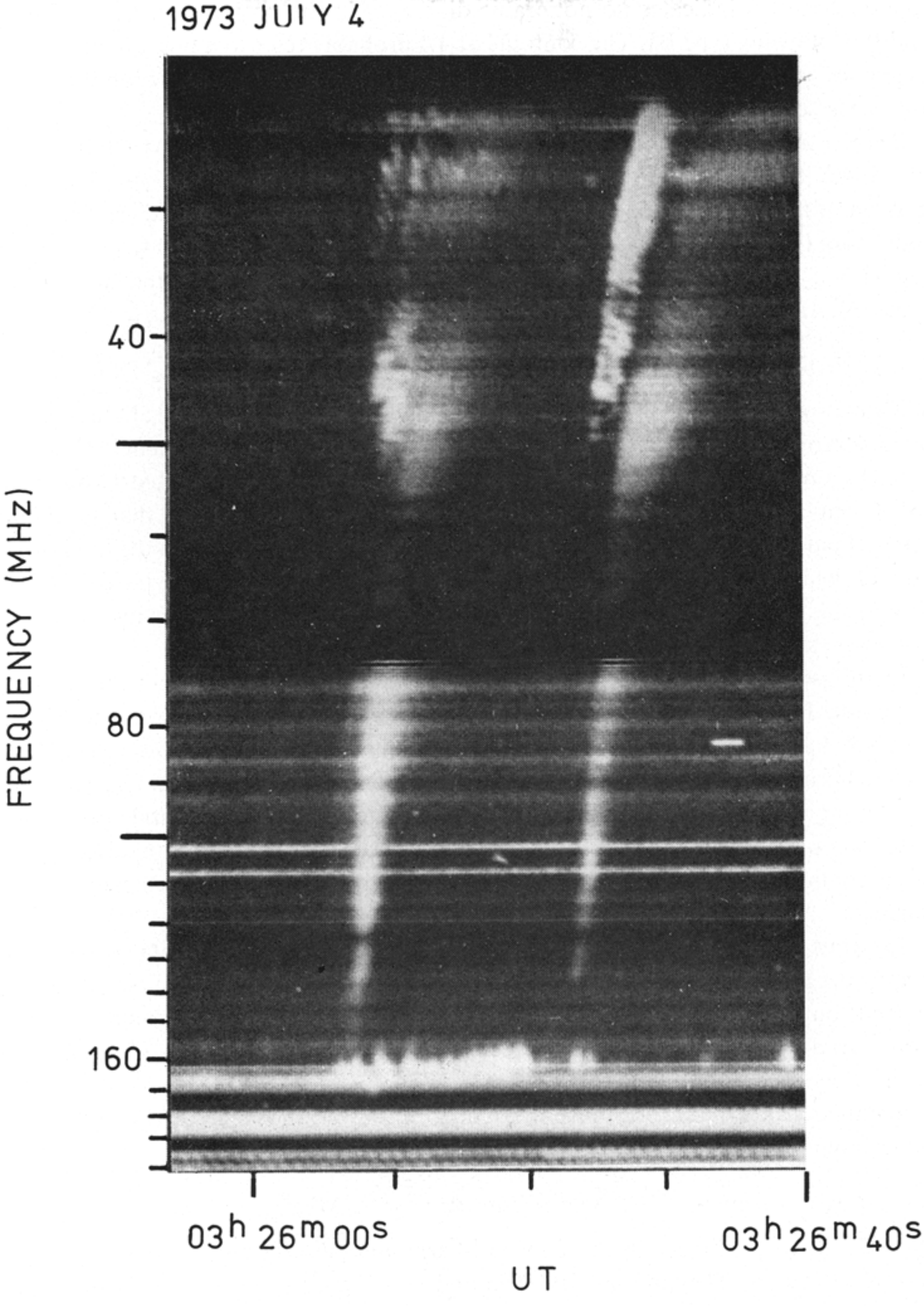

Fig. 3b.

(dotted contour) indicates no noticeable difference in the positions of the precursor and the following type III. The contours at 47^s probably refer to a mixture of the IIIb precursor and the leading part of a type III burst. The hatched contour represents the 160 MHz source position of the type III at 49^s.

There was a subflare with several eruptive centres in progress in McMath region No. 12402 during the time of this event (*Solar-Geophysical Data*, 1973a). The comparison of the McMath-Hulbert Ca plage map Figure 2b (bottom) and the Culgoora radio map (top) suggests that at least two electron streams were ejected from McMath region No. 12402 and in two different directions. This is supported by the fact that the precursor IIIb of this event is of multiple nature, as seen in Figure 2a.

2.3. Type IIIb harmonic pairs

We have found two classes of IIIb fundamental harmonic pairs with about 1:2 frequency ratio. The first class is a IIIb–III pair where only the fundamental is of IIIb type (Figure 3a). Stewart (1974b) has found a harmonic pair of inverted-U bursts of which only the fundamental has striae, showing most convincingly that harmonic IIIb–III pairs do indeed exist. In the second class, a IIIb–IIIb pair, both the fundamental and the harmonic are of type IIIb, as seen in Figures 4a and 5a. We have found no case of the third possibility, namely a III–IIIb pair, where only the second harmonic possesses striae.

In this section we shall first show evidence that the IIIb–IIIb pairs are actually harmonic. Figure 4b is a plot of frequency vs time of the harmonic pair labelled (b) in Figure 4. Each stria in the fundamental is represented by a triangle while striae in the second harmonic are represented by squares and plotted at half the original frequency. Furthermore, several prominent striae can be identified as fundamental and second harmonic pairs as indicated by white arrows in Figure 4a. Such a comparison gives some confidence in the identification of the IIIb–IIIb pair as harmonically related bursts.

The time interval between the second harmonic and the fundamental varies with frequency. Such a frequency-dependence would be expected for the group delay which depends on the coronal density structure. This frequency-dependence could also arise from variation of the relative amplitude of direct and reflected waves superimposed in the second harmonic.

A similar IIIb–IIIb pair is shown in Figure 5; however, the identification of the pair as harmonic is less evident than in the previous case.

2.3.1. *Source Position of IIIb Second Harmonic at* 80 MHz

On 1973 May 20 three IIIb fundamental-harmonic pairs occurred between several type III–V bursts. They are labelled a, b and c in Figure 4a. The type III bursts included in this discussion are indicated by arrows. The sources at 80 MHz are shown in Figure 4c. The contours at half the maximum brightness temperature of left-handed circular polarization are given. Two 160 MHz positions are shown hatched in Figure 4c; the upper position is that of a right-handed type I noise storm.

The observation of the 80 MHz source position of the second harmonic of the IIIb burst labelled (b) in Figure 4a at $05^h03^m15^s.5$ was available only at the early phase of the striae (cf. filled symbols in Figure 4b). It is clear from Figure 4c that – with the exception of the position of maximum brightness of a type III at $02^m51^s.5$ – there are two positions of maximum brightness: the northern position is that of the type IIIb bursts and the southern position (with the exception noted above) is that of the preceding and following type III bursts.* On examining the Culgoora Hα film at the time of this event we found a 1B flare that started in McMath region No. 12352 at 04^h49^m and

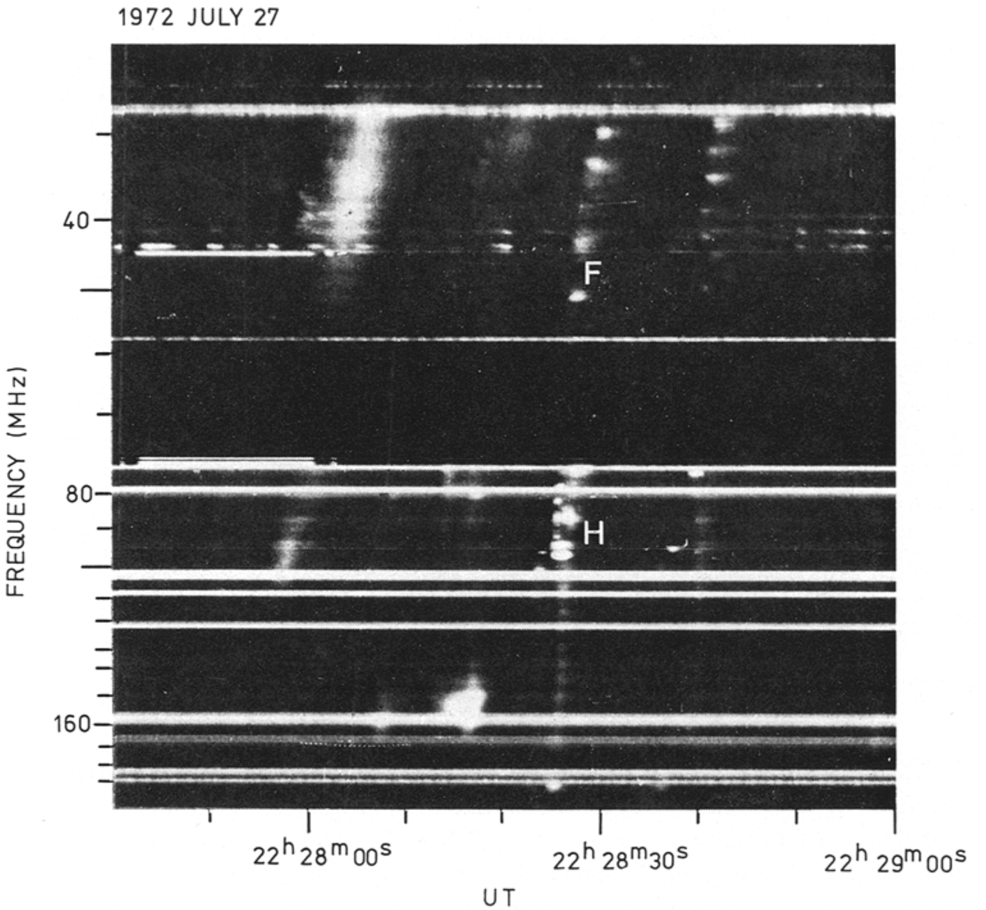

Fig. 5a.

Fig. 5. A harmonic pair of type IIIb bursts observed on 1972 July 27. (a) The dynamic spectrum. Both the fundamental and the second harmonic emissions show the striae. An 'invisible' portion between two striae, and labelled H in the second harmonic, is also 'invisible' in the fundamental, where it is labelled F. (b) Intensity maxima of striae in a harmonic pair of type IIIb bursts of Figure 5a. The symbols have the same meaning as those in Figure 4b.

* The source positions of two other type III bursts are not shown in this figure.

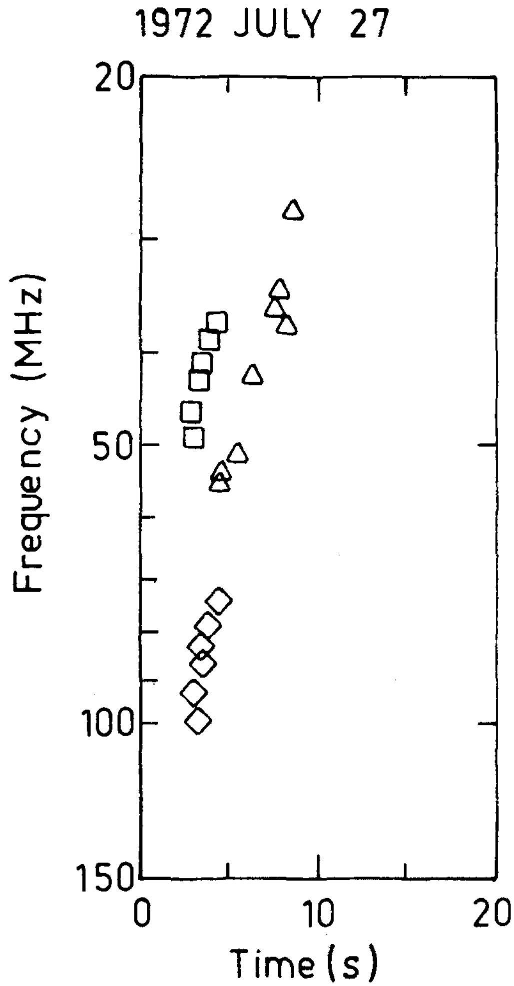

Fig. 5b.

lasted for about 30 min (*Solar-Geophysical Data*, 1973b). This flare possessed two centres. The first, which was near a complex sunspot of δ configuration, brightened first and seemed to be the source of type IIIb bursts. The other flare centre was far away from the sunspot and seemed to be emitting the normal type III bursts.

X-ray flares with multiple peaks in the bands 0.5 to 3 Å and 8 to 20 Å were also associated with this Hα flare (*Solar-Geophysical Data*, 1973b).

At 80 MHz the IIIb bursts labelled b and c in Figure 4a are polarized about 24% and 4%, respectively (in the right-handed sense).

2.3.2. *The Position of IIIb Fundamental at* 80 MHz

We draw attention to a faint fundamental-harmonic pair at $23^h29^m23^s$ in Figure 2a. The source positions of this pair are shown in Figure 2c. The fundamental seems to be bipolar – its net polarization is about 46% in the left-handed sense. On the other hand, the second harmonic is unpolarized at 160 MHz. This is the only event in which we found such a high degree of polarization for a IIIb burst. We shall discuss this point later in Section 3.

2.3.3. *Summary of Observations*

The observational characteristics of type IIIb bursts can be summarized as follows:

(1) Type IIIb bursts occur more frequently at low frequencies (below 60 MHz).

(2) Type IIIb bursts in a group may come from different source positions at 80 MHz.

(3) Type IIIb precursors are rich in striae of short durations; they can occur singly or in compact groups.

(4) In one case (1973 June 28) when the position of a type IIIb precursor was observed at 80 MHz, this source position did not differ noticeably from that of the following type III burst.

(5) In most cases the second harmonic of a type IIIb burst seems to be a normal type III burst.

(6) More rarely type IIIb bursts occur as a fundamental and second harmonic pair, both of type IIIb. In such cases there is evidence that the striae are repeated in the harmonic.

(7) In one case (1973 June 28) when the polarization of both the fundamental and the second harmonic was available, the fundamental IIIb was highly polarized while the second harmonic III was unpolarized.

3. Discussion

The characteristic of the second harmonic of type IIIb bursts as summarized in point (6) at the end of the previous section may rule out the interpretation that the chain of striae can be attributed to propagation effects of radio waves such as absorption or refraction, because the propagation conditions are quite different at the fundamental and the second harmonic frequencies.

Now suppose that there exist thin 'overdense' filaments along the path of a type III electron stream whose cross section is much larger than that of any one filament. These filaments would decrease and increase the gradient of electron density along the path of *some* electrons, as shown schematically in Figure 6a. On entering a filament the electrons pass through a region where the plasma density – and hence the plasma frequency – varies very slowly. This effectively lengthens the source of plasma radiation and the latter may be enhanced, as indicated schematically by the heavy lines in Figure 6b. The opposite is the case on leaving a filament, so that the dotted parts in Figure 6b may not show on the spectrum. We suggest this as the cause of striae in type IIIb bursts. The above description alone, however, is not capable of accounting for the characteristics of IIIb–III harmonic pairs, as noted in point (5) at the end of the previous section.

Melrose (1974) has given estimates of the brightness temperatures of the funda-

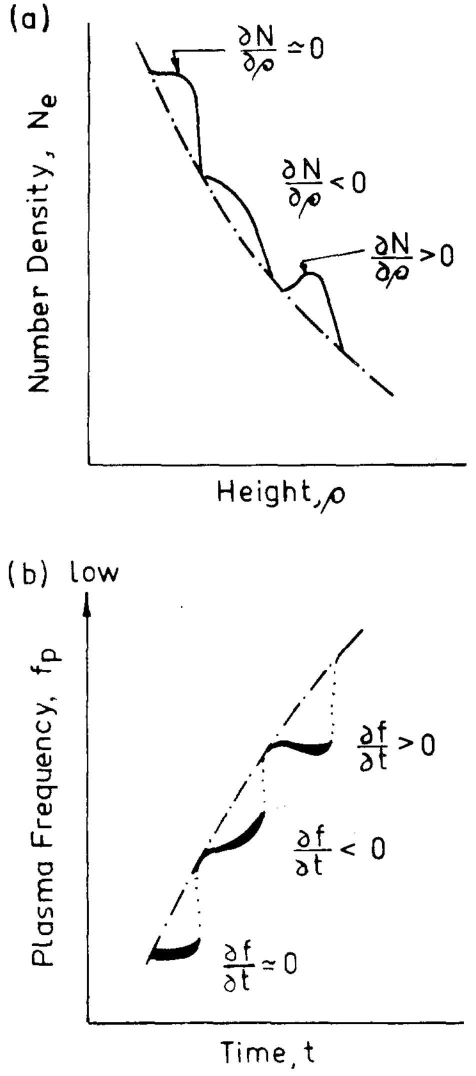

Fig. 6. Schematic pictures of the distribution of electron density and the corresponding frequency drift of radio emissions. In (a) the dot-dash curve indicates the normal distribution of electron density without filamentary structures and in (b) the corresponding frequency drift of normal type III bursts. The solid curve in (a) indicates the distribution of electron density along a path of those stream electrons which do encounter some of the filaments. The heavy curve in (b) indicates the corresponding frequency drift of striae in type IIIb, while the dotted parts would not be detectable by the spectrograph.

mental and second harmonic of type III's assuming a steady state is reached in the source. The fundamental frequency radio waves can be amplified by induced scattering (negative absorption) and the brightness temperature T_1 is then given by

$$T_1 \approx T_1(o)(e^{\tau} - 1), \tag{1}$$

$$T_1(o) \approx 10^9 \mathrm{K},$$

$$\tau = \alpha L,$$

and

$$\alpha \approx 10^{-19} f^2 \frac{\langle T_p \rangle \Delta\Omega}{T_i} \mathrm{cm}^{-1}, \tag{2}$$

where f is in megahertz, T_i is the ion temperature, T_p the effective temperature of plasma waves confined in a limited range of solid angle $\Delta\Omega$, and L the effective distance over which amplification is possible. The latter is inversely proportional to the density gradient. In the normal distribution of coronal electron density N_e (as shown schematically by the dot-dash curve in Figure 6a) Melrose (1974) has given L as of the order of 10^8 cm at the 100 MHz plasma level; he noted that for amplification to be important, i.e., for $\tau \gtrsim 1$, would then require $\langle T_p \rangle \Delta\Omega \gtrsim 10^{13}$ K at that level.

If we assume the normal plasma frequency to be given by Equation (6) below, we find $L_n \approx 4 \times 10^7$ cm at 100 MHz and $L_n \approx 3 \times 10^8$ cm at 10 MHz (here we use the subscripts n and f to refer to conditions outside and inside the filaments respectively). Clearly the corresponding amplification lengths, L_f, will be much larger in the smaller density gradient on the lower side of a filament, as indicated in Figure 6a. If $\tau_n \gtrsim 1$ outside the filament, it would be greater still inside the filament (provided the latter is longer than L_n); in both cases T_1 of the induced fundamental radiation would depend strongly on L, namely as $\exp(\alpha L)$. If, for example $\tau_n = 1$ outside, a threefold increase in amplification length would make the filament more than 10 times brighter than the ambient stream. However, if $\tau = \alpha L \ll 1$ outside and inside the filament (when $T_1 \ll 10^9$ K for the now spontaneously scattered fundamental radiation) T_1 is merely proportional to $L' = 2L$; $T_f/T_n = 10$ would then require $L'_f/L'_n = 10$. Even in this extreme case the required minimum lengths of filament, say 8×10^8 cm at 100 MHz and 6×10^9 cm at 10 MHz, seem plausible.

On the other hand, the brightness temperature for the second harmonic is given by (Melrose, 1974)

$$T_2 \approx 3 \times 10^{-22} f^2 L \frac{\langle T_p \rangle^2}{T_e} (\mathrm{K}), \tag{3}$$

where f is in megahertz. Therefore T_2 is always linearly proportional to L.

Although the brightness temperature within the filaments can be much higher than that outside the filaments (owing to the larger value of L) the total cross-section A_f of the filaments may be much smaller than that of the electron beam A_s. Accordingly, the radio flux from the filaments may or may not predominate over the radio flux of normal type III emission from the ambient plasma. The ratio χ of fluxes from the filament and from the ambient plasma is

$$\chi_1 = \frac{A_f (e^{\alpha L_f} - 1)}{A_s (e^{\alpha L_n} - 1)} \tag{4}$$

for the fundamental, and

$$\chi_2 = A_f L_f / A_s L_n \tag{5}$$

for the second harmonic. Here we have assumed that the temperatures inside and outside the filament are equal. If the temperature ratio were large, it would have to be taken into account in χ_1 and χ_2.

It is evident that

$$\chi_1 \gg \chi_2 \quad \text{when} \quad \tau_f \equiv \alpha L_f \gg 1$$

and

$$\chi_1 \approx \chi_2 \quad \text{when} \quad \tau_f \lesssim 1 .$$

Accordingly,

(1) when $\chi_1 \ll 1$, striae cannot be seen in either fundamental or second harmonic radiation even if the filamentary irregularities exist;

(2) when $\chi_1 \approx \chi_2 \gg 1$, striae appear in both fundamental and second harmonic band; $\tau_f \lesssim 1$ is required in this case to satisfy $\chi_1 \approx \chi_2$;

(3) when $\chi_1 \gg 1$ and $\chi_2 < 1$, striae can be seen in the fundamental band alone, while the second harmonic looks like a normal type III burst; $\tau_f \gg 1$ is required.

For a given filamentary structure, the smaller the ratio A_s/A_f and the higher the electron density of the beam (giving a high $\langle T_p \rangle$) the more favourable the conditions for the appearance of striae in the emitted burst.

Accordingly, even if successive beams of electrons travel along an identical path with filamentary irregularities, either a normal III or a IIIb can occur depending on the properties of the beam. This would explain the observed similar source positions of IIIb's and III's in a group. The observed source sizes of IIIb's and III's in a group are almost the same. This need not conflict with the present model where $A_f \ll A_s$, since the effective value of A_f may be the sum of the cross-sections of thinner filaments distributed over the whole area of A_s. Alternatively, the observed sizes of both the III and IIIb sources may be mainly determined by the scattering of radio waves during propagation.

The decay time of the striae, which is short compared with that of a normal III, may be determined by the decay of the beam electrons, because the plasma waves excited in the filaments escape from the filaments in ~0.1 s to suffer strong Landau damping in the ambient, rarefied plasma (Takakura *et al.*, 1973).

The excess density in the filament can be estimated as follows. We adopt Alvarez and Haddock's (1973) model of plasma density for the normal type III's, i.e.

$$f_p \approx f_p(1)\, \delta^{-1.2}, \tag{6}$$

where $f_p(1) \approx 42$ MHz, $\delta = h/R_\odot$, h is height above the photosphere and $R_\odot$ is solar radius (7×10^5 km).

Equation (6) gives

$$\frac{\mathrm{d}f_p}{f_p} \approx -1.2 \frac{\mathrm{d}\delta}{\delta} .$$

Using Δ to denote finite increments and with $N_e \sim f_p^2$ the above may be written

$$\left|\frac{\Delta N_e}{N_e}\right| \approx 2.4 \left|\frac{\Delta\delta}{\delta}\right|. \tag{7}$$

It is this excess, ΔN_e, in the number density which has to be reached while the density gradient inside the filament remains lower than that outside, in order to equalize the electron densities at δ and, as indicated in Figure 6a, at $\delta + \Delta\delta$, or beyond. If we use the extreme lengths of the earlier example, namely $L_f' = 8 \times 10^8$ cm ($\Delta\delta = 1.1 \times 10^{-2}$) at 100 MHz and 6×10^9 cm ($\Delta\delta = 8.6 \times 10^{-2}$) at 10 MHz, Equation (7) gives $|\Delta N_e / N_e| \approx 6 \times 10^{-2}$ at both frequencies. Again, this seems plausible.

We have no evidence except one case that the type IIIb bursts at 80 MHz are highly circularly polarized compared with type III bursts. On the other hand, de la Noë and Boischot (1972) have noted that the type IIIb's appear to be much more polarized than the type III's though the polarization degree differs from one stria to the other. The condition that the fundamental radiation becomes highly polarized is (Melrose and Sy, 1972)

$$\frac{f_H}{f_p} \gtrsim 3 \left(\frac{V_{Te}}{V_s}\right)^2 + \frac{2V_{Ti}}{V_s}, \tag{8}$$

where f_H is electron gyrofrequency, V_s is the velocity of the electron beam, and V_{Te} and V_{Ti} are the thermal velocities of electrons and protons of the plasma respectively. For this condition to be more easily satisfied in striae, either the magnetic field in the filament must be stronger, or the temperature of the filaments lower, then that of the ambient plasma.

Another implication of inequality (8) is that a high degree of polarization should occur more often at the beginning of the bursts, since it is the fastest electrons that arrive first at any given plasma level and since the larger V_s becomes, the more easily inequality (8) is satisfied.

In an event of 1973 May 20 (Figure 4), the polarization of the second harmonic in the early phase of a stria was 24%. This may indicate that the magnetic field in the filament was very large. The degree of polarization r_c of the second harmonic is given by (Melrose and Sy, 1972)

$$r_c \approx 0.63 \frac{f_H}{f_p}.$$

In order to have $r_c = 0.24$ at $f_p = 40$ MHz, the magnetic field must be 5.5 G.

4. Conclusion

The observational characteristics of type IIIb bursts are summarized at the end of Section 2.

The model of a type IIIb burst proposed in the present paper is as follows. The main cause of the striae is the existence of filamentary irregularities (with excess density of $\lesssim 10\%$) along the path of the electron beam which causes the type III burst. The reduced gradient of plasma density on the lower edges of the filaments explains the slow drift of the striae observed in these bursts (see Figure 6) and also provides a longer effective length for generation of the radiation. Since the fundamental wave can grow exponentially with the length of the effective radio source, high-intensity striae will occur more often in the fundamental than in the second harmonic radiation. In the present model it is the contrast between the emission from the filaments and the emission from the ambient plasma which makes the burst appear as typeIIIb or a normal type III. The higher the electron density of the beam, the easier it is to get striae.

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