

THEMIS



TIME HISTORY OF EVENTS AND MACROSCALE INTERACTIONS DURING SUBSTORMS



A Quest to Understand the Onset of Substorms

WHAT IS THEMIS?

If you look up into the sky on a clear, dark night while in Alaska, Canada, or the Northern United States, you may see a bright greenish-white band of light that stretches across the sky from the East to the West. These are the Northern Lights, also known as the Aurora Borealis. These types of lights also occur near the South Pole, where they are known as the Southern Lights or Aurora Australis.



Auroral bands photographed by Jan Curtis in Fairbanks, Alaska



Break-up aurora photographed by Jan Curtis in Fairbanks, Alaska

If you are lucky, you may watch this auroral band continue to brighten as it moves toward the South. Then, within minutes, you may see the band of light break into many bands of light, some of which will move back overhead and to the North, dancing rapidly and turning red, purple, and white. This sequence of events that you have witnessed is the *expansion onset of an auroral substorm* or *substorm onset*.

From observations and experiments in space, scientists have learned that substorm onset is related to the release of energy in Earth's magnetosphere, which is the space where Earth's magnetic field is dominant. Some of the energy in the magnetosphere is always released in the upper atmosphere as a single auroral band. However there are times when the magnetosphere stores

more energy than it can release in a slow and steady manner and something inside "breaks." Electric currents and electromagnetic waves propagate from the breaking point and suddenly cause the beautiful and mysterious dancing aurora after substorm onset.

There are two main locations and two different types of processes where this "breaking" can occur: at approximately 60,000 km and 120,000 km away from Earth on the side facing away from the Sun, as shown in the figure below. At 60,000 km, a flow of electrical current suddenly follows the magnetic field lines into the upper atmosphere in a dynamic way, perhaps producing the onset of an auroral substorm. There are many different possible processes that may cause this sudden flow. At 120,000 km, a sudden merging of oppositely pointed magnetic fields may occur, known as *Magnetic Reconnection at the Near Earth Neutral Line*. This causes charged particles in the magnetosphere to flow inward until they are forced to flow along the magnetic field lines as a current into the upper atmosphere, perhaps producing substorm onset. Scientists still do not have the appropriate data to decide which process occurs first and when substorm onset occurs relative to these two processes.

To solve this mystery, ground-based observatories (GBOs) and THEMIS satellites will be appropriately lined up in Earth's magnetosphere to determine the sequence of events. THEMIS will learn which physical process is the initial trigger to release the energy in the magnetosphere, leading to an auroral substorm.



