Orientation of Whistler-Mode Chorus Wave Vectors and the Implications for the Chorus-to-Hiss Mechanism

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Whistler-mode chorus wave normal angles are evaluated statistically using Van Allen Probes EMFISIS data. In contrast to previous studies which considered only the polar angle of the wave vector in relation to the background magnetic field, here the azimuthal wave vector angle is also considered. In the polar direction, a bimodal distribution is observed with a primary population of near field-aligned waves and a secondary smaller population of oblique waves. This population of oblique waves is most prevalent in the dawn-through-midnight sector. With respect to the azimuthal direction, it is found that the majority of wave vectors are oriented within approximately thirty degrees of the anti-Earthward direction. This same azimuthal structure is evident in all magnetic local time sectors.

These statistical results detailing the orientation of chorus wave vectors have implications for models which propose chorus waves propagating into the plasmasphere as a source of plasmaspheric hiss. Ray tracing simulations typically require an initially oblique polar wave vector angle with the azimuthal component of the wave vector oriented Earthwards in order for a chorus wave to propagate into the plasmasphere. Based on the statistical distribution of chorus wave vector orientations, the occurrence rate of chorus waves with these required initial conditions is not substantial.

In the noon-through-dusk sector, strong azimuthal density gradients are often present due to the plasmaspheric bulge and/or plasmaspheric plumes. As a consequence of these azimuthal density gradients, chorus waves with a broader range of both polar wave vector angles and azimuthal wave vector angles can gain access to the plasmasphere. With a chorus source located extremely close to a strong azimuthal density gradient, it is possible for the majority of the observed wave normal angle distribution to propagate into the plasmasphere. However, the observed occurrence rate of wave vectors with the orientation required to enter the plasmasphere diminishes quickly as the chorus source moves away, both azimuthally and radially, from the strong azimuthal density gradient.

As such, it can be concluded that strong azimuthal density gradients are actually a requirement if a significant population of chorus waves are to enter the plasmasphere and evolve into plasmaspheric hiss.