

Outline for Today

ESS415/515 Space and Plasmas
day1.2014.html 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 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
- needed for any satellite-based activity

- **Signal source for geophysical phenomena**

- magnetotelluric currents (MT)
- magnetic field perturbations

- **Interconnection with atmospheric phenomena**

- thunderstorms and lightning upward coupling
- global electric circuit

Also see [day1_figures.pdf](#)

Space and Plasmas

Organization of the course (ESS515/415)

(Note: subject to update as we go along)

1. Overview
2. Introduction to plasma physics
3. magnetic fields in a vacuum
4. Single Particle dynamics in Electric and Magnetic fields (3 weeks)
 - guiding center approach
 - particle drifts
 - adiabatic invariants of motion in dipole field
 - hot particle dynamics

MIDTERM

5. Introduction to Magnetohydrodynamics (MHD) (4 weeks)
 - 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/>