LOW FREQUENCY TURBULENCE IN THE SOLAR CORONA AND FUNDAMENTAL RADIATION OF TYPE III SOLAR RADIO BURST

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Abstract. On the basis of the previous numerical simulations, a new mechanism for the emission of the fundamental radio waves of solar radio type III bursts is presented. This hypothesis is to attribute the fundamental radio emission to the coalescence of the plasma waves with the low frequency turbulence, whistler or ion acoustic waves, pre-existing on the way of the electron beam which excite the plasma waves.

It is estimated that ion acoustic waves could be occasionally unstable in the solar corona due to that drifting bi-Maxwellian distribution of electrons as observed in the solar wind, which is probably caused by collision-less heat conduction.

It is also suggested that the reduced damping of the ion acoustic waves in such a distorted electron distribution in the corona may decrease the threshold electric current to cause the anomalous resistivity to be the onset of the solar flares.

1. Introduction

The currently accepted working hypothesis for the radio emission of fundamental waves of the solar radio type III bursts is that the fundamental waves are caused by the scattering of beam excited plasma waves by thermal ions. In a previous paper (Takakura, 1979a), however, it was shown by the numerical simulation that the fundamental radio emission is negligibly small compared with the second harmonic radio emission as ascribed to the coalescence of the primary plasma waves and scattered secondary plasma waves.

It is possible for the fundamental to be comparable or greater than the second harmonic if the flux of electron beam is high enough. However, Takakura (1979b) has shown that the possibility that the harmonic pair of the fundamental and the second harmonic to be observed with comparable intensities may be very small if the working hypothesis is correct, since the amplification gain (negative absorption) of the fundamental waves depends strongly on the parameters which determine the electron flux.

The aim of the present paper is to propose the new hypothesis that the fundamental radio emission is attributed to the coalescence of beam excited plasma waves and the nonthermal low frequency waves, whistler or ion acoustic waves, pre-existing on the way of the electron beam (Section 2). The coalescence of the whistlers and the plasma waves is proposed by Chiu (1970) and Kuijpers (1975) for the interpretations of type III pulsation and intermediate drift bursts in type IV continua.
In Section 3, it is estimated that the ion acoustic waves may occasionally be unstable in the corona due to the drifting bi-Maxwellian distribution of electrons as observed in the solar wind.

2. Coalescence as the Process to Emit Fundamental Radio Waves

In order for the fundamental radio waves to have greater or comparable intensities as compared with the second harmonic, we shall investigate the possibility that the fundamental radio emission is caused by the coalescence of plasma waves with nonthermal low frequency waves pre-existing on the way of the electron beam.

The evidences and the possibility that the ion acoustic waves and/or whistler waves are occasionally occurring in the solar wind (even at coronal heights) are discussed in the next section. It will be shown in this section that such waves propagating nearly along the solar wind can be the candidate to coalesce with the beam-excited plasma waves into the fundamental radio waves.

The necessary conditions for the wave vector \( k \) and the angular frequency \( \omega \) of the waves to be satisfied at the coalescence are

\[
\begin{align*}
k_t &= k_l + k_s, \\
\omega_t &= \omega_l + \omega_s,
\end{align*}
\]

and at the decay,

\[
\begin{align*}
k_t &= k_l - k_s, \\
\omega_t &= \omega_l - \omega_s,
\end{align*}
\]

where subscripts \( t, l, \) and \( s \) represent radio, plasma and slow waves, respectively. Since \( |k_s| \ll |k_l| \), (1) requires \( k_s = -k_l \) and (3) requires \( k_s = k_l \). \( \omega_s \ll \omega_p \) is required to satisfy \( \omega_t = \omega_p \), where \( \omega_p \) is angular electron-plasma frequency. The decay process would be less probable, since \( \omega_t - \omega_s > \omega_p \) is required in order to satisfy the escape condition of the radio waves.

Jackson (1960) has given the following dispersion equation for the ion acoustic waves in the case when the velocity distribution of electrons and ions is given by a sum of one-dimensional drifting Maxwellians,

\[
f_i(v) = \frac{1}{\sqrt{\pi}} \frac{n_i}{v_{T_i}} \exp \left[ -\frac{(v-u_i)^2}{v_{T_i}^2} \right],
\]

where

\[v_{T_i} = (2\kappa T_i/m_i)^{1/2},\]

the dispersion equation is

\[k_s^2 + \sum_j G(Z_j)/D_j^2 = 0,\]