AS 785 **Magnetospheric Physics** **Fall 1995**

Instructor: Professor Jeffrey Hughes
Time: 2:00-3:30 Mondays & Wednesdays
Place: The Astronomy and Space Physics Conference Room (Room CAS 500)

Purpose

This course is designed to acquaint graduate students, especially those doing or intending to do research in space physics, with magnetospheres, particularly the terrestrial magnetosphere. The course will cover established magnetospheric theory and phenomenology as well as a discussion of current problems and priorities in the discipline. This course is intended primarily for students who have completed two years of graduate study in Astronomy and passed the Comprehensive Examination. Students of a similar standing in other departments or programs are of course welcome, especially if pursuing research in space physics.

Level of Presentation and Prerequisites

The expectation is that students will have completed the Astronomy courses recommended as preparations for the Comprehensive Examination, or have a working knowledge of that material. The most relevant courses are AS703 (Intro to Space Physics), AS727 (Cosmic Plasma Physics), and AS725 (Cosmic Gas Dynamics), in that order of importance. Students not in the graduate program in astronomy are urged to discuss their participation in the course with the instructor.

Course Content

The course uses as its primary tool magnetohydrodynamics. However, all descriptions of a plasma have shortcomings, so we will occasionally resort to either particle or kinetic descriptions. The magnetosphere itself provides the structure of the course. The initial introduction and discussion of the various ways of describing a plasma, is followed by a discussion of MHD and its usefulness in describing a collisionless plasma. Thereafter the course follows an outside-in approach to the magnetosphere, beginning with the solar wind, bow shock, and magnetosheath, then the magnetopause, and on to the internal structure and dynamics of the magnetopause and its interaction with the ionosphere. As the whole solar wind/magnetosphere/ionosphere system is in reality one large closely coupled system, there is no ideal way to structure the course. But I feel that ordering the material by region emphasizes that magnetospheric physics is an environmental discipline, and that, at least at Boston University, we primarily use physics as a tool to understand out environment, rather than use our environment to understand physics.

For the last 30% or so of the course we will study a series of classic and/or influential papers in magnetospheric physics. The purpose of this is to introduce students to the research literature, and to some of the intellectual history of the discipline, as well as to these classical papers themselves.

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Course Outline

1: Introduction

- 1.1: Review of Magnetospheric Structure and Terminology
- 1.2: Why Do We Study Magnetospheres?
- 1.3: Approaches to a Physical Description of a Plasma

2: Magnetohydrodynamics

- 2.1: The Equations of MDH
- 2.2: Frozen-in-Flux
- 2.3: The Pressure Tensor
- 2.4: MHD Waves and Discontinuities

3: Solar Wind, Bow Shock and Magnetosheath

- 3.1: Review of the Solar Wind
- 3.2: Hydrodynamic and MHD Descriptions
- 3.3: Collisionless Shocks and Upstream Phenomena

4: The Magnetopause and Magnetic Reconnection

- 4.1: Magnetopause Structure and Boundary Layers
- 4.2: Magnetospheric Convection and Magnetic Reconnection
- 4.3: Fluid Descriptions of Reconnection
- 4.4: Particle Descriptions of Reconnection
- 4.5: Reconnection and Boundary Layers

5: Magnetospheric Configuration

- 5.1: Magnetic Field Configuration
- 5.2: Plasma Populations and their Sources
- 5.3: Magnetospheric Currents

6: Magnetosphere/Ionosphere Coupling

- 6.1: Ionospheric Conductivity and Currents
- 6.2: The Vasyliunas Loop
- 6.3: Field Aligned Currents
- 6.4: Mass Exchange: Particle Precipitation and Ionospheric Upflows
- 6.5: Geomagnetism and Magnetic Indices

7: The Dynamic Magnetosphere

- 7.1: Dynamic Solar Wind/ Magnetosphere Coupling
- 7.2: Magnetospheric Substorms
- 7.3: Magnetic Storms and Space Weather
- 7.4: Convection with Northward IMF

8: Waves in the Magnetosphere

- 8.1: MHD Waves and Magnetic Pulsations
- 8.2: Plasma Waves and Instabilities

9: Auroral Phenomena

- 9.1: Auroral Morphology
- 9.2: Auroral Particle Acceleration

Texts

Primary Text:

Introduction to Space Physics, edited by Margaret Kivelson and Christopher Russell, Camb Univ Press, 1995

Other Relevant Books:

Physics of Space Plasmas: An Introduction, George K. Parks, Addison Wesley, 1991

The Solar-Terrestrial Environment – An Introduction to Geospace: The Science of the Terrestrial Upper Atmosphere, Ionosphere and Magnetosphere, J.K. Hargreaves, Camb Univ Press, 1992

Assessment and Grades

Since this is the first time I have taught this course, I have only an approximate idea of how I will assess your performance. But I anticipate that about 50% of the grade will be based on problem sets and assignments, and about 50% on a paper and presentation on one f the classic papers we will study.