ASTR 435: Astrophysics of Exoplanets
Spring 2023

Lectures: 3:30 p.m. - 4:45 p.m. TuTh, ATL 1113
Instructor: Assistant Prof. Thaddeus Komacek (he/him)
Contact information: Office: PSC 1116, e-mail: tkomacek@umd.edu
Preferred contact: I prefer for students to contact me at office hours (see below) or immediately after class. Please don't hesitate to send an email if something urgent comes up.
Office Hours: Wednesday 3 p.m. - 4 p.m., Friday 11 a.m. - 12:00 p.m., immediately after class, or by appointment. Office hours will be in person by default, but if you contact me in advance we can arrange to meet over Zoom.
ELMS Webpage: All course content (lecture slides, problem sets, project information) will be hosted on the ELMS webpage. Solutions for all assignments will be made available to students on ELMS one week after the due date.
Required Textbook: "The Exoplanet Handbook" by Perryman, 2nd Edition, Cambridge University Press, ISBN 978-1-108-41977-2. Note that because the field of exoplanets is rapidly evolving, this 2018 textbook will not suffice for a full picture of the current study of exoplanets. As a result, we will also read additional handouts (posted on ELMS) that both will fill in gaps in the textbook and provide an up-to-date understanding of exoplanet research.

This course will provide an introduction to the current state of the field of exoplanet research. This course is appropriate for upper-level astronomy majors and students who have a dedicated interest in preparing for a level of knowledge in the study of exoplanets that will prepare them to get involved in current research. In this course, we will cover three primary topics: 1) the various methods by which astronomers detect exoplanets, 2) the demographics of known exoplanets and the implications for our understanding of planet formation synthesizing knowledge of both exoplanets and our Solar System, 3) characterizing the properties of exoplanets, including their atmospheres, interiors, surfaces, and potential for habitability.

Course Schedule
See Table 1 on the following page.

Assignments

In-class participation: Approximately 30 minutes of each class session will consist of exercises that we will complete either as a class or in small groups. Due to the collaborative nature of this work, collegial participation will be critical to each class session. As a result, I will grade on participation – to receive a high mark, please attend class regularly, ask thoughtful questions whenever you have them, answer questions and attempt in-class problems (being correct does not matter for grading), and treat everyone in the classroom with respect.

Pre-class reading questions: Every lecture will be accompanied by required reading from the textbook and/or articles and papers on the topic to be covered, along with course notes that I will share via Overleaf and post on ELMS. Please send me a question about each reading assignment by 9 am the day of each class (i.e., on Tuesday and Thursday mornings),

Date	Topic(s)	Assigned reading
Jan. 26	Course overview, formation of Solar System	Ch. 12.1-12.4
Jan. 31	Detection techniques: radial velocity	Ch. 2.1-2.4, 2.6-2.7
Feb. 2	Detection techniques: astrometry	Ch. 3.1-3.9
Feb. 7	Detection techniques: transits	Ch. 6.1-6.6, 6.13
Feb. 9	Detection techniques: timing	Ch. 4.1-4.2, Ch. 6.20
Feb. 14	Detection techniques: microlensing	Ch. 5.1-5.4
Feb. 16	Detection techniques: direct imaging	Ch. 7.1-7.5
Feb. 21	Inter-comparison of detection techniques	Handout (Wright)
Feb. 23	**Midterm 1**	None
Feb. 28	Exoplanet demographics: detections	Ch. 2.10-2.12, 5.10, 6.25-6.26, 7.10
Mar. 2	Exoplanet demographics: occurrence rates	Handout (Fulton)
Mar. 7	Planet formation: protoplanetary and debris disks	Armitage notes Ch. II
Mar. 9	Planet formation: from pebbles to planetesimals	Armitage notes Ch. III A-B
Mar. 14	Planet formation: formation of rocky and gaseous planets	Armitage notes Ch. III C
Mar. 16	Planet formation: orbital migration and evolution	Armitage notes Ch. IV
Mar. 21	Spring break	None
Mar. 23	Spring break	None
Mar. 28	Guest lecture (*Prof. Komacek at conference*)	TBD
Mar. 30	**Midterm 2** (*Prof. Komacek at conference*)	None
Apr. 4	Exoplanet atmospheres: thermal structure	Handout (Seager)
Apr. 6	Exoplanet atmospheres: loss, composition and chemistry	Handout (Zhang Ch. 3, 5)
Apr. 11	Giant planet interiors and evolution	Handout (Fortney)
Apr. 13	Terrestrial planet interiors and volatile cycling	Handout (Sotin)
Apr. 18	Exoplanet characterization: transmission spectroscopy	Handout (Kreidberg)
Apr. 20	Exoplanet characterization: emission spectroscopy	Handout (Deming)
Apr. 25	Exoplanet characterization: phase curves	Handout (Zhang Ch. 4.3-4.4)
Apr. 27	Exoplanet characterization: atmospheric dynamics	Handout (Zhang Ch. 6)
May 2	Habitability and biosignatures	Ch. 11.7-11.8, Handout (Meadows)
May 4	**Midterm 3**	None
May 9	Future missions & facilities	Handout (Decadal Ch.1-2)
May 11	The next three decades of exoplanet science	Handout (Decadal App. E)
May 19	Final presentations, 10:30 am - 12:30 pm	

Table 1: Preliminary schedule. Any changes will be updated on ELMS.

either via email or using the "review" feature on Overleaf (I will turn on email notifications). Questions submitted via email should be sent to `tkomacek@umd.edu` and contain "ASTR 435" in the subject. I will grade your reading questions on a 2 point scale, where 2 indicates that you have diligently read the material, 1 indicates room for improvement, and 0 is incomplete or unsatisfactory. Late reading assignments will not be accepted.

Problem sets: Problem sets will reinforce your knowledge of material that we cover in class, and provide you with a deeper understanding of exoplanet science. Problem sets will consist of a mixture of derivations, problem solving, and numerical modeling. All problem sets that require coding will require knowledge of Python, and in some cases where another language may be required (e.g., a small amount of Fortran for MESA simulations) I will provide detailed instructions. Problem sets will generally be assigned on Thursday and due prior to the start of class the following Thursday, though for some more detailed problem sets requiring numerical modeling you will have two weeks. Problem sets must be handed in electronically on ELMS (or physically, if you prefer) by the start of the lecture (3:30 p.m.) on the due date, and will be accepted for a flat 2/3 credit up to a week after the due date. Problem sets handed in more than a week after the due date will not be accepted (because the solutions will be posted then).

Exams: There will be three midterm exams on the dates outlined in the course schedule above. Each exam will only cover material since the last exam – i.e., they will not be cumulative. That said, the material in our course will naturally build upon what we learn earlier in the semester. The first midterm will cover exoplanet detection techniques and our understanding of the Solar System. The second midterm will cover exoplanet demographics and the implications for planet formation. The final midterm will cover exoplanet atmospheres, interiors, surfaces, and habitability.

Project & Presentation: This course aims to provide you with the basic tools needed to conduct research in the field of exoplanets. A key skillset required to conduct research is the ability to formulate scientific questions and express your ideas in both written and oral form. To provide you with the opportunity to develop your own research idea related to exoplanets, each student will complete an individual project that will take the place of the final exam and that will be worth the same as a mid-term exam. This project will comprise a written proposal (based on the NSF GFRP) on a novel research project as an application of the topics we learn in class this semester, along with a 5-minute presentation with 2 minutes for questions (similar in format to a AAS conference talk) during the final exam slot. The written project will be due at the beginning of the final exam slot, 10:30 am on May 19, and the presentations will take place from 10:30 am - 12:30 pm on May 19.

Grading

Below is the distribution of grades for the course.

Mid-term 1: 15%

Mid-term 2: 15%.

Mid-term 3: 15%.

Problem sets: 20%. The lowest problem set will be dropped.

In-class participation: 15%. The lowest in-class assignment will be dropped.

Pre-class reading questions: 5%. The lowest pre-class assignment will be dropped.

Project: 15%. The written component will comprise 2/3 of the project grade, and the

oral presentation will comprise 1/3 of the project grade.

The cumulative grading distribution is as follows:

A+ 97-100%	A 93-97%	A- 90-93%	B+ 87-90%	B 83-87%	B- 80-83%
C+ 77-80%	C 71-77%	C- 66-71%	D 60-66%	D- 57-60%	F $<$ 57%

Final course grades may be "curved" upwards, but will not be curved downward from this scale. As a result, the letter grades above are your *minimum* grade for a given cumulative grade percentage.

Course and University Policies

You can find the university-wide course policies at `https://www.ugst.umd.edu/courserelatedpolicies.html`. Below are snippets of specific policies that are especially relevant to this class, along with further discussion of class-specific policies. Please see related tabs on the course policies webpage for links that provide further details on university policies.

COVID-related guidelines:

Note that the public health situation may change abruptly. This course will follow all official UMD guidelines, which will be posted on the University Health & Safety page at `https://umd.edu/4Maryland/health-plan`. I will provide an update to students at the beginning of class at any point where health guidelines affect how this course will operate.

Academic integrity:

The UMD academic integrity guidelines are listed in part below.

UMD maintains a commitment to the principles of truth and academic honesty. Accordingly, the Code of Academic Integrity is designed to ensure that the principle of academic honesty is upheld. While all members of the University share this responsibility, the Code of Academic Integrity is designed so that special responsibility for upholding the principle of academic honesty lies with you as a student.

To promote academic honesty on campus you will be asked by your course instructor to write by hand and sign the following pledge on every examination. Writing this pledge will serve as a reminder of your commitment to academic integrity.

I pledge on my honor that I have not given or received any unauthorized assistance on this examination.

Failure to sign the pledge is not a violation of the Code of Academic Integrity, but neither is it a defense in case of violation of this Code. Students who do not sign the pledge will be given the opportunity to do so. Refusal to sign must be explained to the instructor. Signing or non-signing of the pledge will not be considered in grading or judicial procedures. Material submitted electronically should contain the pledge, submission implies signing the pledge. On examinations, no assistance is authorized unless given by or expressly allowed by the instructor. On other assignments, the pledge means that the assignment has been

done without academic dishonesty, as defined below.

Code of Academic Integrity defines five major types of Academic Dishonesty:
Cheating: fraud, deceit, or dishonesty in any academic course or exercise in an attempt to gain an unfair advantage and/or using or attempting to use unauthorized materials, information, or study aids in any academic course or exercise.
Fabrication: unauthorized falsification or invention of any information or citation in an academic course or exercise.
Facilitating Academic dishonesty: knowingly helping or attempting to help another to violate any provision of this Code.
Plagarism: representing the words or ideas of another as one's own in any academic course or exercise.
Self-plagarism: the reuse of substantial identical or nearly identical portions of one's own work in multiple courses without prior permission from the current instructor or from each of the instructors if the work is being submitted for multiple courses in the same semester.

Specific to this class: Please note that the University Code of Academic Integrity applies to all aspects of this class, including exams, homework, and activities. Students are encouraged to discuss assignments and other class material with one another, but copying or pharaphrasing from other students' written answers is not permitted. All written work must be a students' own, and even if you discussed the problem with other students (which is completely okay, and even encouraged) the answers must be fully in your own words. Similarly, posting answers in group chats or social media and copying answers from those sources is not allowed and constitutes plagiarism. Additionally, copying from websites, e.g. chegg.com, is plagiarism and is not permitted. All written work submitted via ELMS-Canvas will be checked using Turnitin for evidence of plagiarism. **If you collaborate on a problem set, you must state the names of the students with whom you collaborated on the assignment and submit your own individual solutions, written without consulting the solutions of your peers.**

Attendance and Missed Assignments:
The UMD excused absence policy is listed in part below.
An excused absence is an absence for which the student has the right to receive –and the instructor has the responsibility to provide– academic accommodation.

Students are expected to take full responsibility for their own academic work and progress. Students, to progress satisfactorily, must meet all of the requirements of each course for which they are registered. Students are expected to attend classes regularly. Consistent attendance offers students the most effective opportunity to gain command of course concepts and materials. Excused absences must be requested promptly and must be supported by appropriate documentation.

Excused absences do not alter the academic requirements for the course. Students are responsible for information and material missed on the day of absence. Students are within reason entitled to receive any materials provided to the class during the absence. Students

are responsible for making provision to determine what course material they have missed and for completing required exercises in a timely manner.

Events that justify an excused absence include:
Religious observances
Mandatory military obligation
Illness of the student or illness of an immediate family member
Participation in university activities at the request of university authorities
Compelling circumstances beyond the student's control (e.g., death in the family, required court appearance)
Absences stemming from work duties other than military obligation (e.g., unexpected changes in shift assignments) and traffic/transit problems do not typically qualify for excused absence.

Specific to this class: Even if you have an excused absence, homework must be handed in electronically by the due date. In-class exercises may be done as homework if you have an excused absence from class, due one week from the original in-class assignment date. If you have an excused absence due to illness on the date an assignment is due, it can be turned in with no penalty one week from the original due date. Contact Prof. Komacek via e-mail if you have a prolonged illness or if you miss an exam due to illness. Please also contact Prof. Komacek if you have religious, military, university activity, or other compelling circumstances before missing class in order to arrange for make-up work.

Accessibility:
The University of Maryland is committed to creating and maintaining a welcoming and inclusive educational, working, and living environment for people of all abilities. The University of Maryland is also committed to the principle that no qualified individual with a disability shall, on the basis of disability, be excluded from participation in or be denied the benefits of the services, programs, or activities of the University, or be subjected to discrimination. The University of Maryland provides reasonable accommodations to qualified individuals. Reasonable accommodations shall be made in a timely manner and on an individualized and flexible basis.

Discrimination against individuals on the grounds of disability is prohibited. The University also strictly prohibits retaliation against persons arising in connection with the assertion of rights under this Policy.

Accessibility & Disability Service (ADS) facilitates reasonable accommodations to qualified individuals. For assistance in obtaining an accommodation, contact Accessibility and Disability Service at 301.314.7682, or adsfrontdesk@umd.edu. More information is available at `counseling.umd.edu/ads/`.

Specific to this class: Students with a documented disability should contact Prof. Komacek ASAP to discuss any concerns you have and to develop a detailed plan for ensuring that you have an equitable chance to fully participate in this course.

Mental Health and Physical Wellness:

UMD Health Center (`https://www.health.umd.edu`): Provides many services including Primary Care, Immunizations, Physical Therapy, LGBTQ+ Health and Wellness, Substance Use Intervention and Treatment, or a Massage. Call 301-314-8184 for appointments. You may walk in to the Health Center if you have an urgent concern including if you have a high fever, if you are concerned about a friend at risk, are experiencing a panic attack or are feeling suicidal. For Emergencies always call 911.

Counseling Center (`https://www.counseling.umd.edu`): Is the primary campus provider for psychological and consultation services offering free and confidential counseling sessions to registered UMD students, they also offer workshops and a Safe and Inclusive Support drop in hour. Call 301-314-7651 for an appointment.

If you have an urgent concern, you may walk in to the center and receive counseling without an appointment. After Hours: call Counseling Center After-Hours Crisis Support at 301-314-7651.

Maryland Psychotherapy Clinic and Research Lab (`http://www.mpcrl.umd.edu/Home_FINAL.html`): Provides low-cost counseling and psychotherapy to adults in the Prince George's, Montgomery County, and Washington, D.C. area.

HELP Center (`https://www.counseling.umd.edu/cs/immediatehelp/`): Is University of Maryland's student-run peer counseling and crisis intervention hotline that provides free and confidential help to the UMD community. Anyone affiliated with the university can call and be connected to student counselors who are trained to help with any problems you may be facing. All calls are kept strictly confidential. No issue is too big or small. We also provide walk-in counseling and free, confidential pregnancy tests without an appointment. For peer to peer support or call the HELP Center hotline 301-314-4357.

Campus Advocates Respond and Educate (C.A.R.E.) (`https://health.umd.edu/CARE`): Provides resources and options for those impacted by sexual assault, dating or domestic violence. CARE is not an official reporting entity; we are a resource that can help you navigate your options and connect you with the appropriate resources. CARE keeps information private and confidential. You can even be anonymous. According to Title IX of the Educational Amendments of 1972, sexual harassment is prohibited. Under Title IX, sexual assault is considered a form of sexual harassment. View the University of Maryland's Sexual Misconduct Policy at ocrsm.umd.edu.

You can also call the Stop Violence Hotline 301-741-3442 (24 hours).

Campus Chaplains (`https://thestamp.umd.edu/Memorial_Chapel/Chaplains`): In the open, inclusive environment of many cultures and faiths, the Chaplaincies work collectively to serve the spiritual needs of the University of Maryland. Call 301-314-9866.

Non-discrimination:

The Non-Discrimination Policy prohibits discrimination and harassment on the basis of "protected classes." Protected classes include: race, color, sex, gender identity or expression,

sexual orientation, marital status, age, national origin, political affiliation, physical or mental disability, religion, protected veteran status, genetic information, and any other legally protected class. The Non-Discrimination Policy also prohibits retaliation against any individual who files a complaint or participates in an investigation under the Policy.

The Office of Civil Rights Sexual Misconduct (OCRSM) responds to all complaints of discrimination, harassment, and retaliation based on a protected class. To file a complaint go to OCRSM (`https://www.ocrsm.umd.edu`) and under Reporting, complete the online complaint form. For more information please contact OCRSM by phone at 301-405-1142, or email civilrights@umd.edu.

Civility and Respect:
The University of Maryland promotes civility and respectful treatment among all members of its diverse campus community, and fosters the discovery and dissemination of knowledge through the free and open exchange of ideas. The University values and protects the intellectual and academic freedom, freedom of speech, and freedom of expression of all students, faculty, and staff. The University provides a welcoming and inclusive environment to enable all members of the University community to pursue their academic, personal, and professional goals. Threatening or intimidating conduct directed toward members of the University community that is motivated by their actual or perceived protected status interferes with these values and commitments, and is therefore prohibited.

The University prohibits threatening or intimidating acts motivated in whole or in part because of an individual or group's actual or perceived protected status, including the following:

Threats: Expressions of intent to commit an act or acts of physical violence to a particular individual or group of individuals or to cause damage to their property; or to engage in an act or acts which endangers the health and safety of another person.
Intimidation: An act or acts that is intended to or that recklessly frightens or coerces and that places another person or persons in reasonable fear of imminent harm.

Protected status is defined in state and federal law as well as in the University of Maryland NonDiscrimination Policy and Procedures VI-1.00(B). The Code of Student Conduct V-1.00(B) addresses prohibited conduct by students, including the conduct outlined above.

Bias Incident Support Services (BISS) addresses hate-bias incidents targeting UMD students, faculty and staff. The program responds, educates and reports to the campus community about bias and its impact, and maintains the Bias Incident Response Protocol. The program is housed under the Office of Diversity Inclusion. 301-405-2842, or biassupport@umd.edu. To report hate-bias incidents use the online Hate-Bias Incident Report Form (`https://pdc-svpaap1.umd.edu/ci-rpf313/odi/Odi/somerpt`)

Add/drop deadlines: The course add/drop deadline without withdrawal ('W') is February 7. The course add/drop deadline with a withdrawal ('W') is April 11. See

https://www.registrar.umd.edu/deadlines.html for more information.

University Resources

Below is a sample of university resources that you may find helpful during the course of the semester. You can find links to further relevant resources at the UMD Course Policies webpage.

Writing center: UMD offers live tutoring and 24-hour feedback for your writing as part of your undergraduate enrollment. I strongly recommend taking advantage of this resource, especially for the two homework essays due in the latter part of this course. See https://english.umd.edu/writing-programs/writing-center for more information.

One Button Studio: UMD has easy-to-use "One Button" recording studios throughout campus that include high-resolution cameras, studio microphones, and a projector. These enable people with no production experience to make high-quality video recordings, such as those for the class project. Please see https://faculty.umd.edu/1button-studios for more information on how to access the One Button Studios.

Basic Needs Security: UMD has a campus food pantry, network that assists with food and stable housing and otherwise assists students who are/were in foster care, houseless, or without a supportive family system, and a student crisis fund for those who are in need of immediate financial support. Please see https://studentaffairs.umd.edu/basic-needs-security for more information.