School of Physical Sciences, DCU, Seminar Series

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Thur 9th October 2014 16.00-17.00, N115

# A statistical study of whistler wave normal angle distribution in the plasmasphere

Abstract:

A method for the determination of the wave normal polar angle of a whistler mode signal observed on board a spacecraft from the ratio of the wave magnetic field amplitude to electric field amplitude is applied for DE1 PWI ELV/VLF wave data processing. The present study develops a method of determination of the wave normal direction based only on the wave amplitude data. It should be noted, however, that the sign of the k-vector is cannot be determined by such a method, which provides only the angle between the wave normal and the background magnetic field direction. The proposed technique is applied to both DE1 and Akebono ELF/VLF measurements, allowing useful comparisons. DE1 crossed the plasmasphere at all local times and nearly all latitudes over a 3 year period covering well the frequency range of the plasmaspheric hiss in both equatorial and auroral regions. The statistical results for plasmaspheric and auroral hiss polar angle dependence on $L$-shell, magnetic latitude, magnetic local time and geomagnetic activity conditions is obtained and compared with statistical results from Cluster mission. Near the geomagnetic equator, plasmaspheric hiss wave normals are mainly close to the direction of the background magnetic field. The distribution of the polar angle $\theta$ at the geomagnetic equator was concentrated in a 30$^{\circ}$ cone, with a maximum around $10^{\circ}-15^{\circ}$. Due to the curvature of the background magnetic field lines and the increasing magnetic field magnitude at higher latitudes, wave normals tend to rotate outward from the Earth, increasing the mean value and the variance of the $\theta$ distribution along the ray path. The probability density functions of the wave amplitudes and wave-normals are usually non-symmetric and have significant non-Gaussian tails. The plasmaspheric hiss showed a clear dependence of polar angle on magnetic latitude $\lambda$ for all wave amplitudes: the mean value of the polar angle increases with $\lambda$, being roughly $\sim 2\lambda$ for $\lambda>10^\circ$, reaching the resonance cone angle at $\lambda \sim 30^{\circ}-40^{\circ}$. For the auroral hiss, $\theta$ is close the local resonance cone value $\cos\theta_{res}\sim(f/f_{ce} )$ for whistler waves. The proposed technique can be very useful in allowing to supplement whistler wave normal angle statistics obtained from recent probes (such as Cluster or THEMIS) with other statistics derived from continuous measurements of only one or two components of the wave magnetic and electric fields onboard various spacecrafts covering different regions of the magnetosphere.