Exploring space physics under the aurora borealis: The University of Alaska Fairbanks Space Physics graduate program.

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Abstract

Situated in the sub-arctic, the University of Alaska Fairbanks (UAF) provides students with the unique opportunity to study space physics in a ground-based laboratory. In addition to core physics courses such as classical mechanics, mathematical physics, and electromagnetism, UAF offers a broad graduate curriculum in Space Physics and Heliophysics including: Fundamentals of Plasma Physics, Advanced Plasma Physics, Space Physics, Magnetospheric Physics, Aeronomy and Auroral Physics, Numerical Simulation of Fluids and Plasmas, Inverse Theory, Geophysical Fluid Dynamics, and Nonlinear Dynamics. We present an overview of our curriculum and show examples of "learning moments" in space weather from the perspective of ground-based instrumentation. It is our experience that students are highly motivated when theory and abstraction are paired with direct observation of auroral phenomena and experiences with the sounding rocket program at the Poker Flat Research Range.

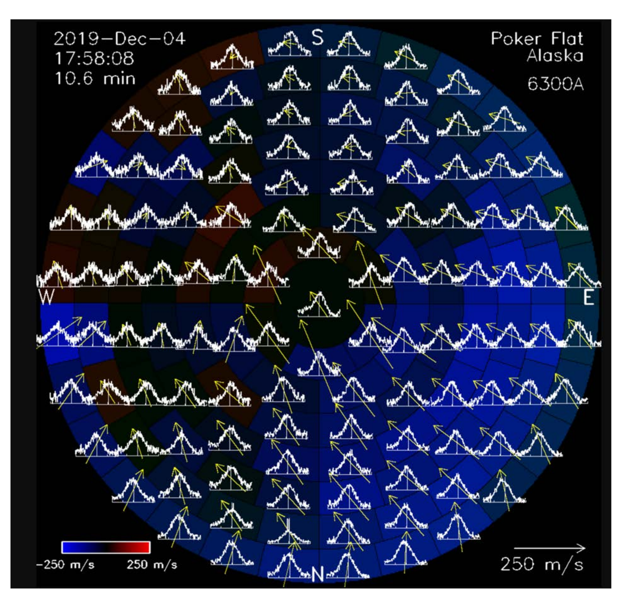
Space Physics and Aeronomy

The Space Physics and Aeronomy research group studies the Earth's geospace environment and the magnetospheres of other planets. Major topics investigated by the group are associated with the response of the magnetosphere, ionosphere and upper atmosphere to solar disturbances that reach the Earth after propagating through interplanetary space. Most significantly we study the aurora borealis, a spectacular natural phenomenon that can be observed from Fairbanks on a regular basis.

Researchers in the group carry out their studies using theory and simulation, sounding rockets, analysis of satellite-based observations, and ground-based observations of magnetic fluctuations, low-frequency sound waves, light from auroral emissions and radio signals reflected from atmospheric irregularities. The group is affiliated with the UAF Physics and Electrical Engineering departments, Poker Flat Research Range, the Poker Flat Incoherent Scatter Radar, SuperDARN and HAARP. ***We summarize current research topics here***.

Thermospheric Weather

We study fluid dynamics of Earth's atmosphere above ~100 km, involving ground-based optical remote sensing, in-situ sounding rocket measurements, and satellite remote sensing, to understand how "space weather" perturbations affect atmospheric conditions in Earth's thermosphere.



Active Plasma Experiments

The Geophysical Institute has a long history in active plasma experiments. Here we show the AZURE (Auroral Zone Upwelling Rocket Experiment). fired from Andøya Space Center, Norway.

Academic Curriculum

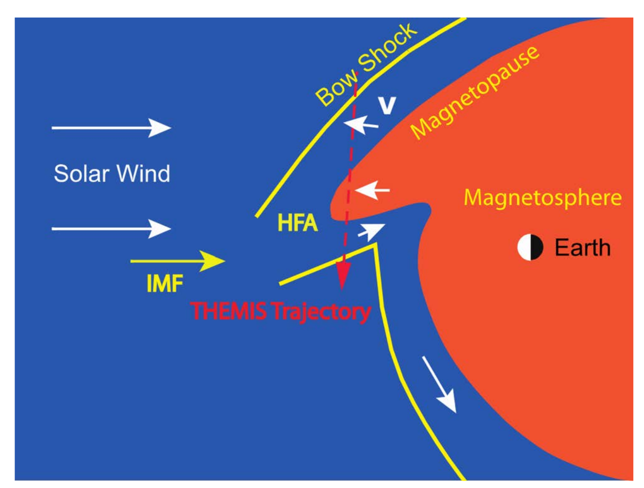
- Fundamentals of Plasma Physics
- Advanced Plasma Physics
- Space Physics
- Magnetospheric Physics
- Aeronomy and Auroral Physics
- Inverse Theory
- Nonlinear Dynamics
- Fundamentals of Geophysical Fluid Dynamics
- Methods of Numerical Simulation of Fluids and Plasmas
- Core Skills (high performance computing)
- +Mathematical Physics, Classical Mechanics, Classical Electrodynamics

Ground-based Optics

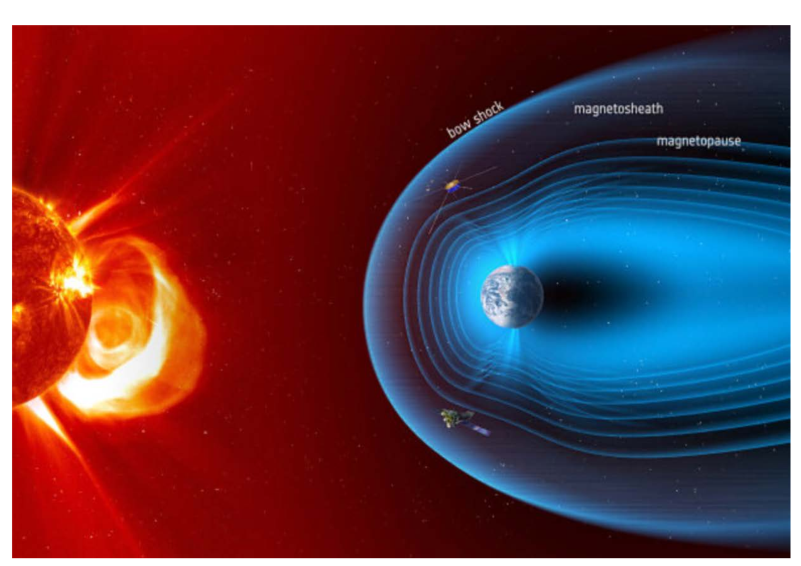
Photo Credit: Jason Ahrns

Transient Phenomena at the Bow Shock

The interaction of the Earth's magnetosphere with the solar wind is a fundamental problem in space plasma physics. Transient processes occurring at the Earth's bow shock can significantly modify the solar wind-magnetosphere-ionosphere interaction.



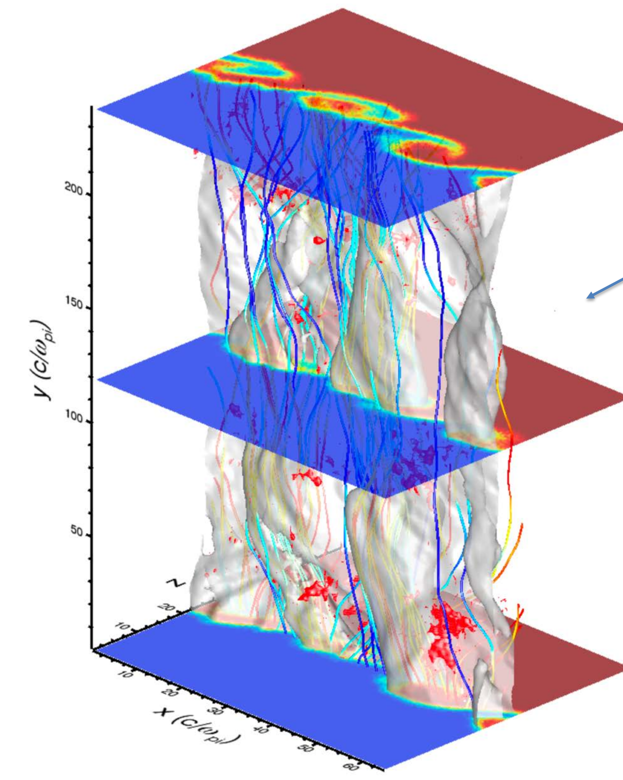
Imaging Earth's Magnetosphere



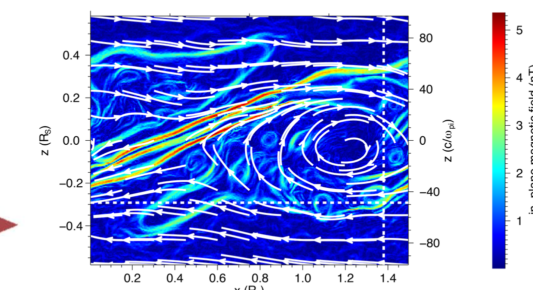
Credit: ESA/ATG medialab

Soft x-rays are used as a diagnostic of the Sun-Earth connection by measuring the solar wind and its dynamic interaction with the magnetosphere.

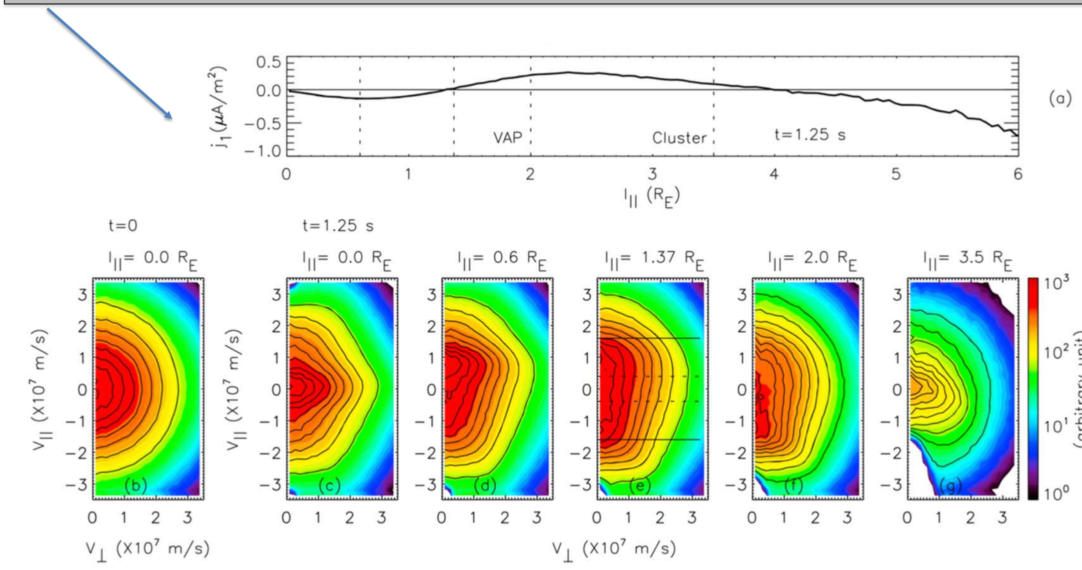
Numerical Simulation



We use numerical simulations to study fundamental processes in space plasmas. Hybrid code simulations of the Kelvin-Helmholtz instability at Saturn. [*Delamere et al.* 2018]

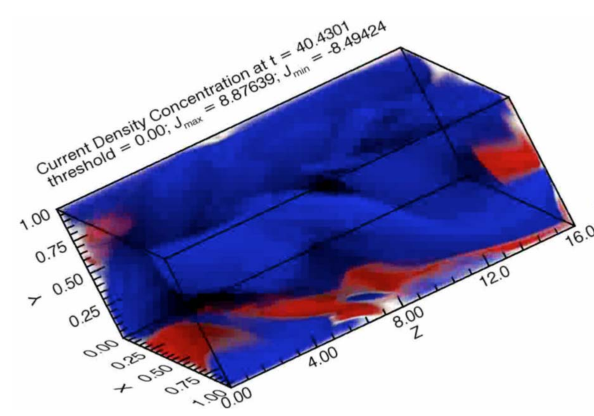


Hybrid fluid-kinetic electron simulations of electron dynamics within a kinetic scale standing Alfven wave in the inner magnetosphere [*Damiano et al.*, [2018].



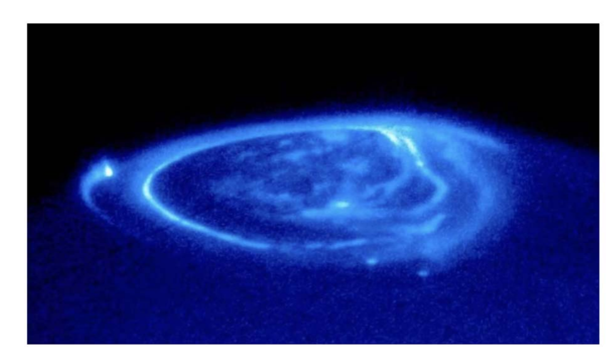
Turbulence and Plasma Heating

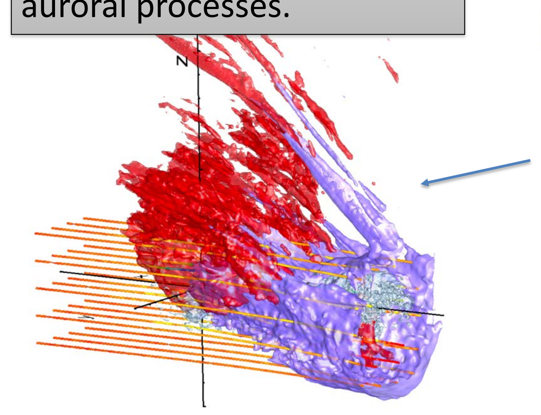
Non-adiabatic heating is ubiquitous in space plasmas. Here we show a 3-D simulation of turbulent heating in the solar corona [*Ng and Dennis*, 2016]



Comparative Magnetospheres

Auroral phenomena occur throughout the solar system. Comparative studies are extremely beneficial for understanding terrestrial magnetospheric physics and auroral processes.

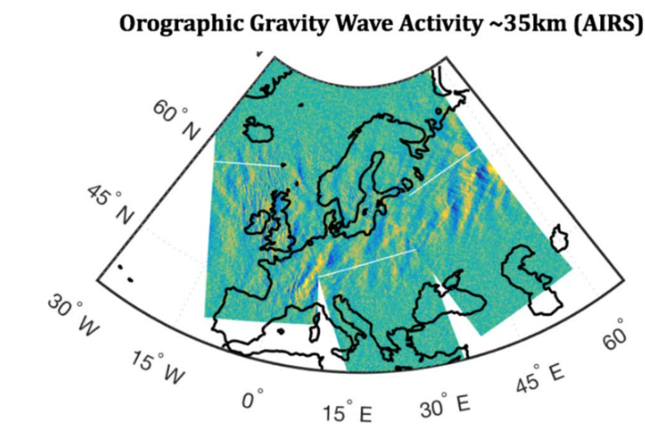




Interaction of Pluto's atmosphere with the solar wind. Hybrid simulations showing the highly asymmetric structures associated with large ion gyromotion.

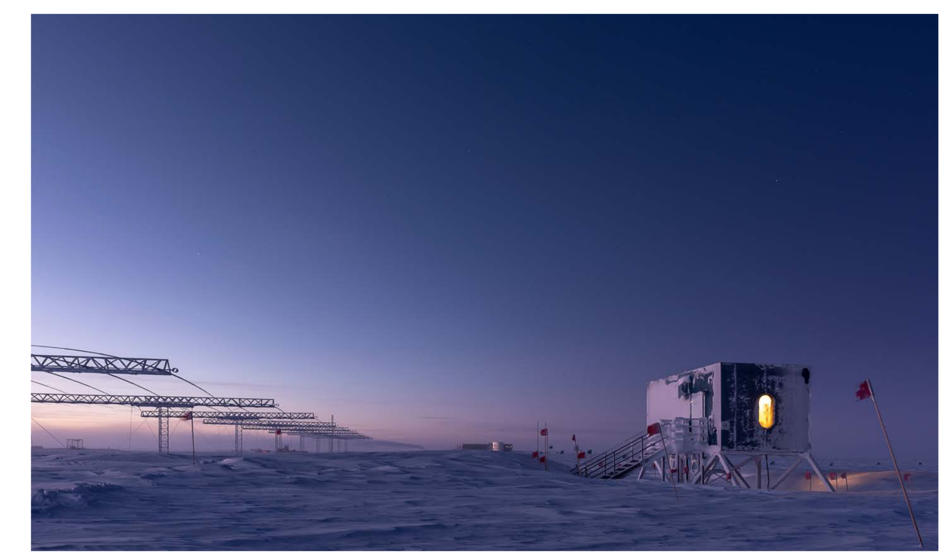
Terrestrial Influences on Space Weather

Terrestrial weather such as strong convection, or windy days in the mountains can have influences which couple into the near Earth space region.



SuperDARN

The Geophysical Institute SuperDARN group operates five radars (Kodiak, Adak East, and Adak West in Alaska, and McMurdo Station, and South Pole Station in Antarctica) and partners with the Japanese National Institute for Information and Communications Technology research for operation of a sixth (King Salmon, Alaska). The figure below shows the South Pole Station radar at a time near sunrise (September 9, 2018), which occurred about two weeks later.



Poker Flat Research Range

Poker Flat Research Range is the world's only scientific rocket launching facility owned by a university. Poker Flat is located approximately 30 miles north of Fairbanks, Alaska and is operated by the University of Alaska's Geophysical Institute under contract to NASA's Wallops Flight Facility, which is part of the Goddard Space Flight Center. In addition to launching sounding rockets, Poker Flat is home to many scientific instruments designed to study the arctic atmosphere and ionosphere.

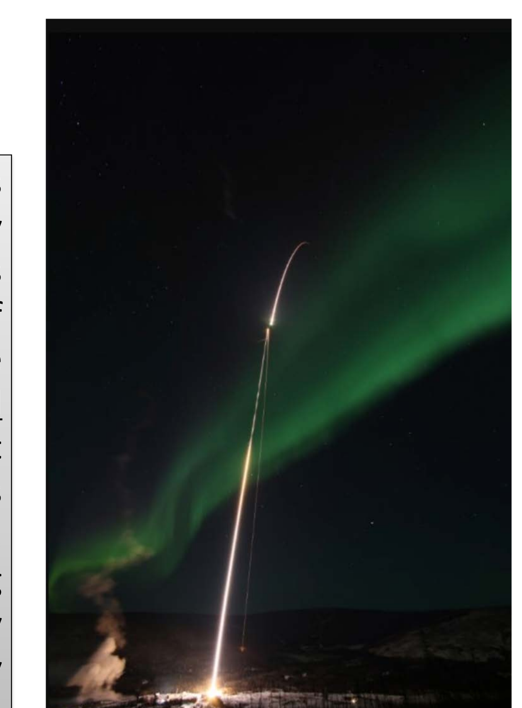


Photo Credit: Merrick Peirce