PHYS 672 -- Magnetospheric Physics -- Spring 2016

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Class meets:	MWF 10:30 AM - 11:30 PM, Reichardt Runcorn Room (Room 300)
Office hours:	MWF 9:25 AM - 10:25 AM or by appointment
Credits:	3 credits: 3 hours/week of lecture.
Textbook:	No textbook required
Prerequisites:	Graduate standing; PHYS 626
Course Home Page:	http://www.gi.alaska.edu/~chungsangng/phys672/phys672.html

I. Course Description

The UAF Catalog listing for PHYS 672 Magnetospheric Physics: "The physics and dynamics of Earth's magnetosphere. Discusses the magnetosphere as a test bed for microscopic plasma processes equilibrium configurations, plasma instabilities, highly nonlinear eruptive plasma processes, and global dynamics which involve the interaction of various regions of the magnetosphere. Introduction to various aspects of magnetospheric physics with a systematic discussion of the various elements of the magnetosphere, their structure and dynamics, and a discussion of the relevant plasma physics."

II. Course Goals

The main goal of this course is to introduce the basic observational facts, and theoretical concepts of magnetospheric physics at the graduate level, so that graduate students of space physics can have the basic knowledge and tools to conduct their research. Through working on the project, this course also provides chances for students to practice some independent research and presentation skills.

III. Student Learning Outcomes

- Know the basic structure and dynamics of the magnetosphere.
- Know some basic plasma physics processes related to magnetospheric physics.
- Know how to search the literature independently and be able to the most current status of some aspects of magnetospheric physics.

IV. Textbook

You are not required to purchase any textbook for this course. Lecture notes are mainly based on past lecture notes of this course taught by Prof. Otto, and Prof. Zhang. Some materials could be from the following references:

1. Kivelson and Russell, 1995, Introduction to Space Physics, Cambridge University Press.

2. Baumjohann and Treumann, 1997, 2012, Basic Space Plasma Physics, Imperial College Press.

3. Treumann and Baumjohann, 1997, Advanced Space Plasma Physics, Imperial College Press.

4. Kamide and Chian (Eds.), 2007, Handbook of the Solar-Terrestrial Environment, Springer.

5. Liu and Fujimoto (Eds.), 2011, The Dynamic Magnetosphere, Springer (http://link.springer.com/book/10.1007/978-94-007-0501-2).

6. Gurnett and Bhattacharjee, 2005, Introduction to Plasma Physics: With Space and Laboratory Applications, Cambridge University Press.

7. Parks, 1991, 2003, Physics of Space Plasmas, Addison-Wesley.

8. Gombosi, 1998, Physics of the Space Environment, Cambridge University Press.

9. Khazanov, 2011, Kinetic Theory of the Inner Magnetospheric Plasma, Springer.

10. Schindler, 2006, Physics of Space Plasma Activity, Cambridge University Press.

11. Koskinen, 2011, Physics of Space Storms-From the Solar Surface to the Earth (http://link.springer.com/book/10.1007/978-3-642-00319-6).

12. Eddy, 2009, The Sun, The Earth, and the Near-Earth Space, NASA (ilwsonline.org/publications/SES_Book_Interactive%20508.pdf).

You will find it extremely useful to have some mathematical references, handbooks, or tables, e.g., table of integrals. There are many options available from the Internet, but you should be cautious about the accuracy of information obtained there. One recommendation is Abramowitz and Stegun: Handbook of Mathematical Functions, which can be downloaded freely. Another one is the *NRL Plasma Formulary*, which you can order a free copy or download it online.

There is another textbook that is coming out this year: Russell, Luhmann, and Strangeway, Space Physics An Introduction.

There is a large volume of observation data and general information on magnetospheric physics or space physics in the Internet. Some links are listed in here: http://www.gi.alaska.edu/~chungsangng/phys672/observation.html.

V. Instructional method and reading assignments

The course is for 3 credits, and so 3 hours per week are devoted to lectures in the classroom. However, since this is a graduate level course and that the topics and mathematics are quite advanced, there is not enough time to explains everything in details by lecturing. Students must help themselves by reading and studying before each class. It is also important for students to participate actively during lectures in discussion and asking questions. Reading materials and assignments will be posted on Blackboard.

VI. Homework

Doing homework is very important in order to do well in this class. There will be approximately one homework set assigned per week. Homework questions and due dates will be posted on Blackboard. You should work on your homework as early as possible before a deadline so that you can have time to ask for help during classes or in my office hours if you encounter difficulties in solving these problems. Late homework will not be accepted.

To emphasize the importance of doing homework, homework grade will count towards 30% of the total grade of the course, excluding the assignment with the lowest grade.

While it is good for you to have discussion with classmates or search the Internet for additional information, your submitted homework should be of your own, but not a direct copy from another source. If you finish a question with the help of another person, a solution book, or a solution you found in the Internet or passed on to you from another student, you need to cite that at the end of your answer for that question. There is no deduction of points for using help that you cited if it is not a direct copy. However there can be deduction up to the maximum points of that homework set if you used help but failed to cite. Also, you should use help only to enable you to do a problem yourselves. Keep in mind that you will be required to do similar questions on your own during exams. In addition, it is against the UAF Honor Code to misrepresent work which is not your own. Plagiarism on homework or on an exam will result in a failing grade.

Solutions to the homework problems will be posted on Blackboard after the due date. Therefore, late homework will not be accepted.

VII. Project

Since this course is mainly for graduate students, who are supposed to do physics research, 20% of the total grade will be given for doing a project. Students will be given choices of some review papers on some aspects of magnetospheric physics to study. The final product of the project for this semester will be a 15 minute talk and a presentation file for the talk. Then there will be a few more minutes for questions. There should also be a list of references in the file, although you don't need to read through it. Your talk should cover at least the following aspects: 1. The main points and conclusions of these papers; 2. What do you learn from these papers beyond what are covered in this course; 3. Choose one aspect discussed in these papers. Search for and present some other new development recently (up to last year) related to that particular aspect. Presentations will take place during the last two lecture hours. You should submit your presentation file to me before you present.

VIII. Examinations

There will be one in-class midterm exam and a final exam. See the schedule below for date and time.

Tips for getting more points in an exam: Exam questions will be graded based on the method used, as well as the answer. Therefore, you should write down explicitly and clearly step by step how you come up with your answers. Even if you don't know how to answer a question (or parts of a question), write down everything you can think of that might help formulate an approach to answer it. If you don't know how to answer the first part of a question, you should move on to answer other parts by assuming an answer to the first part. This will help you getting partial credit.

IX. Grading

The final grade will be composed of:

Midterm exam	20 %	Mandatory
Final exam	30 %	Mandatory
Project	20 %	
Homework	30 %	Homework set with lowest grade is dropped
Total:	100 %	

The course will be graded approximately according to the following scale:

> 90 %	A
83 % -- 90 %	A-
76 % -- 83 %	B+
70 % -- 76 %	B
63 % -- 70 %	B-
56 % -- 63 %	C+
50 % -- 56 %	C
43 % -- 50 %	C-
36 % -- 43 %	D+
30 % -- 36 %	D
23 % -- 30 %	D-
< 23 %	F

Note that the passing grade for graduate students is B. Therefore, in order to pass this course, you should get most of the points in homework/project, and to get enough points in exams.

X. Getting Help

My office hours are listed above. I will be at Reichardt 108 during these office hours. Canceled office hours will be announced in class or by email. If you need to see me outside these office hours, please set up a time by appointment to come to my office at Elvey 706E. These are hours set aside especially to help you - do not feel like you are imposing or cheating by coming in. If you have problems that need immediate attention, please send me an e-mail or give me a call at my office phone number.

XI. Disabilities Services

The Physics Department will work with the Office of Disabilities Services (203 WHIT, 474-7043) to provide reasonable accommodation to students with disabilities.

XII. Tentative Schedule

Below is a tentative schedule (subject to change):

Date	Day	Main Topics
1/15	F	Syllabus, Introduction
1/20	W	History/Structure of the Earth's magnetosphere, Coordinate Systems
1/22	F	Basic Equations, Plasma Properties and Parameters
1/25	M	Kinetic or Fluid Equations for Plasmas
1/27	W	Fluid Moments, Typical Fluid Approximations
1/29	F	Two-Fluid or Single Fluid (MHD) Equations
2/1	M	Properties of the Two-Fluid and MHD equations
2/3	W	Representation of Magnetic Fields
2/5	F	Dipole Magnetic Field
2/8	M	Field Line Representation by the Vector potential
2/10	W	Local Magnetic Field Properties, Magnetic Fields and Electrical Current
2/12	F	Electric Fields
2/15	M	Single Particle Dynamics: Gyro Motion, Electric and Polarization Drifts
2/17	W	Magnetic Gradient and Curvature Drifts
2/19	F	Adiabatic Invariants

2/22	M	Bounce Motion of Trapped Particles in the Inner Magnetosphere
2/24	W	Particle Drift Motion, Sources and Sinks of Ring Current Particles
2/26	F	Ring Current: Magnetic disturbance and Storms
2/29	M	Solar Wind
3/2	W	Rankine Hugoniot Conditions and MHD Discontinuities
3/4	F	Hydrodynamic Shocks
3/7	M	MHD Shocks
3/9	W	Foreshocks and deHoffmann-Teller Frame, Bow Shock Structure and Heating
3/11	F	Magnetosheath Flow and Structure
3/21	M	Mid-term Exam
3/23	W	Magnetic reconnection, Diffusion, and Lundquist Number
3/25	F	Sweet-Parker Reconnection
3/28	M	Petschek Reconnection
3/30	W	Application and Further Discussion of Magnetic Reconnection
4/1	F	The Magnetopause: Basic Properties and Observations
4/4	M	Magnetopause Structure, Configuration, Currents
4/6	W	Observation/Models of Magnetopause Reconnection
4/8	F	Viscous Interaction
4/11	M	Magnetotail models
4/13	W	Convection in the Magnetotail
4/15	F	Magnetosphere-Ionosphere Coupling, Currents and Convection in the Ionosphere
4/18	M	Magnetospheric Substorm: Growth Phase
4/20	W	Expansion, Recovery Phases, Steady Magnetospheric Convection
4/25	M	Planetary Magnetospheres: Mercury - Mini Magnetosphere
4/27	W	Jupiter and Saturn - Giant Magnetospheres
4/29	F	Project Presentation 1
5/2	M	Project Presentation 2
5/3	T	Final Exam (10:15 AM to 12:15 PM)

5/9	M	This is absolutely the last day for submitting your late work, if any, to me (by 5 PM), as well as discussing with me about your grades.
5/11	W	Final grades will be submitted by noon. They will also be posted on Blackboard.