PTYS 505A Principles of Planetary Physics

Fall 2013
KSS 312

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class time: MW: 1100-1215
office hours: After class, by appointment, or just about anytime you can find me

Requirements:
You must be proficient (or willing to become so) in vector calculus, differential equations and partial differential equations. You must know, or learn (quickly) a programming language, such as Fortran, C, Matlab, etc.

Grade Distribution:

2D Hydrodynamics Code
Each of you will be required to write a 2D (magneto-)hydrodynamics code. You can write it in any language you prefer (C, Fortran, Matlab, etc.). We will cover in class each step in writing this code (linear diffusion problem, critical Rayleigh number, nonlinear terms) and you will be given a book to guide you through the project. At the end of the semester you will present results from your code (images, movies, quantitative results, etc.). This will give you experience writing and debugging code, something you will have to do throughout your career regardless of your field/discipline. The code will be worth 50% of your grade (breakdown: 15% Critical Rayleigh number, 25% working non-linear code, 10% presentation).

Applications/Paper Reviews
For several of the topics discussed in class you will read planetary science papers where the physics you learned is applied. These will be both new and old papers, reviews and original science. Each of you will be required to read 3 papers from the assigned list, plus one you pick. For each paper you will be expected to: 1) read the paper *in depth and individually* 2) meet with partner to discuss the paper in depth 3) write (with your partner) a review of the paper that includes (at least): A) the main goal and results of the paper, B) a description of the way the goal/results were obtained and C) how the paper fits into what we learned/discussed in class. This written review should not exceed 3 pages. Finally, 4) you and your partner will present the review to the class in a 20 minute talk. For the assigned papers, this will be done in class on scheduled days. For the paper you choose, you will have to choose in pairs and clear the paper with me. These reviews will take place on the last day of lecture and during the final exam. The sum of these reviews will be worth 50% of your grade (12.5% each review).

Problem Sets/Prelim Prep
I will not assign problem sets as I prefer you spend your time working on the code or reading/discussing a paper. However, in light of the prelim, I will hand out the problem sets students received in the previous incarnation of this class. You can expect prelim questions to be like these, or to be directly related to your code development, or the papers we discuss in class. *Note: this provides a strong incentive to give your classmates intelligent, thoughtful and complete reviews of the papers you read. Also, this is an incentive for students other than those assigned to at least skim the papers.

Tentative Schedule and Topics to be covered

1) Kinetic Theory, Boltzmann Equation, Mean-Free Path, Viscosity and the Central Limit theorem:
    Application 1: Saturn's Rings (9/9)
2) Navier-Stokes Equations, Convection, Waves, Geophysical Fluid Dynamics
    Application 2: GFD 10/16
    Application 3: Wave Transport 10/28
3) Dynamic Similarity, Non-Dimensional numbers, Turbulence
    Application 4: Scaling relations in rotating, magnetized convection experiments (11/6)
4) Magnetohydrodynamics, Dynamos, Alfven waves, Magnetism in Solar System, Solar Wind
    Application 5: Geo-, Planetary and Solar Dynamos (11/25)
    Application 6: Magnetism in Exo-planets (12/9)

Tentative Calendar for Code Development

Introduction to the Model Equations -9/23, 9/25 -Linear Code Assigned
Critical Rayleigh number discussion 10/2
Linear Code completed - 10/21
Discussion of Non-linear code - 10/23
Magnetic Equations discussed - 11/6
Nonlinear Code Completed - 12/18

Textbook
There is no suitable textbook to cover all of these topics. However for each topic I will put relevant useful books on reserve in the library. Some useful books:
An Introduction to the Kinetic Theory of Gases, Jeans CUP
Atmospheric and Oceanic Fluid Dynamics, Vallis, Cambridge
Gas Dynamics, Shu
Magnetohydrodynamics, Jackson
* An Introduction to Modeling Convection in Planets and Stars -Glatzmaier (I will hand out a PDF as it is not yet in print)

Application Papers Sign Up:
Note: These are the likely papers, some may change slightly due to class interest. Wild card papers will be announced at least two weeks prior to assigned review.

The Velocity Dispersion in Saturn's Rings (Goldreich & Tremaine 1978): 9/10

The collisional dynamics of particulate disks (Shu & Stewart 1985) : 9/10 *
(Both groups also read: Saturn from Cassini Huygens*: 14.1.1 & 14.1.2) 9/10

(2 papers) Venus' Super-rotation: Leovy 1973 and Leovy 1992 10/15

The Quasi-Biennial Oscillation: Holton & Lindzen (1972)

Wild Card:

Internal Gravity Waves in Massive Stars: Rogers et al 2013

(Two Papers) Jupiters Zonal Jets: Busse 1976 & Williams 1978 10/29

Jet Formation: Dritschel & McIntyre 2008

Scaling Behaviour in Rayleigh-Benard convection with and without rotation (King et al. 2013) 10/29

Wild Card:

On the Genesis of Earth's Magnetism -Roberts & King (2013) Section 4-7 11/12

Dynamo Scaling Laws and Applications to the Planets (Christensen SSR 2010) 11/12

Magnetism in Hot Jupiters A: (two papers) Perna et al. 2010, Perna et al. 2010 (magnetic drag and ohmic dissipation). 11/26

Wild Card:

Dynamics of the Interplanetary Gas and Magnetic Fields, Parker 1958