CSI 769/ASTR 769
Solar and Heliospheric Physics
Syllabus

Prerequisites: Classical Mechanics (PHYS 303), Electromagnetic Theory (PHYS 305), Analytical Geometry and Calculus (MATH 213), or permission of instructor

Credits: 3

Date: Thursday
Time: 4:30 PM to 7:10 PM
Place: Research Bldg 1, room 302

Instructors: Jie Zhang

Contact Info: (703)993-1998 (phone), jzhang7@gmu.edu (e-mail)

Office Hour: 2:00 PM to 3:30 PM, Tuesday, or by appointment

Office: Room 351, Research Bldg 1

Description: This course provides an advanced understanding of physics processes that govern space plasma, with a focus on understanding the structure and dynamics of Sun's atmosphere. The topics include magnetic field (3-D extrapolation, helicity, nullpoint and separator), magnetohydrodynamics (MHD), magnetic reconnection, flare dynamics, coronal mass ejections, shock and particle acceleration, and solar wind. After taking this course, students should (1) have a deep understanding of magnetism and MHD physics, (2) understand the physical mechanisms leading to energetic eruptions, (3) learn state-of-the-art computational tools to model physical processes and compare with observations. Understanding the Sun and heliosphere is also practically important because of the societal need of predicting space weather. This course is intended for graduate students who are interested in space science and astrophysics.

Content:

- Introduction/Overview: Solar Physic and Space Weather
- Plasma radiation
- Maxwell and MHD Equations
- Magnetic Field 1: potential and force free field, helicity
- Magnetic field 2: 3-D morphology, null points, separators
- Magnetic reconnection 1: current sheet
- Magnetic reconnection 2: Magnetic annihilation
- Magnetic reconnection 3: Steady reconnection
- Magnetic reconnection 4: unsteady reconnection
- Solar application 1: classic models of flares and CMEs
- Solar application 2: state-of-the-art models of flares and CMEs
- Heliosphere and solar wind
- Shock and particles
- Shock sheath and magnetic clouds

Homework

6 – 8 assignments

Project:

Students are required to conduct two advanced research projects that involves in-depth physics, advanced data analysis, intensive computation and literature study. The following two projects are suggested: (1) calculating coronal magnetic field using PFSS model, and (2) CME initiation and 3-D magnetic field configuration, or CME evolution and interaction with solar wind.

Exams: one midterm and one comprehensive final exam

Grades:

Homework (20%), Projects (40%), Midterm (15%), Final Exam (25%)

Class URL: http://solar.gmu.edu/teaching/2008_CSI769/

Text Book (required):

1. "Magnetic Reconnection – MHD Theory and Applications", Eric Priest and Terry Forbes, Cambridge University Press, ISBN 0-521-03394-2, 2000

Supplement Reference Books (will be reserved at Johnson Center Library):

2. "Physics of the Solar Corona", Markus J. Aschwanden, Praxis Publishing, ISBN 3-540-30765-6, 2006
3. "An Introduction to Plasmas and Particles in the Heliosphere and Magnetospheres", May-Britt Kallenrode, 2004
4. "Solar and Stellar Magnetic Activity", Carolus J. Schrijver and Cornelis Zwann, 1999
5. "Physics of Space Environment", Tamas I. Gombosi, 1998, Cambridge University Press (ISBN: 0-521-59264-X)

Computational Tools:

- **NASA Community Coordinated Modeling Center: http://ccmc.gsfc.nasa.gov/**