APPH E6101x Site Information

Plasma Physics 1

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General

Welcome to the APPH E6101x class information site.

This is the first semester of a two-semester sequence in plasma physics. Plasma physics is the study of "luminous matter", matter that has been heated sufficiently or prepared specially in order to be ionized. In plasma long-range electromagnetic forces are much more important than short range forces. Plasma dynamics is often dominated by "collective" motion involving the correlated motion of large populations of neighboring particles. Since plasma motion generates electric and magnetic fields, plasma behavior exhibits sometimes very beautiful nonlinear physics.

Plasma is studied in the laboratory and in space. Most of the visiable universe is in the plasma state. Laboratory generated plasma are used to studied the fundamental properties of high-tempeature matter, and they are employed for many valuable applications like surface processing and lighting. Integrated circuits are manufactured using plasma processing, and plasma dispays are status symbols of today's world of entertainment. Controlled fusion energy research reflects the remarkable success of plasma physics. The controlled release of more than 10 MW of fusion power has occured within the strong confining fields of tokamak devices, and the world is now building the first experimental fusion power source, called ITER.

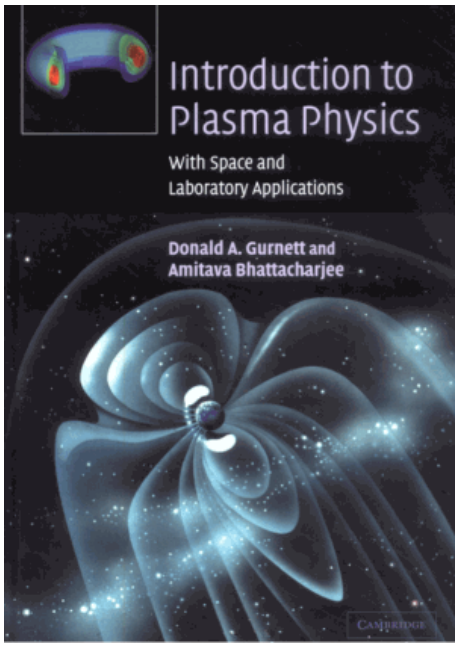
Topics covered include: Motion of charged particles in space- and time-varying electromagnetic fields. Kinetic description of plasmas. Collisional Boltzmann equation (and collision operators in Fokker-Planck forms.) Classical transport equations and collisional relaxation processes. Linear electrostatic and electromagnetic waves in field-free plasmas. Vlasov equation and Landau damping.

APPH 6101 requires a prior experience with electromagnetics (and some electrodynamics) and partial differential equations. The formal pre-requisits are APPH E3300y Applied Electromagnetism and APMA E3102y Applied Mathematics II: Partial Differential Equations. The goal of this course is to provide a solid understanding of both the fundamental aspects of plasma physics and introduce students to research problems in the fields of laboratory and space plasma physics.

Textbook

The primary course textbook is *Introduction to Plasma Physics* by Don Gurnett and Amitava Bhattacharjee. This is an excellent introduction to plasma physics, and we will be following the outline of textbook in the course. The Amazon.com link to this text is here.

I will occasionally refer to another excellent (but **very optional**) textbook that has more examples from the laboratory and from fusion research. This is Introduction to Plasma Physics by Rob Goldtson and Paul Rutherford. (The Amazon.com link to this text is here.)



Instructor & Class Time

Feel free to contact me, Prof. Mike Mauel, anytime. I also try to answer my emails frequently. If you have have question (even if you're stuck on a homework problem), send me an email.

Lectures will be held every Thursday evening, 5:00-7:30 PM, in Room 214, S. W. Mudd Building.

Grading

A student's grade for the course will be based primarily on one *closed-book* midterm (25%) and one final exam (50%). The midterm date will be October 27.

I will also assign weekly homework assignments that count only for about 25% of your final grade. Completing these homeworks will be the most important action you can take to learn the material. Homeworks are due at the beginning of the following class period.

Lectures

This Web Site is a convenient resource for APPH E6101x. (I will also link to materials on the Columbia CourseWorks site for APPH E6101x. After logging into to CourseWorks, you must select "AP 6101" to view and download materials.)

An introduction to the course is available in Adobe PDF format.

Lecture Date	*Subjects*
Sept 8	• Introduction to course and policies • What is a plasma? • Characteristics of the matter in the plasma state • Chapter 2 in Gurnett and Bhattacharjee • Homework #1 (Due Sept. 15)
Sept 15	• Charged particle motion in a magnetic field • Chapter 3 in Gurnett and Bhattacharjee • • Homework #2 (Due Sept. 22)

Sept 22	• Adiabatic invariants • Chaotic orbits • Homework #3 (Due Sept. 29)
Sept 29	• Waves and dispersion relations • Cold plasma waves • Chapter 4 in textbook • Homework #4 (Due Oct. 6)
Oct 6	• More cold plasma waves • Homework #4 (Due Oct. 6)
Oct 13	• Waves in inhomogeneous plasma • Ray paths • Homework #4 (Due Oct. 20)
Oct 20	• Introduction to plasma kinetic theory • Moments: plasma fluids equations • Chapter 5 in textbook • Short review
Oct 27	• **MIDTERM**
Nov 3	• Collisional conductivity and diffusion • Introduction to Magnetohydrodynamics • Chapter 6 in textbook • Homework #5 (Due Nov. 10)
Nov 10	• More MHD • MHD waves • Homework #6 (Due Nov. 17)
Nov 17	• MHD Equillibria • MHD Stability • Homework #7 (Due Dec. 1)
Nov 24	• ***No class (Thanksgiving Holiday)***
Dec 1	• Electrostatic waves using the Vlasov approach • Chapter 8

- Homework #8 (Due Dec. 8)

Dec 8	• Landau damping • Review
TBD	• FINAL EXAM

Plasma Science Links

- Access to the Physics of Plasmas (Requires CU password.)
- Access to Physical Review Letters (Requires CU password.)
- Access to Nuclear Fusion (Requires CU password.)
- APS Division of Plasma Physics
- Yahoo's search list for Plasma Physics
- Wikipedia's page for Plasma Physics
- Fusion Energy Research
  - The Franklin Institute's "Energy Hotlist"
  - PPPL
  - NIF
  - ITER
  - The "Fire Place" (News and information about fusion energy research.)
  - IAEA
- Tim Eastman's Outreach Sites:
  - Tim Eastman's "Plasmas International"
  - Tim Eastman's "Perspectives on Plasmas" site
- Space Weather…
  - spaceweathercenter.org
  - Today's space weather
  - spaceweather.com
  - Rice University's links to space weather
  - NASA's International Solar-Terrestrial Physics (ISTP)

Course Weblog

Since Fall 2004, I have decided to keep a "weblog" (also known as a "blog") about my academic work. When I started, the weblog was intended only for APPH E4010x Introduction to Nuclear Science. I am not sure if anything important will be recorded there. The blog is like an instructor's diary. Based on my experience from last year, the weblog was essentially unused by students except for the occasional glance. (Students are too busy to read this stuff, and I'm too busy to write anything interesting!)

Nevertheless, the link to my (personal) course blog is here. I am not promising to provide frequent updates.

I also have a link to this page from Columbia's CourseWorks site under the APPH E6101x links.

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Go to Prof. Mauel's HomePage
