ON THE INTERMEDIATE DRIFT BURST MODEL

G. MANN

Zentralinstitut für Astrophysik der Akademie der Wissenschaften der DDR, Observatorium für solare Radioastronomie, Tremsdorf, 1501, G.D.R.

M. KARLICKÝ

Astronomical Institute, Czechoslovak Academy of Sciences, 25165 Ondřejov, Czechoslovakia

and

U. MOTSCHMANN

Institut für Kosmosforschung der Akademie der Wissenschaften der DDR, Berlin, 1199, G.D.R.

(Received 5 March, 1987)

Abstract. A modification of the presently existing intermediate drift burst model by Kuijpers (1975) and Bernold (1983) is suggested. It is shown that whistler solitons cannot be responsible for intermediate drift bursts. Here, they are interpreted as the radio signature of localized formstable whistler wave packets propagating along the magnetic field in a coronal loop. In the frame of this modified model, the magnetic field strengths derived from fiber burst data agree with previous estimates by Dulk and McLean (1978).

1. Introduction

Intermediate drift bursts also called fiber bursts are observed as special fine structures in the dynamic frequency spectrum during solar type-IV radio bursts (Young *et al.*, 1961; Slottje, 1981; Elgarøy, 1982). They appear as an emission stripe frequently associated with an absorption edge at the low-frequency side with drift rates intermediate between that of type-II and type-III bursts. Typically, a drift rate of $D_f = -7.5$ MHz s^{-1}, an instantaneous bandwidth of $b_f = 2$ MHz, and a frequency separation between emission and absorption of $\Delta f = 2$ MHz are found in the 300 MHz range (Elgarøy, 1982). Elgarøy (1982) observed a maximal drift rate of -14 MHz s^{-1} for some fibers in this frequency range.

The presently existing model of intermediate drift bursts bases on the thesis by Kuijpers (1975) and Bernold (1983). According to this model the fiber bursts are generated by coalescence of packets of whistler solitons and Langmuir waves into electromagnetic waves. Both whistler waves and Langmuir waves are excited by a loss-cone instability produced by high-energy electrons trapped in coronal loops. The whistlers are reflected near the lower-hybrid frequency ($\omega_{\rm LH}$) level (Kennel and Thorne, 1967). There, the whistler density becomes large and the whistlers can evolve into solitons. Whistler solitons are only generated for $x = \omega_W/\omega_{ce} > 0.25$ under coronal conditions (Karpman and Washimi, 1977; Spatschek *et al.*, 1979; Mann, 1985). ω_W and ω_{ce} denote the whistler frequency and the electron-cyclotron frequency, respectively. Kuijpers (1975) explains the continuum generation by scattering of Langmuir waves on ions. Thus, the frequency separation between emission and absorption is approximately

equal to the whistler frequency. On the other hand, Bernold suggests that the continuum and the fibers are produced by the same mechanism (whistler + Langmuir waves). But the whistler solitons are assumed to be coherently trapped in a density duct so that the fibers occur. Kinetic Alfvén solitons (Hasegawa and Mima, 1976) could act as such ducts.

This model contains some problems:

(i) Because whistler solitons can only exist for $x > 0.25$ in the corona the magnetic field strengths derived by this model are lower than expected. This problem was already emphasized by Dulk and McLean (1978) (see also Table I). Such magnetic field strengths would lead to a plasma-beta $\beta \gtrsim 1$. That contradicts the stability of coronal loops (Dulk and McLean, 1978).

TABLE I

Plasma parameters derived from fiber burst data representative for the 300 MHz level

x	0.3	0.03	0.023
ω_{pe}/ω_{ce}	43	22	20
ω_W (10^6 s^{-1})	13	2.6	2.2
B (G)	2.5	4.9	5.4
β[a]	2.2	0.6	0.5

[a] β is calculated for a suitable coronal temperature of 2×10^6 K.

(ii) In the solar corona whistler waves cannot propagate undamped longer than 1 s for $x \geq 0.25$ owing to cyclotron damping. Consequently, coronal whistler solitons cannot be responsible for intermediate drift bursts (see Section 2).

We propose a modification of the presently existing model removing these problems.

Which wave mode is the exciter of fiber bursts? The exciter of type-II bursts is assumed to propagate with the Alfvén velocity v_A, approximately. But the fiber bursts show a drift rate significantly larger than that of type-II bursts. That favours the whistler mode because it is the only one propagating with a group velocity essentially larger than v_A (see also the argumentation by Kuijpers, 1973). Now, we consider the fibers as the radio signature of a localized formstable low-frequency ($x \ll 0.25$) whistler wave packet. Such packets are connected with a ponderomotively induced density hump, which causes an absorption edge at the low-frequency side of the emission stripe (see Section 3). Because the whistlers are reflected at the ω_{LH}-level (Kennel and Thorne, 1967), these wave packets can already be originated at this level and disappear due to cyclotron damping at higher coronal levels. Then, the derivation of the magnetic field strength and the corresponding plasma-beta provides acceptable values (Dulk and McLean, 1978) using a x-value in the range $x_{LH} = \omega_{LH}/\omega_{ce} \lesssim x \ll 0.25$ (see also Table I). The radio radiation of the whistler wave packet is produced by its coalescence