Astronomy 381: Planetary Astrophysics

Spring 2020

Course Information

Unique Course Number: 46225
Meeting times: T/Th 9:30-11:00 am
Classroom: PMA (RLM) 15.216B
Course website: Canvas (canvas.utexas.edu)

Contact Information

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Office hours: T/Th 11:00am-12:00 pm

Course Description

Over the past quarter century, the field of exoplanets has accelerated from the first detection of a planet orbiting another star to become one of the leading areas of active research in Astronomy. This graduate-level course will introduce students to the dynamic field of planetary systems. Topics will include exoplanet detection methods, formation and migration pathways, demographics and orbital architectures, atmospheres and interiors, statistical properties, and habitability. In addition, students will gain practical experience analyzing actual data sets, reading journal articles, and developing research skills. Requires graduate standing or consent of the instructor.

Course-Level Learning Objectives:

The primary aim of this course is to establish a strong foundation of knowledge and techniques used to interpret the properties of planets and planetary systems. After taking this course, you will be able to:

- Construct physical models of planets and planetary systems to explain observations and make testable predictions.
- Develop and assess ballpark estimates for poorly defined problems in planetary astronomy through "order of magnitude" calculations.
- Formulate and pose fundamental questions about planet formation, detection, and evolution.
- Identify signals from planets in a variety of actual datasets.
- Summarize and critically examine the content of journal articles in astronomy.
- Read and synthesize material from review papers with present-day literature.

Prerequisites: Graduate standing or consent from instructor. Students are expected to be proficient in a programming language of their choice (e.g., Python, IDL) to plot data, graph

functions, and carry out other computational tasks. Students should also have a strong grasp of calculus and mathematical modeling.

Textbooks and Materials

- **Required**: We will use *Exoplanets* (edited by Sara Seager, The University of Arizona Press, 2010) as the primary reference for this course. We will mainly use this book for the fundamentals of planetary dynamics and theory. Some of the observational results are out of date as a result of the rapid progress in the field over the past decade, so additional material will be provided.
- Textbook readings will be supplemented with journal articles and review papers. Access to major scientific journals in Astronomy is required. These are available online when accessing the Astrophysical Data System or publishers' websites through UT. PDFs of these publications will also be posted to Canvas.
- Laptop and familiarity with a programming language to create plots and carry out computational exercises in class. I recommend Python 3 for this, although any language of your choice is fine. Please contact me if you have questions or if you don't have a laptop readily available.

Below are additional references that may be helpful if you would like supplementary material:

- Murray and Dermott, "Solar System Dynamics", 1999
- Perryman, "Exoplanet Handbook", 2nd ed, 2018
- Armitage, "Astrophysics of Planet Formation", 2010
- Seager, "Exoplanet Atmospheres: Physical Processes", 2010
- Goldstein, "Classical Mechanics", 3rd ed., 2001
- "Protostars and Planets VI", Ed. Beuther, Kessen, Dullemond, Henning, 2014

Course Requirements

This course is organized following evidence-based teaching practices that are designed to improve student understanding as well as long-term retention of the material. Students are expected to read the textbook chapters and journal articles ahead of class following the course schedule listed in Canvas. An outline of topics we will cover is included at the bottom of this syllabus. (These may be subject to slight modification throughout the semester). Selected topics will then be reinforced through lectures and discussions in class.

This class will consist of lectures, exercises, and guided activities. Learning assessments will be made through homework, take-home programming projects, and in-class oral reviews of journal articles.

Homework: Homework assignments will be made available at least two weeks before they are due. There will be three assignments during the semester. Each assignment will count for 10% of the final grade, or 30% altogether.

Programming projects: There will be three programming assignments in this course. These will be made available at least two weeks before they are due. Students will be required to submit not only their results, but also a printed copy of the code they wrote. Each assignment will count for 10% of the final grade, or 30% altogether.

For an introduction to Python, I recommend the free textbook "Python for Astronomers: An Introduction to Scientific Computing" by Pasha and Agostino (https://prappleizer.github.io/textbook.pdf). Interactive tutorials can be found here: https://prappleizer.github.io.

In-Class Participation and Journal Article Reviews: This class will be structured with a combination of shorter lectures as well as interactive lessons and activities. These in-class exercises are an important part of the course, so attendance and active participation is very important. The interactive material and discussions are intended to reinforce the concepts in the class and assist you in completing your homework assignments.

Students will sign up to serve as Primary and Secondary Reviewers of research articles and topical review papers throughout the semester. A list of papers with dates will be made available. As Primary or Secondary Reviewer, you are expected to read the paper in advance, complete and submit to me the "Article Questions" sheet before class begins, and present a "chalk talk summary" of the paper to the class. The guidelines for the presentation are as follows:

- Primary Reviewers should give a ~5 min summary addressing the following questions:
    - What was the purpose/motivation of this research or review?
    - What data or methods were used?
    - What is the most important result, and why?
    - What is something you didn't understand?
- Primary Reviewers should then spend ~5 min discussing one specific measurement, equation, or quantitative result you found interesting to share with the class in greater depth.
- The task of Secondary Reviewers is to consider how you might go beyond this paper. You have access to all the ground- and space-based telescopes and supercomputers currently in operation. Spend ~5 min describing what related scientific question you would address and how you could go about answering it with existing resources. Think about what kind of experiment, hypothesis test, or case study you might carry out.
- No slides are allowed, but I will project the paper onto the screen and can scroll to figures or equations. You may bring notes to the board or doc-cam.
- The whole presentation should last about 15-20 min and will be followed with a Q&A from the audience. If you don't know the answer to a question, that's ok! But aim to address any questions as best as possible.

- Note that papers published in Science and Nature usually have a "supplementary material" section that can be accessed through the publisher's website. This usually includes all the important details of the methods and analysis.

By the end of the semester, you must review six papers: 3 as Primary Reviewer and 3 as Secondary Reviewer. 3 of the papers must be journal articles and 3 must be topical reviews. It is your responsibility to sign up for the appropriate number in each category.

When you are not Primary or Secondary, you are expected to read the articles and come up with questions to ask. **You must ask at least six questions during the semester.** These will be tracked, and only one will count per class. The goal of this is to get you used to asking scientific questions, which are an important part of digesting material in casual settings and after scientific talks.

If you do not submit the "Article Questions" beforehand, you can receive half credit by submitting it within one week of the assigned presentation. No credit will be given after that. If there are extenuating circumstances, any option for credit will be at the discretion of the instructor.

Presenting the six papers will make up 30% of your total grade. Asking the six questions will make up 10% of your grade.

There will be no tests or final exam for this course.

Course Policies

Communication:

- The course webpage on the Canvas system will be updated with announcements, supplementary resources, and deadlines. It is your responsibility to check Canvas daily. I recommend setting up email alerts to be notified when I send messages or post assignments. You may also wish to download the mobile app.

- It is also your responsibility to keep track to the administrative deadlines related to the course, for example add/drop dates and Pass/Fail credit deadlines.

- Email is recognized as an official mode of university correspondence. You are responsible for reading your email for both university and course-related information. Please check your email daily.

- All questions related to this course should be directed through Canvas. Please consult this syllabus for answers first!

Courtesy and use of electronics:

- **You are expected to arrive to class on time.** Out of consideration to me and your fellow students, do not leave class early unless you have talked to me in advance.

- Phone use, social media, and texting during lecture or activities is not permitted. Please make sure your phones are silenced before class begins.

Travel:

- As part of my duties as faculty, I may be required to travel during the semester. I will do my best to minimize the impact of this travel and maintain communication while away. When I am gone, I will either cancel class for that day or another UT astronomer will lead the class in my place.

Syllabus Changes:

- I reserve the right to make changes to the syllabus and class schedule, if necessary. If any changes are made they will be announced through Canvas and new versions will be uploaded.

Policy on Deadlines

Missing Homework or Programming Project: **Late homework and projects will not be accepted.** If you do not complete an assignment for emergency reasons, contact me by email within three days of the due date of the assignment. In some situations, late assignments may be accepted at my discretion, but documentation will generally be required.

Missing Presentations: If an emergency or personal event occurs which causes you to miss one of the presentations you are signed up for, you must arrange to switch with someone else and notify me at least 2 days beforehand. If the emergency occurs within 2 days of the presentation and you contact me **prior** to the start of class, I will work with you to schedule a time to make it up. Documentation will generally be required.

Emergencies and University Closings: If an emergency occurs (for example, a death in the family or hospitalization) that influences your performance in the class, you must contact me as soon as possible and provide documentation within one week. I will work with you to schedule a new deadline for homework and projects you missed.

Grading

This class will not be graded on a curve unless I decide to do so after the course has ended. Final grades will be assigned based on the following breakdown:

Homework (30%)
Programming projects (30%)
Journal Article Reviews (30%)
Journal Article Questions (10%)

	93.00% ≤ ***A*** ≤ 100%	90.00% ≤ ***A-*** <93.00%
87.00% ≤ ***B+*** < 90.00%	83.00% ≤ ***B*** < 87.00%	80.00% ≤ ***B-*** < 83.00%
77.00% ≤ ***C+*** < 80.00%	73.00% ≤ ***C*** < 77.00%	70.00% ≤ ***C-*** < 73.00%
67.00% ≤ ***D+*** < 70.00%	63.00% ≤ ***D*** < 67.00%	60.00% ≤ ***D-*** < 63.00%
	F < 60%	

Academic Dishonesty

The University of Texas Honor Code: The core values of The University of Texas at Austin are learning, discovery, freedom, leadership, individual opportunity, and responsibility. Each member of the university is expected to uphold these values through integrity, honesty, trust, fairness, and respect toward peers and community. Students who violate University rules on scholastic dishonesty are subject to disciplinary penalties, including the possibility of failure in the course and/or dismissal from the University. Standards for Academic Integrity are posted at http://deanofstudents.utexas.edu/conduct/index.php

Plagiarism: The University of Texas at Austin takes plagiarism very seriously. This applies to programming projects as well as homework questions. You may read more about plagiarism at the Student Judicial Services website: http://deanofstudents.utexas.edu/conduct/academicintegrity.php

The minimum penalty for cheating is receiving a zero on the assignment on which you cheated. I reserve the right to seek a penalty I deem appropriate for the given case of academic dishonesty, including failing the class and being reported to Student Judicial Services. For more information, read in the General Information Catalog about scholastic dishonesty (i.e. cheating).

Students with Disabilities

Please notify me of any modification/adaptation you may require to accommodate a disability-related need. The University of Texas at Austin provides upon request appropriate academic accommodations for qualified students with disabilities. For more information, contact Services for Students with Disabilities (SSD) at (512) 0471-6259 (voice) or (512) 232-2937 (video phone) or http://diversity.utexas.edu/disability/. If you request academic accommodation for a disability, please provide appropriate documentation from the SSD Office at the beginning of the semester.

Mental Health Services

Graduate life can be challenging and stressful. Diminished mental health, including significant stress, mood changes, excessive worry, or problems with eating and/or sleeping can interfere with optimal academic performance. Similarly, problems with relationships, family worries, loss, or a personal struggle or crisis can also contribute to decreased academic performance.

UT Austin's Counseling and Mental Heath Center (https://cmhc.utexas.edu; 512-471-3515) provides mental health services to support the academic success of students. This includes

counseling services, wellness workshops, free and confidential therapy groups, and general information. I encourage you to browse their website and actively seek support if you're experiencing any of these difficulties.

Harassment and Assault

Harassment of any sort will not be tolerated in this classroom or related workspaces. Title IX makes it clear that violence and harassment based on sex and gender are Civil Rights violations subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories such as race, national origin, etc. If you or someone you know has been harassed or assaulted, you can find the appropriate resources through the University Title IX Coordinator (512-232-3992), UT Austin Campus Police (512-471-4441), the Student Ombuds Services (which can provide *confidential* advice, resources and help; 512-471-3825), and the UT Counseling and Mental Health Center (512-471-3515).

Diversity, Equity, and Inclusion

Astronomy belongs to ***all*** people, independent of race, religion, gender, gender identity, gender expression, or sexual orientation. Incidents of discrimination, assault, harassment, threats, intimidation, profiling, or coercion based on membership or perceived membership will not be tolerated.

Students with Children

I recognize the difficulty of being a full time student with children. If you have children, or other family commitments, please come see me to discuss any modifications of the course policies which will maximize your success in this course.

*Course Schedule**

Week	Topics	Exoplanets**
Week 1	Course overview	Introduction to Exoplanets: Seager & Lissauer, 3
Week 2	Planetary Dynamics	Keplerian Orbits and Dynamics of Exoplanets: Murray & Correia, p. 15
Week 3	Detection Methods: Radial Velocities	Radial Velocity Techniques for Exoplanets: Lovis & Fisher, p. 27
Week 4	Detection Methods: Transits	Exoplanet Transits and Occultations: Winn, p. 55
Week 5	Detection Methods: Direct Imaging	Direct Imaging of Exoplanets: Traub & Oppenheimer, p. 111
Week 6	Detection Methods: Astrometry and Microlensing	Astrometric Detection and Characterization of Exoplanets: Quirrenbach, p. 157; Microlensing by Exoplanets: Gaudi, p. 79
Week 7	The Solar System in Context	
Week 8	Protoplanetary Disks and Planet Formation	Protoplanetary and Debris Disks: Roberge & Kamp, p. 269; Terrestrial Planet Formation: Chambers, p. 297; Giant Planet Migration: D'Angelo, Durisen, & Lissauer, p. 319
Week 9	Planet Migration	Planet Migration: Lubow & Ida, p. 347
Week 10	Planets in Binaries	
Week 11	Planet Statistics and Demographics	Statistical Distribution of Exoplanets: Cumming, p. 191
Week 12	Planet Atmospheres	Giant Planet Atmospheres: Burrows & Orton, p. 419
Week 13	Planet Interiors	Terrestrial Planet Interiors: Sotin, Jackson, & Seager, p. 375; Giant Planet Interior Structure and Thermal Evolution: Fortney, Baraffe, & Militzer, p. 397
Week 14	Brown Dwarfs	
Week 15	Habitability	Terrestrial Planet Atmospheres and Biosignatures: Meadows & Seager, p. 441

** Subject to minor changes*
*** Exoplanets, ed. S. Seager, The University of Arizona Press*