Astronomy 402/602: Syllabus

Class time: MW 7:20-10pm

Professor: Peter Plavchan
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professional schedule:
https://calendar.google.com/calendar/embed?src=ka6peqmd2mqvnoc6tr9h3vtlh8%40group.calendar.google.com&ctz=America%2FNew_York
Office Hours: TBD, subject to change

Graduate Teaching Assistants:
Justin Wittrock
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Course information will be posted on Blackboard

Required Textbook:
Observational Astronomy, by Birney, Gonzalez, and Oesper

Recommended Texts:
Measuring the Universe: A Multiwavelength Perspective, by George H. Rieke
An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurement, John R. Taylor
Handbook of CCD Astronomy, Steve B. Howell

Grading:

	Undergraduate
Lecture Q&A	10%
Class Exercises	30%
Telescope Proposal	15%
Observing project (written)	30%
Observing Project (oral)	15%

Late Assignments:

Late assignments will be accepted until I start grading a given assignment. After I start grading an assignment, no late assignments will be accepted unless there is a pandemic or national justice movement related valid reason.

COVID-19 Specific Information

All students taking courses with a face-to-face component are required to take Safe Return to Campus Training prior to visiting campus. Training is available in Blackboard. Students are required to follow the university's public health and safety precautions and procedures outlined on the university Safe Return to Campus webpage. Similarly, all students in face to face and hybrid courses must also complete the Mason COVID Health Check daily, seven days a week. The COVID Health Check system uses a color code system and students will receive either a Green, Yellow, or Red email response. Only students who receive a "green" notification are permitted to attend courses with a face-to-face component. If you suspect that you are sick or have been directed to self-isolate, please quarantine or get testing. Faculty are allowed to ask you to show them that you have received a Green email and are thereby permitted to be in class.

Please:

- Complete their daily Mason COVID Health Check online health survey before coming to campus or leaving their residence hall;
- Quarantine at home if their health survey produces a yellow or red condition;
- Be prepared to show their daily green health status upon entering any classroom; and
- Practice all enhanced hygiene practices, including wearing a face covering that covers the nose and mouth, washing hands, maintaining at least six feet of physical distance, and staying away from campus and getting tested if they feel any symptoms consistent with COVID-19.

Specific to ASTR 402/602:

The class was chosen to be hybrid with a mix of online and in person instruction. **It is my intent this fall to make use of the in-person option sparingly given the current COVID-19 case levels in the region.** Specifically - I want to be able to show the Observatory to anyone that has not seen it before and would be interested in seeing it. I also want to offer the ability of students who so choose to use EXPL 1004 for class time and its computers as needed.

Course Overview:

The goal of this course is to introduce you to the observational, statistical, and computational techniques used by observational astronomers. You will learn how to acquire scientific information from observations, evaluate the validity of a scientific hypothesis based on a statistical analysis of data, and present your work to a variety of audiences. In order to fully develop these skills, you will be expected to do an observational research project and write it up as you would for publication. The class writing assignments are designed to improve your scientific writing and analytical thinking skills.

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.

Course Goals:

MASON IMPACT

Overall goal:

- You will gain an understanding of the astronomical observation process by which a scientist can go from a question about the universe → observations → analysis that produces at least part of the answer to the question.

Specific goals:

- You will be able to operate the campus telescope such that you can select a source, take an image of your source and the necessary calibration images.
- You will learn the basic steps in reducing optical data such that you can perform the steps on a set of images you take independent of a structured lab exercise.
- You will show that you can extract information from images and draw scientific conclusions about the objects 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 engage in a deep exploration of an observational topic of your choice. You will challenge yourself to delve deeply into a topic and explore it in many different directions.

- 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 poster of the work for a campus-wide audience.

Introduction:

In order to learn about the techniques used by observational astronomers we must cover a lot of ground in this course. We will learn about telescopes and detectors, methods for taking, reducing, and analyzing data, and the statistics required for understanding the data and analysis. The course will rely heavily on the use of computers and you will be expected to become proficient in using the Linux environment and data analysis programs.

In addition to the topics described above, you will learn about the process of defining a scientific research question, collecting information to try to address the question, and critically assessing your results to determine what you have (and have not) learned from the data that you collected.

Because of the quantity and diversity of material that you will need, this class will require substantial time and effort. You must expect to invest a significant amount of time in this class to succeed. The time investment will include time spent [remotely] operating the campus telescope at night for observing. This is a four-credit course that will include 3 hours of "lecture" and 3 hours of "lab."

In return for your effort, we will work hard to help you build these skills and see how they are important for whatever future direction you may take. We will also work to make this class friendly, collaborative, and fun. You will be expected to work with other students in the class, please do your part as it is important for collaboration that everyone does their share.

Writing Intensive Course:

This course fulfills the writing-intensive requirement in the astronomy major. It does so through weekly homework and lab-type exercises (approximately 250 words/week), an observing project proposal (at least 1000 words), and a paper about your observing project (at least 2500 words for which you will write a draft and submit a revised version). Your ability to write is important in science or whatever career you pursue. We will develop your technical writing skills throughout the class. Note that well written and complete answers are important on the homework as well as on the proposal and project paper.

Research Scholarship Course:

This course is designated as a Research and Scholarship Intensive Course, which means that you will have the opportunity to actively participate in the process of scholarship. Several components of this class are linked to the research scholarship goals.

1. *Telescope Proposal:* The telescope proposal is an opportunity to describe the research project you want to do and justify why it is scientifically interesting. The proposal will address several the research scholarship goals including: **(1) Justify that the project intends to be engaging and novel to a particular audience; (2) Articulate and refine the question; and (3) Present their understandings from a scholarly perspective for a specified audience.**

2. *Observing Project and Paper:* The observing project and the associated paper will give you the opportunity to explore a research question making use of telescope observations and/or archival data. The results will be summarized in journal format as discussed below. This project will address the following research scholarship goals: **(1) Present their understandings from a scholarly perspective for a specified audience; (2) Articulate and refine the question; (3) Gather evidence appropriate to the question; and (4) Assess the validity of key assumptions and evidence.**

3. *Observing Project Presentation:* The observing project presentation will be a presentation of your project including its background, goals, and results to the other members of the class. The presentation will address the following research scholarship goal: **Justify that the project intends to be engaging and novel to a particular audience.**

Computers:

The use of computers is fundamental to astronomical work so they are going to play a very important role in this class. If classes are in person, we will use the computers located in the classroom. These computers are all running the Linux operating system with which you will become familiar if you are not already. For data reduction, we will use AstroImageJ and other software written for professional optical data reduction, may become necessary. You will also be expected to use a computer for some of the plotting and analysis of data, for this purpose you can use the Python programming language or Topcat which is freely available to you.

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.

Astro 402/602 Lab:

Astronomy 402/602 consists of a lecture and laboratory portion of the class. We will adopt an inverted class structure – lectures will be videos watched before class. You are expected to post a minimum of two questions per lecture video prior to class to be discussed in class. The questions will be discussed in class as a means to review the lectures. After the lecture review, in class you will work on the class exercises, which build to the project proposal, analysis, paper and presentation.

All exercises, project work, and lecture Q&A will be done with Google Docs as your lab notebooks. One Google Doc will be for exercises, project observations and analysis; a second for lecture Q&A. You will keep these lab notebooks throughout the semester, and Dr Plavchan will create it and share it with you.

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.

Our telescope is completely remotely operable, with some periodic maintenance.

Telescope observing will be done outside of class, due to the inherent randomness of weather. You will need to have some flexibility in your evening schedule so that you can sign up for observing on other evenings outside of class nights.

For the observations, we also may have access to remote telescopes that we can use if too many problems arise or if they would provide a useful supplement to the campus telescope for your designed investigation. We may spend some of our lab time (particularly if we encounter bad weather) learning to use this remote facility.

Accommodations for Disabilities:

If you are a student with a disability and you need academic accommodations, please see me and contact the Office for Disability Services (ODS) at 993-2474, http://ods.gmu.edu. All academic accommodations must be arranged through the ODS.

Academic Integrity:

GMU is an Honor Code university; please see the Office for Academic Integrity 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. There will be collaborative projects in this class, for those projects all contributors should be credited. For individual projects on which only your name appears, you are welcome to discuss your ideas but the end result must be yours alone. If you are ever unclear as to the expectations for a part of this class please ask for guidance and clarification.

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).

Privacy

Students must use their MasonLive email account to receive important University information, including communications related to this class. I am not allowed to respond to messages sent from or send messages to a non-Mason email address.

Telescope Proposal

Ultimately for this class you are going to obtain a series of observations that you will then analyze. As astronomers, we need to submit a proposal that describes the observations we are going to carry out to get time on a telescope. The format of the proposal is given below. Because this is the writing intensive class for the major the proposal must be **at least** 1000 words long. In general, there are 3 important parts of every proposal:

I. Abstract: The goal of the abstract is to sum up the main justification for the project. You will talk about what you are going to do and why in a paragraph.

II. Scientific Justification: The scientific reason that you are going to pursue the project. What is it you are going to get out of these data in the end? You will need to look at the literature and really design your project and what you are going to get out of it in the end. Here is where you describe the hypothesis that you are going to test with your observations.

III. Technical Justification: This section describes the resources you will need (filters, observing times, S/N, weather conditions, number of observing sessions, durations of observing sessions, spacing of observing sessions, etc) to complete the project. When writing this part of the proposal, consider the following:

a) Target source (why was this chosen rather than another),
b) Time when the target is visible (at the time of the observations, but you can also comment on its observability during the class time – i.e., if the telescope had been available would you have been able to do this project),
c) Length of time for which the source is visible at the telescope,
d) Filters to be used,
e) Number of exposures,
f) Length of exposures,
g) Time separation of exposures if that is relevant,
h) Number and duration of calibration exposures and how they will be used in the data analysis,
i) Expected S/N of the observed sources.

Project Paper

The goal of the project paper is to describe the observations, data reduction, and results of your research project. Because this is the writing intensive class, there is a word limit **minimum** to the paper that is 2500 words. The format for this paper will follow the format of astronomical publications so it may be helpful for you to have a look at the Astronomical Journal to see an example of what this format looks like. The audience for the paper will be a scientific audience – it should be written at the level of an Astronomical Journal article but with a bit more detail as to your method than might typically be included in such a paper. 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. This section will look a lot like your scientific justification section from the telescope proposal (I highly recommend that you look at any comments on your proposal justification and edit this section accordingly).
3) Data Reduction: describes the details of the data reduction you have done. This section needs to be very thorough! 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. Include figures where they are relevant.
4) Results: describes the results of your project. This section should be about the science that was done with the data. Use figures to illustrate your results.
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 Astronomical Journal

These projects will be done in groups of 2-3, but the write-up must be your own. You will fail the paper if what you turn in is not original. This doesn't mean that you can't talk about the work that you are doing, it means that what you submit MUST BE IN YOUR OWN WORDS! Also make sure that you are the first author on the paper and anyone else that contributed is co-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.

Date	**Reading/Assignment due**	**Lecture Topic**	**In Class Activity**
Aug 24		Coordinates and Time	Introductions; **Exercise 1, #1&2:** Coordinates and Time; Lecture
Aug 26			Telescope training Option 1 OR **Exercise 1 #3-8:** Coordinates and Time
Aug 31		Light Review	Telescope Training Option 2 OR **Exercise 1 #3-8:** Coordinates and Time
Sept 2	Exercise #1 due	Statistics	**Exercise 2**: Statistics
Sept 7		No Class – Labor Day	
Sept 9			**Exercise 2**: Statistics
Sept 14	Exercise #2 due	Telescopes	Proposal outline **Exercise 3:** Telescopes
Sept 16	Proposal outline due		**Exercise 3:** Telescopes
Sept 21	Exercise #3 due	CCDs	**Exercise 4:** Image calibration
Sept 23			**Exercise 4:** Image calibration

Sept 28	Exercise #4 due	Image processing	**Exercise 5:** Image Processing
Sept 30			**Exercise 5:** Image Processing
Oct 5	Telescope proposal due Exercise #5 due	Aperture Photometry	**Exercise 6:** Relative Photometry
Oct 7			**Exercise 6:** Relative Photometry
Oct 12		No classes	
Oct 13		Proposal reading	Telescope allocation committee meeting
Oct 14	Exercise #6 due	Radio astronomy	**Exercise 7:** Radio astronomy
Oct 19			**Exercise 7:** Radio astronomy
Oct 21	Exercise #7 due		**Exercise 8:** Green Bank preparation Lab
Oct 26	Exercise #8 due	Interferometry	**Exercise 9:** Green Bank Analysis
Oct 28	Exercise #9 due		Green Bank presentations
Nov 2		Time Domain Astronomy	Project work

Nov 4			Project work
Nov 9	Project paper outline due	Spectroscopy	Project work
Nov 11			Project work
Nov 16	Project presentation draft due		Project work
Nov 18			Project work
Nov 23	Project paper draft due	Infrared Astronomy	Project work
Nov 25		Thanksgiving – no class	
Nov 30		High energy astronomy	Project work
Dec 2	Observing Project Presentations		
Dec 9	Observing Project Paper due		