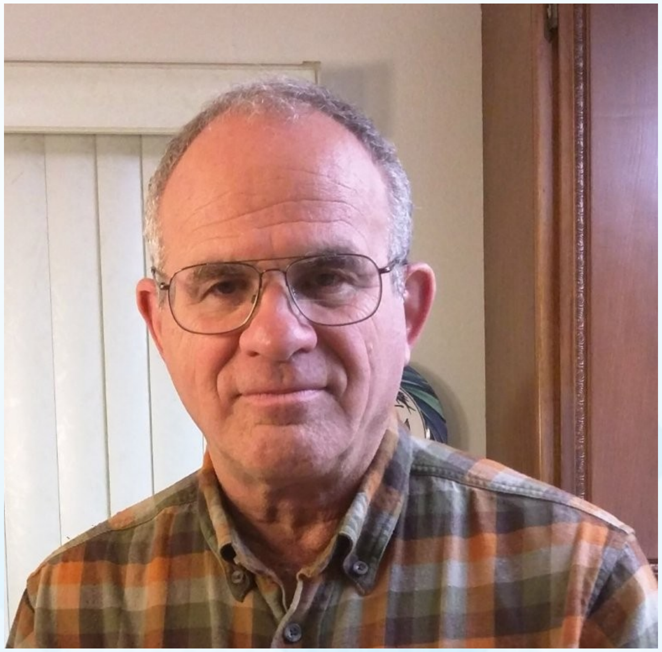
Plasma Physics Seminar

UCLA College | Physical Sciences Physics & Astronomy

Physics & Astronomy Building (PAB) Room 4-330
Friday April 10th at 12:30 PM
Via Zoom: https://ucla.zoom.us/my/pab4330

Whistler Wave Ducting Explained As Bi-directional Linear Mode Conversion



Paul Bellan (CalTech)

Whistler waves, discovered a century ago, are lightning-instigated audio-frequency electromagnetic waves that bounce back and forth with minimal attenuation between magnetically conjugate locations in Earth's northern and southern hemispheres. The nearly lossless bouncing has been attributed to existence of a “duct” that acts like an optical fiber linking the two conjugate locations but how this duct actually works has been a mystery. In the work to be described in this talk, the coupled equations governing whistler waves propagating along a duct with cylindrical cross section are derived and then solved numerically. The equations are expressed in terms of magnetic and current flux functions and show that a solution exists where the waves are finite in the duct but decay exponentially outside the duct. Furthermore, this solution has the property of having zero radial Poynting flux at all radii, so, as required for whistler waves to bounce back and forth losslessly between magnetically conjugate terrestrial locations, no wave power leaks from the duct. The coupled equations are solved numerically for a tangible realistic situation by dividing the radial domain into an inner and an outer region. The interface between these two domains is at a mode conversion location where fast and slow modes inside the duct merge and effectively reflect. The consequence of this effective reflection is that there are both fast and slow standing waves in the duct. In the region external to the duct, the wave solutions are also standing waves, but with a strong exponential decay and a radial wavelength intermediate between that of the fast and slow waves in the duct. The numerical solution agrees well with estimates made from analytic models. Detailed examination in the vicinity of the mode conversion location shows that the classic assumption that a wave has a dependence ~exp(ik · x-iwt) fails to describe the true nature of what is happening.

Host: Derek Schaeffer