BEAT STRUCTURE IN PULSATING TYPE IV SOLAR RADIO BURSTS AND A POSSIBLE MECHANISM*

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Abstract. Pulsating type IV solar radio bursts with beat structure are presented and analysed in this paper. Based upon the theory of whistler soliton emission we interpret the beat structure by the combination of two components with different pulsation frequencies due to radial oscillations of two legs of the magnetic loop. The large depth of pulsation is also explained in this model.

1. Introduction

Periodic or quasi-periodic pulsations are interesting and not rare phenomena in type IV solar radio bursts at meter and decimeter wavelengths. A model that radial oscillations of magnetic flux tubes may modulate synchrotron emission from trapped energetic electrons was investigated extensively (e.g., Rosenberg, 1970; McLean and Sheridan, 1973; Tapping, 1978; Roberts et al., 1983, etc.).

In recent years, the radiopolarimeter at Trieste Observatory recorded some interesting pulsating type IV bursts at frequencies 237, 327, 408, 505, and 610 MHz. In these events the pulsating flux densities are modulated, and appear like what we call 'beat structure'. In this paper we will interpret this beat structure by the combination of two components of periodic whistler soliton emissions with different pulsation frequencies.

2. Observations and Power Spectra

Many pulsating type IV solar radio bursts have been observed at Trieste Observatory since 1968 (Abrami, 1968). By means of high scan frequency (about 40 Hz) it is possible to detect rapid variations of the flux density. Some of these events reveal a peculiar feature that the depth of pulsation varies with time, i.e., what we call 'beat structure' (Figure 1(a)). Usually, this structure occurs during the main phase of the bursts, and appears evident in some relatively short time intervals compared with the duration of the bursts. Using Fourier analysis (Messerotti, 1985), we obtained the power spectra of these events, which show two bigger peaks in the higher frequency range. These peaks can be seen more clearly in Figure 1(b), where we filtered the data with a high-pass filter (cut-off frequency = 0.5 Hz). It is well known that the combination of two oscillations with slightly different frequencies and fixed phase difference will produce a modulation of the amplitude, or beat. Based upon this idea we propose a model in the next Section.

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Fig. 1. Pulsating emission with beat structure from 07:23:36 to 07:23:52 UT in a type IV burst on 12 October, 1981 at frequency 327 MHz. The scan frequency is 39 Hz (26 ms). (a) Plot of flux density vs time; (b) power spectrum for the high-pass filtered data (cut-off frequency = 0.5 Hz). The ordinate $I$ represents the relative intensity (normalized to 100) of different frequency components.

3. Model and Interpretation of the Beat Structure

We adopt a similar model proposed by Bernold and Treumann (1983; see also Figure 2), in which the energetic electrons with energy of a few tens of keV are trapped in a coronal loop in solar flares. The distribution of these electrons will develop temperature anisotropy ($T_\perp > T_\parallel$, where $\perp$ and $\parallel$ represent perpendicular and parallel directions to the magnetic field) or a loss cone, and consequently excite two kinds of waves, upper hybrid waves and whistler waves, at the top region of the loop.

Under solar conditions we have $\omega_p \gg \Omega_e > \omega_w > \Omega_i$, where $\omega_w$ is the frequency of whistler waves, $\omega_p$ is the plasma frequency, $\Omega_e$ and $\Omega_i$ are the gyrofrequencies of