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Generation of High-Frequency Plasma Waves and Their Role at Earth's Magnetopause

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The complex interaction between the solar wind and geomagnetic field drives intricate plasma processes in the magnetosphere across various spatiotemporal scales. This interaction is mediated by magnetopause which acts as the boundary between solar wind and comparatively stagnant magnetosphere. Solar wind mass, momentum, and energy are transferred to the magnetosphere via magnetopause, which causes geomagnetic activities and can directly control Earth's space weather. The complexity increases as the solar conditions vary with timescales less than seconds to hours. They trigger various plasma instabilities which are unstable to plasma waves at ion and electron scales. As the magnetospheric plasma is collisionless, these waves will play a crucial role in the energy transfer between electromagnetic fields and different particle populations. Waves can act as catalysts or may dampen the ongoing magnetospheric process. Many plasma processes are cascaded over there and are linked to each other. It is fascinating how such small-scale processes can affect large spatiotemporal scales. Hence, understanding the magnetopause dynamics is crucial to get insights in the near-Earth space weather.

In this work, we use the smallest possible measurement scale i.e. electron-driven waves as a tool to study the magnetopause. These are high-frequency plasma waves that can grow at a rapid rate compared to other temporal scales and thus play a significant role in wave-particle interactions. We used datasets from NASA's Magnetospheric Multiscale Mission (MMS) satellites. This study reveals how the background plasma conditions around the magnetopause are often unstable to intense electron-scale wave activity and the role of these waves in plasma dynamics.