INTENSITY OF CHORUS EMISSIONS AND AMPLIFIED WHISTLER-MODE SIGNALS FROM VLF GROUND TRANSMITTERS

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Magnetospheric whistler mode waves in the magnetosphere, both natural and man-made (such as those transmitted from Siple Station), play a key role in wave induced particle precipitation (WIPP). The critical parameter is the saturation intensity B_s of these waves, which modify radiation belt dynamics. The value of B_s also differentiates between the weak-field [1], and strong-field models [2][3], that attempt to explain wave growth and emission triggering. The peak intensities predicted by these two models may differ by an order of magnitude or more. The fundamental difference between them is the assumption of the input field B_{in}, which in the strong field model is required to be $\geq$ the trapping value, whereas the weak field model requires no assumption of B_{in} value and indeed it shows the same saturation value for any value of B_{in}, assuming no interfering signals along with B_{in}.

Since the growth rate of the Siple pulse is a well-measured parameter, these two models can be tested by finding either the input or the output intensity of these waves at the interaction region (IR) near the magnetic equator for typical duct locations near L=4. To obtain the input B_{in} to the IR, we can use the signal from the Siple Station transmitter as measured in the F-region above Siple Station, Antarctica by a sounding rocket [4]. A model of the duct [5] is used to calculate the fraction of this incident wave that is captured by the duct. Analysis using the slowly-varying (WKB) approximation shows that the ducted wave falls off in strength versus altitude at about the same rate as for non-ducted waves. This finding allows satellite measurements of non-ducted Siple signals to be used as proxies for the ducted signals, thus providing a reliable estimate of B_{in}.

A final check on B_s is to apply a new technique based on the band-limited impulse (BLI) and its associated positive frequency offset (PFO) of the emission that is stimulated by the termination of an applied Siple pulse. Analysis shows [6] that the PFO can be connected to B_s just before termination, giving values of about 5 PT assuming pitch angle $\alpha \approx 60°$ [7]. In effect, the BLI sweeps upstream through the $J_\perp(z)$ distribution, switching very rapidly all of these currents upward in frequency by the amount of the PFO, thus establishing the TE at nearly the same amplitude as the original amplified signal. This result is consistent with small-signal theory as well as with the independent estimate of B_{in} based on ducting efficiency.

In view of the large discrepancy between the "strong" and "weak" field model predictions for B_s (weak field $\sim 1-5\,\mathrm{m}\gamma$; strong field $\sim 23-30\,\mathrm{m}\gamma$) and the experimental data, it is suggested that the assumption of an input signal at or exceeding the trapping level [2][3][8] is not valid as a starting point for modeling the CWI. On the other hand, the results of the weak field simulation of [1] are in acceptable agreement with experimental data on both the amplitude and phase shift of amplified VLF test signals from Siple Station. This agreement supports the use of the weak-field model of the CWI to explain the amplification of Siple signals and their associated triggered emissions and confirms the hypothesis of phase bunching by Brice [9] as the basis for the CWI.

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