Quasi-linear Diffusion Coefficients for Highly Oblique Whistler Waves

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1. Extended Abstract

Whistler mode waves have important effects on radiation belt electrons. The interactions are often well-described by quasi-linear diffusion coefficients for energy and pitch angle (and a cross diffusion coefficient). These coefficients take into account both the frequency and wave normal angle distributions of the waves, which have usually been modeled as quasi-parallel or at most moderately oblique. However, recent analysis of observations from the Cluster and Van Allen Probes satellites have revealed highly oblique waves present in both chorus and plasmaspheric hiss. Furthermore, the upcoming DSX mission is planning to radiate VLF waves from a dipole antenna, which are predicted to be generated and propagate in a highly oblique mode. It is therefore important to examine the diffusion rates expected from such waves, for which the wave normal angles approach the "resonance cone" and lead to very large values of the refractive index μ.

Using the longitudinal approximation of cold plasma theory, and taking the limit of large μ, it is possible to greatly reduce the complex expressions for the diffusion coefficients to finite sums over harmonic number of a relatively simple integral, which can be further approximated and evaluated in closed form for large and small values of the particle pitch angle. In addition, a variable transformation used allows the troublesome normalization integral to be computed exactly with comparatively little effort.

If the total value of the wave magnetic field is held fixed as the wave normal angle increases, the diffusion coefficients are shown to increase without bound, scaling as powers of the maximum allowed value of μ, or alternatively of $\mu_{\|}$. Consideration of these maximum values, determined by warm plasma or other effects, then becomes paramount. Scalings holding constant the total electric field, Poynting flux, and energy density will also be presented.