F & H SOLAR RADIO EMISSION: DELAYED FUNDAMENTAL

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ABSTRACT

The suggestion is made that the excessive time delays between the two components of f-h type III pairs might be partly accounted for by an initial production of the second harmonic only, followed later by the production of both components. The source is assumed to be inside coronal streamers. Theoretical arguments lend some support to the suggestion of a delayed start of the fundamental.

1. INTRODUCTION

Several papers have appeared in the literature over the past few years on (a) the dominance of second harmonic type III radiation, (b) the excessive time delays between the harmonic and the fundamental components, (c) the location of the source of radiation and (d) the similarity of intensity-time profiles between harmonic components of f-h pairs and single type III events (for example: Caroubalos et al., 1974; Daigne et al., 1974; Haddock and Alvarez, 1973; Hughes and Harkness, 1963).

The similarity mentioned in (d) might be interpreted as indirect evidence for the harmonic nature of the single events in the decametric range of wavelengths, while the prevalence of the second harmonic in (a) is observed below 1 Mhz. The observed time delays between fundamental (f) and second harmonic (h) exceed the delays expected from differences in group velocities. For example Harkness and Hughes (1963) observed a 2s lag of the fundamental behind the harmonic of the 80f/160h combination and a 4s lag in the 40f/80h combination.

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2. DISCUSSION

Computations of delay times show that at any given frequency of emission, the delays depend greatly, not only on the electron distribution model, but also on the electron density at the source region. If the source of radiation lies in or *behind* coronal streamers of enhanced densities, greater propagation delays are expected. Using the coronal electron density distribution functions of Alvarez and Haddock (1973) and of Newkirk (1961) with the density increased uniformly in the latter by a factor of 2, yield delay times for the 80f/160h and 40f/80h combinations that are, at most, 50% of the observed delay times.

If, in the initial phase of pair production, the emission of harmonic radiation began earlier than that of the fundamental, rather that at the *same time*, then an excessive delay would result. For this to occur there must be some mechanism operating which would favour h production initially and pair production later. We suggest that in the initial phase of production, when the density of the exciting electron stream is perhaps greatest, harmonic production is favoured and, as the exciter ascends through the streamer and diffuses slightly, conditions become more favourable for both f and h production. This would give the harmonic, in some if not all cases, an initial head-start on the fundamental.

On these assumptions, single events that show harmonic characteristics are more likely produced outside of streamers or in low density streamers. Harmonic radiation also becomes dominant in the more tenuous outer regions of the solar corona - the regions of low radio frequency emissions.

3. THEORETICAL ASPECTS

Smith (1974) has shown that the ratio of the total volume emissivities of fundamental and harmonic radiation J_1 and J_2 respectively, is given by

$$J_1/J_2 \lesssim 10^{-20}\, N_e^{3/2}/W_p T_e^{\frac{1}{2}}, \tag{1}$$

where W_p = energy density in plasma waves, T_e = electron temperature, N_e = ambient coronal electron density. W_p is proportional to the electron stream density N_s so it is possible to write the proportionality,

$$J_1/J_2 \sim N_e^{3/2}/N_s. \tag{2}$$

Smith (1974) has shown $J_1/J_2 \lesssim 10^{-6}$ for a type III event at 55 kHz at which frequency the dominance of the h-component has been observed. Expression (2) shows that harmonic emission is more favourable for high density exciters and low density ambient plasmas in accord with the assumptions above.

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4. CONCLUSION

The suggestion is made that the production of the fundamental component of type III pairs suffers a delayed start which puts the starting edge of the h-component ahead of the f-component. It would be interesting to see if excessive delays are also observed between other corresponding features on both components. For this, a search on high quality spectral data is needed.

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DISCUSSION

D.Smith: I never meant the formula quoted to be applied at meter wavelengths so that I would not place too much weight on the proportionality which you derived.

Achong: I accept your comment.

Wild: What is the variation of the excessive harmonic/fundamental delay with distance of burst position from the center of the disk? It seems that unless one knows this variation, it would be difficult to start building a theory. If it turns out that the excess delays occur mainly for off-center bursts, then the cone-model just described by Dr. Sheridan might in itself explain the delays.

Achong: I have not looked for center-to-limb variations in the time-delays, but this should be important information.