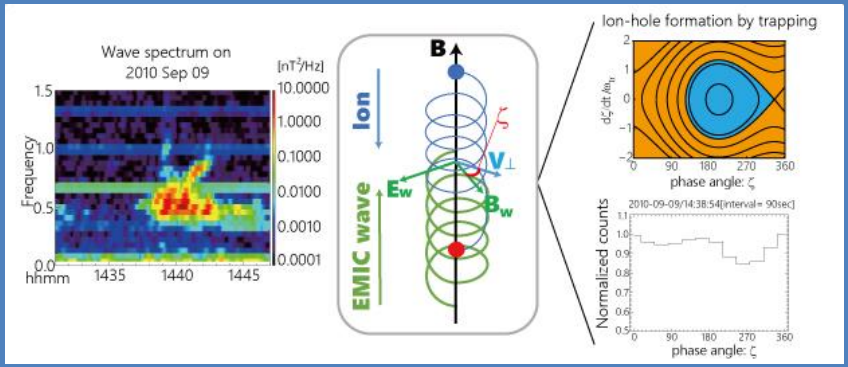
First direct evidence of energy exchange between plasma waves and particles in space supported by THEMIS data

Space is not empty and the NASA Heliophysics THEMIS spacecraft is providing data to help us see how invisible space processes work.

In collisionless space plasmas, **electromagnetic waves** are thought to control energy transfer between charged particles causing cross energy coupling. Direct evidence for this energy exchange process has not previously been obtained for any plasma instabilities in space. Scientists from the **United States and Japan** have identified a signature that would detect this process in data. Their results, using **NASA Heliophysics THEMIS data**, represent the **first direct evidence** of energy exchange between plasma waves and plasma particles in space.

A paper on these findings was published in the *Geophysical Research* Letters on September 14, 2017.



*These figures show wave particle interactions in the magnetosphere. The **left figure** shows the electromagnetic ion cyclotron waves observed by THEMIS. The **middle figure** is an animated schematic showing how the EMIC waves and ions are thought to interact. The **top right figure** is also an animated schematic showing an ion hole. The **bottom right figure** shows the depression seen in the data identified as an ion hole. Credit: Shoji, et al.*

The team compared computer simulations of wave-particle interactions with THEMIS observations of an **ion hole** in the three-dimensional proton distribution function. An ion hole appears as a significant depression in particle counts (when sampled as a function of the phase angle) resulting from the magnetic field of the wave interacting with the perpendicular velocity of the proton particles. These holes were predicted to form as a result of interaction between electromagnetic ion cyclotron (EMIC) waves and resonant ions. EMIC waves may be responsible for **ion scattering** within the magnetosphere.

These results show that the analysis method they developed can be used to **identify an energy exchange process** through direct comparisons with observations of wave-particle interactions in space.

A number of **NASA Heliophysics missions** provide data and observations on less-understood processes in near-Earth space. The **THEMIS spacecraft,** in addition to the **Van Allen Probes** and the **Magnetospheric Multiscale Mission**, provide a wealth of observations on different aspects of near-Earth space.

In concert with data from a number of missions in the **Heliophysics System Observatory** and rocket and balloon-based heliophysics investigations, NASA Heliophysics provides information to paint **a start-to-finish picture of physical processes in the magnetosphere**, showing us that space is, indeed, not empty.