ASTR 420/620 - Exoplanets – Syllabus

Lecture: MW 1:30pm-2:45pm – Planetary Hall 220

Instructor: Dr. Peter Plavchan

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Office: Planetary 243
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Office Hours: TBD

Materials:

Required: *The Exoplanet Handbook* by Perryman

Required: *How Do You Find an Exoplanet* by Johnson

Reference: *Exoplanets* by Seager

Reference: *Exoplanet Atmospheres* by Seager

Exams: None

Homework: There will be homeworks and group projects, covering material from the class.

Grading Policy:

Homeworks	70%
Project Paper	20%
Project Presentation	10%

A curve will be applied.

Grade determined as follows: Median class course grade will be curved to a B+/A-.

Course Outline – ASTR 420/620 – 2018 Spring Semester

Class Date	Week #	Lecture Topics	Notes
1/22	1	Course Overview; Exoplanet History	HW1 out
1/27	2	--	Class canceled: prof travel; Train on telescope & CCD

Class Date	Week #	Lecture Topics	Notes
1/29	2	--	Class canceled: prof travel; Train on telescope & CCD
2/3	3	Solar System Formation & Review	HW 1 due; HW2 out
2/5	3		
2/10	4	Keplerian Orbits Pt 1	
2/12	4	--	Class likely canceled: prof travel
2/17	5	Keplerian Orbits Pt 2	
2/19	5		
2/24	6	Detection Techniques: Transits	
2/26	6		
3/2	7	ExoStats	
3/4	7		
3/9	8	--	Spring Break
3/11	8	--	Spring Break
3/16	9	Detection Techniques: Radial Velocities	
3/18	9		Class likely canceled: prof travel
3/23	10		Class likely canceled: prof travel
3/25	10	Detection Techniques: Direct Imaging & Future Space Missions	
3/30	11	Detection Techniques: Timing & Microlensing	
4/1	11		
4/6	12	Exoplanet Demographics	
4/8	12		
4/13	13	Planet Formation	
4/15	13		
4/20	14	Planetary Atmospheres	
4/22	14		
4/27	15	Planetary Habitability	
4/29	15		
5/4	16	Project Presentations	Last Class

Course Description:

Are there other Earth-like planets out there? Humanity has pondered this question for millenia. Over the past 25 years, over 3000 exoplanets have been confirmed and/or validated to orbit other stars. These discoveries accelerated with the launch of the NASA Kepler mission in 2009, and will continue to accelerate with the launch of future NASA and European missions such as TESS, the James Webb Space and WFIRST, and with new ground-based observatories and instrumentation. We now know exoplanets outnumber stars in our Galaxy, and that Earth-mass exoplanets with the potential for liquid surface water exist by the billions in our Galaxy alone. Science fiction is now science fact.

This course will cover the modern knowledge of exoplanets, including the recent history of the field, the different discovery methods, important benchmark exoplanets and exoplanetary systems, and the characterization of exoplanet demographics, composition and atmospheres. We will explore the different tools and techniques employed, making use of theory, simulation, archival research and observations. The field of exoplanet science is fundamentally driven by a revolution in the obtainable precision of traditional astronomical measurements, which have in turn been enabled by new technology, the exploitation of the time domain, and new advanced algorithms that take advantage of increasing computational resources and improved statistical methods. In this course, we will make use of the technology, algorithms, and statistical methods that underlie these advances in precision and look towards the future unexplored vistas of the exoplanet field.

Overall goal:

The goal of this course is to introduce you to the theoretical, observational, statistical, computational techniques used by exoplanet astronomers.

The skills you will develop in this class are extremely useful for a wide variety of careers including, but not limited to, astronomy. We are committed to making this course useful for your future career goals, whatever they may be. Please let us know what those goals are, as best you know them at this stage. We want to help you see how you might apply what you are learning and shape the course to best meet your goals, where that is possible.

Specific goals:

- You will be able to operate the campus telescope such that you can select a source, take a sequence of images of your source and the necessary calibration images, and use AstroImageJ to generate a light curve of a transiting exoplanet.
- You will show that you can extract information from light curves of transiting exoplanets to draw scientific conclusions about the exoplanet that you have observed.

- You will show that you can evaluate the statistical significance of the conclusions you draw from your observational data.
- You will gain experience executing custom computational programs and tools for data analysis. You will be able to run custom programs independently and understand the process of creating your own computational tools.
- You will show that you can describe scientific work to a variety of audiences by giving a presentation of your final project to the class and preparing a paper of the work for a scientific audience.

Computers:

The use of computers is fundamental to astronomical work so they are going to play a very important role in this class. For data reduction, we will use astroImageJ. We will also use other professional software for detailed plotting and analysis of the reduced data (such as TOPCAT, ExoFAST, and others).

Working with computer programs takes time and effort, but these are important and very marketable skills for future jobs. Take the time to work on your computer skills and particularly your programming skills and you will reap the benefits in this class and in looking for jobs in the future.

You will be expected to write and/or use some programs in a programming language of your choice (Matlab, Python).

Telescopes:

Using telescopes is always a bit tricky and never works as you plan it. There will undoubtedly be obstacles to deal with including instrumentation that does not always work as planned and weather that can sometimes be uncooperative. You will spend some of our unscheduled class time learning to use this facility.

Useful Campus Resources:

Writing Center: A114 Robinson Hall; (703) 993-1200; http://writingcenter.gmu.edu

Counseling and Psychological Services (CAPS): (703) 993-2380 http://caps.gmu.edu

Policies:

Withdrawal: If you need to withdraw from this course you must do it within the University established time frame. For fall 2017 the last day to withdraw with no tuition penalty is September 5. From then on tuition penalties apply. The last date to drop, with a 67% tuition penalty, is September 29. See the GMU academic calendar http://registrar.gmu.edu/calendars/fall-2017/ for other important dates.

Students with Disabilities: Please contact Disability Services (SUB I, Room 4205, Phone 703-993-2474, http://ods.gmu.edu if you have a learning or physical disability that will require accommodation in the astronomy laboratory. You must obtain the proper paperwork and notify your instructor in advance to be accommodated.

Academic Integrity:

GMU is an Honor Code university; please see the University Catalog for a full description of the code and the honor committee process. The principle of academic integrity is taken very seriously and violations are treated gravely. What does academic integrity mean in this course? Essentially this: when you are responsible for a task, you will perform that task. When you rely on someone else's work in an aspect of the performance of that task, you will give full credit in the proper, accepted form. Another aspect of academic integrity is the free play of ideas. Vigorous discussion and debate are encouraged in this course, with the firm expectation that all aspects of the class will be conducted with civility and respect for differing ideas, perspectives, and traditions. Collaborative group work is encouraged in the lab, but it will be considered academic dishonesty to attach your name to work when you did not actively participate and contribute.

Sexual Harassment, Sexual Misconduct, and Interpersonal Violence

As a faculty member and designated "Responsible Employee," I am required to report all disclosures of sexual assault, interpersonal violence, and stalking to Mason's *Title IX Coordinator* per *university policy 1412*. If you wish to speak with someone confidentially, please contact the *Student Support and Advocacy Center* (703-380-1434), *Counseling and Psychological Services* (703-993-2380), *Student Health Services*, or *Mason's Title IX Coordinator* (703-993-8730; cde@gmu.edu).

Project Paper

The goal of the project paper is to describe the observations, data reduction, and results of your research project. There is a word limit **maximum** to the paper that is 1000 words. The format for this paper will follow the format of short-form astronomical publications so it may be helpful for you to have a look at the ***Research Notes of the American Astronomical Society*** (http://rnaas.aas.org/). To see an example of what this format looks like: https://arxiv.org/pdf/1801.04460.pdf. The audience for the paper will be a scientific audience – it should be written at the level appropriate for a RNAAS article. The primary components of your paper will be:

1) Abstract: an overview of what has been done and the results of your project.
2) Introduction: explains why this project is of interest and what the goals of the project are.
3) Data Reduction: describes the details of the data reduction you have done. Discuss all of the observations you have and details including but not limited to: telescope used, types of observations take, duration of observations, step-by-step description of the data reduction procedure including all calibration, photometry, etc.
4) Results: describes the results of your project. This section should be about the science that was done with the data. One Figure or Table is allowed.
5) Conclusions: this section describes how your results fit with the hypothesis that you made in your telescope proposal. More importantly, it places the results in the context of the scientific literature.
6) References: bibliography in the style of the RNAAS.

These projects will be done in groups of 2-4, and so will the write-ups. Also make sure that anyone else that contributed is an author (if they did a significant amount of work like you partner is expected to have done) or is cited in the acknowledgements if they were part of a useful discussion of the work or contributed a useful idea (but not a significant part of the results).

Project Presentation

Presenting your research is an important skill as an astronomer. It is also a skill that crosses many disciplines and professions. At the end of the semester we will have a presentation session (or two depending on the number of students) in which each group will present the research they have done over the course of the semester. The talk should be directed at your fellow students (i.e., upper level astronomy students – we may have additional people viewing the talks, but this is still your target audience). Everyone in your group is expected to give part of the presentation so you will need to coordinate what each member of your group is talking about. This means that you will need to work together and ultimately to practice the talk together before this final presentation. Important things to include in the talk:

- Background material explaining what has been done before in this field. This is where you set the stage for the project you have just executed.
- An explanation of why you pursued this particular project, why it is interesting, and what questions you hoped to answer. This is where you lay out the hypothesis that you made.
- A thorough discussion of your observational method, data reduction, and analysis.
- Summary of your results, discussion of whether your results support or negate your hypothesis, discussion of where these results fit within the larger context of the field and the literature. This section could also include a revision of the hypothesis and discussion of possible future work.