GENERATION OF INTERMEDIATE DRIFT BURSTS IN SOLAR TYPE IV RADIO CONTINUA THROUGH COUPLING OF WHISTLERS AND LANGMUIR WAVES

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Abstract. The possible generation of intermediate drift bursts in type IV dm continua through coupling between whistler waves, traveling along the magnetic field, and Langmuir waves, excited by a loss-cone instability in the source region, is elaborated. We investigate the generation, propagation and coupling of whistlers.

It is shown that the superposition of an isotropic background plasma of 10^6 K and a loss-cone distribution of fast electrons is unstable for whistler waves if the loss-cone aperture 2α is sufficiently large ($\sec\alpha \geqslant 4$); a typical value of the excited frequencies is 0.1 ω_{ce} (ω_{ce} is the angular electron cyclotron frequency).

The whistlers can travel upwards through the source region of the continuum along the magnetic field direction with velocities of 21.5–28 v_A (v_A is the Alfvén velocity).

Coupling of the whistlers with Langmuir waves into escaping electromagnetic waves can lead to the observed intermediate drift bursts, if the Langmuir waves have phase velocities around the velocity of light.

In our model the instantaneous bandwith of the fibers corresponds to a frequency of 0.1–0.5 ω_{ce} and leads to estimates of the magnetic field strength in the source region. These estimates are in good agreement with those derived from the observed drift rate, corresponding to 21.5–28 v_A, if we use a simple hydrostatic density model.

1. Introduction

Intermediate drift bursts or 'fiber' bursts (see Figure 1) have been observed in solar type IV dm continua by Young *et al.* (1961), Slottje (1972a) and Elgarøy (1973); their drift rates are intermediate between type III and type II drift rates. Typically, a fiber burst consists of two adjoining depression and enhancement ridges relative to the surrounding continuum with the emission feature on the high-frequency side. Both the drift rate and the ridge separation led to the suggestion (Kuijpers, 1973) that fiber bursts are generated by whistler wave packets traveling through the source

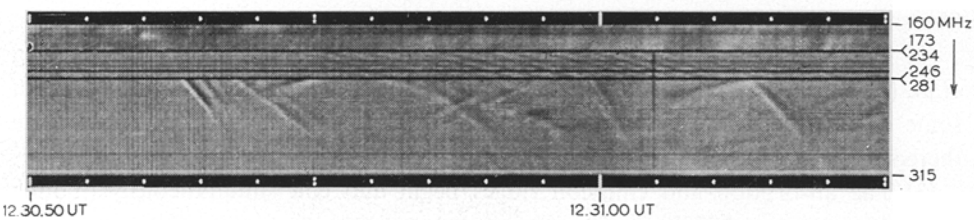

Fig. 1. Example of intermediate drift bursts observed with the 60-channel Utrecht spectrograph on March 6, 1972. The figure shows the flux variations (<3 s with respect to a floating zero level; range ±1.7 dB). Each channel has a width of 0.9 MHz.

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region and coupling with the locally excited Langmuir waves, which presumably cause the observed continuum emission (Kuijpers, 1974).

In Section 2 the observations are reviewed. Section 3 deals with the nature and the propagation properties of whistler waves. The excitation of whistlers is the subject of Section 4. The possible coalescence of whistlers with Langmuir waves into transverse waves and the efficiency of this process are determined in Section 5. Finally, in Section 6 we argue that the model might apply to the situation in a type IV source region. In this paper we neglect the influence of collisions.

We assume that the source originates from fast electrons, injected into a stationary magnetic arch configuration and that the fast particles are, at each point, distributed outside a local loss-cone thus giving rise to an instability for Langmuir waves. Subsequently the transverse waves are produced by induced scattering on the thermal ions (Kuijpers, 1974).

2. Observations

The observational characteristics of intermediate drift bursts are summarized in Table I.

TABLE I

Observed characteristics of intermediate drift bursts

Frequency range (MHz)	950–500[a]	340–310[c]	320–200[b]	175–145[c]
Instantaneous band-width (MHz)	10	1.75	1.5–3	0.5
Single frequency duration (s)	0.2–0.6	0.25	0.2–0.4	0.25
Frequency drift (MHz s^{-1})	−10 to −50 (−150)[d] +19 to +25	−9.5	−10 to −2 + 6 to +2	−3.5
Frequency extent of single fibers (MHz)	(20)[d] 50–150 (300)[d]		(5)[d] 50–100	

[a] Young *et al.* (1961).
[b] Slottje (1972a, b); here the listed values refer to emission and absorption ridges separately.
[c] Elgarøy (1973).
[d] The values between brackets are rarely observed.

(1) In most cases the fibers appear as fine structures within a continuum burst which lasts 5–50 min, although the fibers are sometimes observed as emission ridges before or after the continuum (Young *et al.*, 1961). Often the fibers cluster in time with (sometimes nearly constant) intervals of a few seconds or much less between successive fibers and are very similar within one group.

(2) The absorption edge is typically on the low frequency side; according to Young *et al.* (1961) and Elgarøy (1973) the absorption edge is at the high frequency side in some cases, but with the Utrecht 60-channel spectrograph no convincing example thereof has been recorded (Slottje, 1974).

(3) The absorption and emission ridges begin and end simultaneously (Young *et al.*, 1961; Slottje, 1972b).

(4) The majority of fibers have a negative frequency drift rate. Generally the absolute value of the drift rate of an individual fiber decreases with decreasing fre-