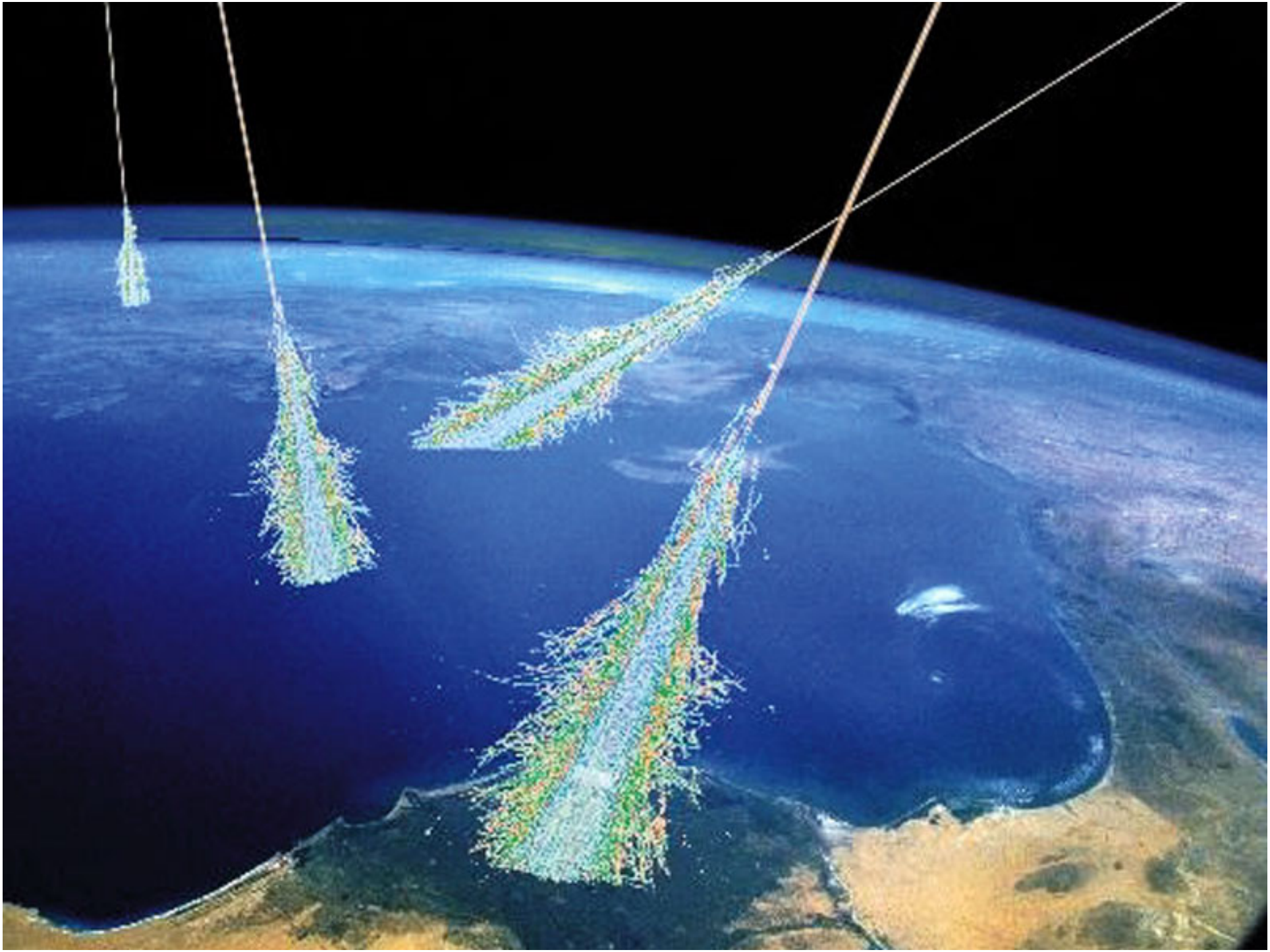
# ESS415/515 Space and Plasmas
# Jan 6, 2014 (First Day)

1. What is a plasma?
2. Why should we require you to study it?
3. Organization of the course

**Next: Introduction to Solar Terrestrial Plasma Physics**



# What is a plasma?
# (Various definitions)

**plasma: (Webster: 1913)** >> (in physics) a state of matter in which charged particles have sufficient energy to move freely, rather than bound in atoms as in ordinary matter; it has some of the properties of a gas, but is a conductor of electricity; plasmas are found naturally in the atmosphere of stars, and can be created in special laboratory apparatus

**plasma (WWWebster Dictionary )**a collection of charged particles (as in the atmospheres of stars or in a metal) containing about equal numbers of positive ions and electrons and exhibiting some properties of a gas but differing from a gas in being a good conductor of electricity and in being affected by a magnetic field

**plasma (Source: WordNet (r) 1.6 [wn] ):** n 1: an electrically neutral ionized gas in an electric discharge; distinctly different from solids and liquids and normal gases 4: (physical chemistry) the gaseous state of hot ionized material consisting of ions and electrons and present in the stars and fusion reactors: sometimes regarded as a fourth state of matter distinct from normal gasses

**plasma (www.encyclopedia.com):** in physics, a fully ionized gas containing approximately equal numbers of positive and negative IONS. A plasma is an electric conductor and is affected by magnetic fields. The study of plasmas, called plasma physics, is important in efforts to produce a controlled fusion reaction (see NUCLEAR ENERGY; NUCLEAR REACTOR). In nature, plasmas occur in the interior of stars and in interstellar gas, making plasma a form of matter in the universe (see STATES OF MATTER).

**plasma (Parks, 1991):** a plasma is composed of a collection of discrete ionized particles, but not every collection of charged particles qualifies as a plasma. In its simplest form, a plasma consists of electrons and one species of ions, for example, proton (p+). A more complex plasma system includes neutral atoms, for example, molecules.

**plasma (Chen, 1984):** A plasma is a quasineutral gas of charged and neutral particles, which exhibits collective behavior. [*collective behavior*: motions that depend not only on local conditions but on the state of the plasma in remote regions as well.]

**plasma (Nicholson, 1983):** A plasma is a gas of charged particles, in which the potential energy of a typical particle due to its nearest neighbor is much smaller than its kinetic energy.

# Why would anyone want to study plasma physics?

(not exhaustive)

- **Needed to explain natural phenomena:**
  - 99.9% of known matter is in the plasma state
  - Aurora borealis, ionospheric currents, radiation belts
  - solar wind, solar activity
- **Practical Uses**
  - Plasma instruments (thrusters, etc)
  - prediction of ionospheric and magnetospheric disturbances
  - communications
  - Fusion Energy
- **Signal source for geophysical phenomena**
  - magnetotelluric currents (MT)
  - magnetic field perturbations
- **Interconnection with atmospheric phenomena**
  - thunderstorms and lightning upward coupling
  - global electric circuit

# Space and Plasmas
# Organization of the course (ESS515/415)

Overview
Introduction to plasma physics (parts of Parks Ch. 2)
magnetic fields in a vacuum (parts of Parks Ch. 3)
Single Particle dynamics in Electric and Magnetic fields (Parks Ch 4)
guiding center approach
particle drifts
adiabatic invariants of motion in dipole field
hot particle dynamics
**MIDTERM**
5. Introduction to Magnetohydrodynamics (MHD) (Parks Ch 5, etc)
MHD equations, Poynting's Theorem and Ohm's Law
Equation of State and Full Set of Equations
Frozen in Condition, Reconnection
Current systems in the magnetosphere
Magnetosphere - putting it all together
**FINAL**
Homework (~7 problem sets) - 50% of grade
Midterm - 20%
Final - 30%
**Office Hours:** by arrangement (usually before or after class can be arranged)
**Electromagnetism Review** (for those who need to brush up on it) - TBD in first 2 weeks.
**WEB page**: http://www.ess.washington.edu/bobholz/ess515/

# Space and Plasmas
# Organization of the course
# (ESS515/415)

- **Overview**
- **Introduction to plasma physics (parts of Parks Ch. 2)**
- **magnetic fields in a vacuum (parts of Parks Ch. 3)**
- **Single Particle dynamics in Electric and Magnetic fields (Parks Ch 4)**
  - **guiding center approach**
  - **particle drifts**
  - **adiabatic invariants of motion in dipole field**
  - **hot particle dynamics**
- **MIDTERM**
- **Introduction to Magnetohydrodynamics (MHD) (Parks Ch. 5)**
  - **MHD equations, Poynting's Theorem and Ohm's Law**
  - **Equation of State and Full Set of Equations**
  - **Frozen in Condition, Reconnection**
- **Current systems in the magnetosphere (Parks)**
  - **Magnetosphere - putting it all together**
- **FINAL**

# Grading

- Homework (~7 problem sets) - 50% of grade
- Midterm - 20%
- Final - 30%
- **Office Hours:** by arrangement (usually before or after class can be arranged)

- **WEB page**: http://earthweb.ess.washington.edu/bobholz/ess515/
- Next: EM Review