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The impact of cold electrons on whistler waves

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Relative to other particle populations with higher energies, the cold ~eV plasma populations of the near-Earth environment are the least studied. In general, this is because issues associated with spacecraft charging make reliable measurements of the cold plasma properties and their interpretation difficult. However, the cold plasma plays a major role in magnetospheric dynamics, affecting phenomena such as solar-wind/magnetosphere coupling, substorm dynamics, waves and wave-particle interaction physics.

In this presentation, we will discuss the impact of cold electrons on various processes affecting whistler waves. First, the cold plasma controls the properties of the cyclotron instability which is believed to be the generating mechanism of whistler-mode chorus waves. Specifically, it affects the resonance conditions between particles and waves, the wave growth rates, and the saturation level of the instability Second, the cold plasma also controls the properties of the whistler waves as they propagate in the space environment because it is often the dominant source of the plasma density. Our latest modeling results indicate that there exists an additional new mechanism: whistler waves of sufficient amplitude can trigger secondary instabilities and couple very efficiently with the cold electron populations. This leads to damping of the primary whistler waves and heating of the cold electrons. Taken all together, these results show that the cold plasma plays a critical role in determining the properties of the whistler waves in the environment (including the wave amplitude). As such, it has strong impact on the rates of resonant pitch-angle scattering and energization associated with wave-particle interactions, with important implications on the dynamics of the plasma sheet, ring current, and radiation belts.