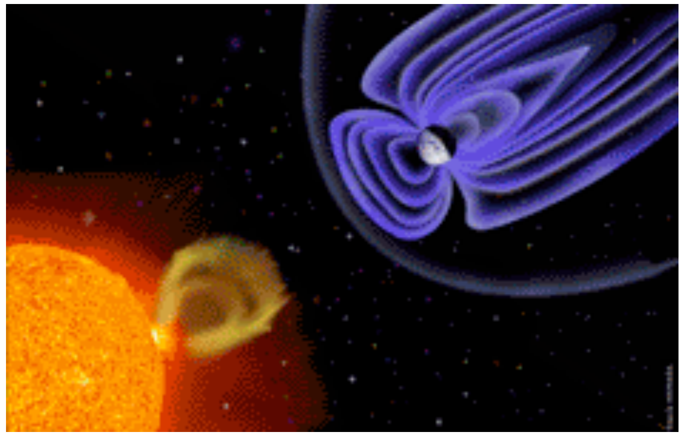
AS703: Introduction to Space Physics

Fall 2014

Course Description



The temperature of the sun's surface is 4000K-5000K, but just outside the surface, in a region called the corona, the temperatures exceed 1.5 million degrees K. The mechanism that heats and sustains these high temperatures remains unexplained. Nevertheless, these high temperatures cause the corona to expel vast quantities of material, creating the solar wind. This plasma wind travels outward from the sun interacting with all solar system bodies. When the solar wind approaches planet Earth, it compresses and distorts the region dominated by the Earth's magnetic field called the magnetosphere. The magnetosphere channels the solar wind around most of the atmosphere and also into the polar regions. This channeling process drives large currents through the magnetosphere and into the charged part of the atmosphere below it; the partially ionized region called the ionosphere. These processes frequently energize particles creating the ring current, the radiation belts, and send energized particles crashing into the neutral atmosphere creating the Aurora Borealis. The field of space physics studies physical phenomena from the Sun's outer layers to the upper atmospheres of the planets and, ultimately, to the point where the Solar wind's influence wanes. Understanding this region enables us to have a space program and to communicate through space. It also gives insight into plasma processes throughout the universe.

The goal of this course is to provide an introduction to space and solar physics. Since the local space environment is predominantly filled by plasma and electromagnetic energy, a substantial amount of time will be dedicated to learning the basics of plasma physics. This course will be followed by AS 727, a plasma physics course that will provide more in-depth knowledge of the behavior of dynamical plasmas.

Mechanics: Times, Dates, & Places

Lecture Time and place: Wednesday and Friday 9:30-10:50am in CAS 502

Instructor: Meers Oppenheim, Office: CAS 517, Work phone: (617) 353-6139 Home phone: (617) 965-7345, FAX: (617) 353-5704, email: meerso@bu.edu

Course WWW page address : At http://learn.bu.edu/ you will be able to see your grades and obtain copies of assignments

Problem solving session/ Office hours: Tuesdays 5-6pm in CAS 500

Office hours: Mondays and Tuesdays, 2:00-3:00 pm, or by appointment or just drop by.

Exam dates: Midterm - Wednesday, Oct. 22 (in class), Final Monday, 12/, 9:00a.m. - 11:00a.m (in class).

Requirements and Grading

- Prerequisites: Junior level electrodynamics, mechanics, statistical mechanics, vector calculus, partial differential equations and complex analysis (or consent of the instructor).
- Problem Sets (25% of grade)
  - Weekly problem set assignments
  - Solutions will be handed out at the time of an assignment's due date in order to provide immediate feedback. Hence, no extensions or late problem sets will be accepted.
  - Students may work in groups but must write up solutions individually.
  - Recommendation: students should initially attempt problems individually.
  - To receive full credit on a problem, a problem set must include a reasonably clear explanation of the method used to obtain a solution. **Note:** Not every problem will be graded.
- Midterm test in class (25% of grade)
- Final exam (45% of grade)
- Class participation (5% of grade)

Academic Conduct

The Dean of CAS/GRS has asked faculty to remind students of the academic conduct code. The objective of the GRS academic conduct code is: "In order to ensure that the academic competence of students be judged fairly, and to promote the integrity of graduate education, the Graduate School embraces two broad principles: (1) No honest student should be put to a disadvantage because of the dishonesty of another student; (2) Penalties should be commensurate with the misdemeanors." Details of this policy can be found at http://www.bu.edu/grs/academics/resources/adp.html.

Bibliography

Assigned texts:

Introduction to Solar System Plasmas by Thomas E. Cravens

Other space physics books:

Introduction to Space Physics by Kivelson and Russell
Introduction to Plasma Physics by D. A. Gurnett and A. Bhattacharjee
Basic Space Plasma Physics by W. Baumjohann and R. Treumann

Recommended Plasma book: *Introduction to Plasma Physics and Controlled Fusion* by F. Chen
More advanced space oriented plasma physics book: *Plasma Physics* by Sturrock (also, costs less than $30)
Ionospheric Physics book: *Ionospheres* by Schunk and Nagy
Ionospheric Physics book: *The Ionosphere* by M. Kelley

Course Outline

I. Introduction to Space and Plasma Physics (Cravens, Ch. 1,3 (skim Ch. 2), Gurnett & Bhattacharjee (B&G) (ch. 1-3, 6); [Kivelson & Russel (K&R), Ch. 1, 2])

   A. Introduction to Space Physics
   B. Review of Electromagnetism
   C. Single Particle Motion

        1. Charged particle motion
        2. Particle Drifts
        3. Adiabatic invariants
    - D. Introduction to the collective behavior of charged particles: Plasma Physics
    - E. Introduction to MHD

- II. The Sun (Cravens Ch. 5, [K&R Ch. 3])
    - A. Structure of the Sun
    - B. Solar Atmosphere & Radiation
    - C. Solar Magnetism & Solar Cycle
    - D. Solar Activity: Flares, Prominences, etc.
- III. Solar Wind (Cravens Ch. 6 & 7, G&B Ch. 6 [K&R Ch. 4 & 5])
    - A. The origin of the Solar Wind: The Solar Corona & Composition
    - B. Solar Wind Outflow
    - C. Solar Wind Magnetism and shocks
    - D. The Heliosphere and Heliopause
    - E. Solar Wind Interactions with Solar System Bodies
- IV. Planetary Atmospheres
    - A. Composition, Structures, & Temperatures of Planetary Atmospheres
    - B. Atmospheric Loss & Evolution
    - C. Atmospheric Dynamics
- V. Ionospheric Physics (Cravens Ch. 7, [K&R Ch. 7 & 14])
    - A. Ionization Production & Losses
    - B. Ionospheric Structure & Chapman Layer Theory
    - C. Diffusion & Transport in the ionosphere
    - D. Radio Wave Transmission, Reflection, and Scattering
    - E. Equatorial Ionospheric Physics
    - F. Auroral Ionospheric Physics
- VI. Magnetospheric Physics (Cravens Ch. 7 & 8 ,[K&R Ch. 6, 9, 10, & 13])
    - A. Solar Wind – Magnetospheric coupling & Magnetic convection
    - B. Magnetospheric structure
    - C. Magnetospheric – Ionospheric coupling
    - D. Magnetospheric Dynamics
- VII. Space Weather