ASTR 402/602
Observational Techniques

Fall 2021, Section 001

Instructor Information

Instructor	Contact	Lectures
Dr. Rob Parks (He/Him) **Office Hours** MWF 11:00 AM – 12:00 PM Appointments also possible **Office Location** Research Hall, Room 216 Or on Discord	**Email (preferred)** jparks23@gmu.edu **Email (Google Docs)** parksj762@gmail.com **Office #** (703) 993-1276 **Cell #** (404) 840-8361	**Lecture Hall** Exploratory Hall, Room 1004 **Graduate Teaching Assistants** Kevin Collins *Email*: kcolli3@gmu.edu

General Information

Course Overview

The goal of this course is to introduce the observational, statistical, and computational techniques used by modern astronomers. The course will teach how to acquire observational data, extract scientific information from these data, evaluate the validity of a scientific hypothesis based on a statistical analysis of said data, and present the results to a variety of audiences. To fully develop these skills, an observational research project is expected with the process and results written up as if for publication. The class writing assignments are designed to improve scientific writing and analytical thinking skills.

The skills developed in this class are extremely useful for a wide variety of careers including, but not limited to, astronomy. George Mason is committed to making this course useful for any number of future career goals. Please communicate these goals so that the course can be better shaped to achieve them, wherever that is possible.

Course Goals and Introduction

The overall goal for ASTR 402/602: "Observational Techniques" is to gain an understanding of the astronomical observation process by which a scientist can go from a question about the Universe to observations to analysis that produces at least part of the answer to the question.

Specific goals for the course are:

1. To be able to operate the campus telescope to acquire images of a target object along with all necessary calibration images.
2. To learn the basic steps to reduce a set of images taken independently of a structured lab exercise.
3. To learn how to extract information from images and draw scientific conclusions about the target object(s).
4. To be able to evaluate the statistical significance of the conclusions drawn from the above extracted data.
5. To gain experience executing custom computational programs and tools for data analysis along with developing additional personal tools.
6. To engage in a deep exploration of an individualized observational topic by delving deeply into the topic and exploring it in many different directions.
7. To show proficiency in describing scientific work to a variety of audiences. This is accomplished through presenting the final project to the class and preparing a poster of the work for a campus-wide audience.

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 answer 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 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 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 your 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. We will be using 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 along with other software written for professional optical data reduction, if 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.

ASTR 402/602 Lab

Astronomy 402/602 consists of a lecture and laboratory portions to the class. We will adopt an inverted class structure – lectures will be videos watched before class. Videos will be hosted on the following channel: https://www.youtube.com/channel/UCqPt-mMHr1Bq-XxI7iyah_g. 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 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. Parks 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 by 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.

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, the proposal must be **at least** 1000 words long. In general, there are 3 important parts to 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. As this is a writing intensive course, there is a minimum word limit of **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 be expected 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 taken, 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 you can not collaborate with your group members, but 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 group members) 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 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.

Course Diversity Statement

An emphasis upon diversity and inclusion throughout the campus community is essential to achieve these goals. Diversity is broadly defined to include such characteristics as, but not limited to, race, ethnicity, gender, religion, age, disability, and sexual orientation. Diversity also entails different viewpoints, philosophies, and perspectives. Attention to these aspects of diversity will help promote a culture of inclusion and belonging, and an environment where diverse opinions, backgrounds, and practices can be voiced, heard, and respected.

The reflection of Mason's commitment to diversity and inclusion goes beyond policies and procedures to focus on behavior at the individual group and organizational level. The implementation of this commitment to diversity and inclusion is found in all settings, including individual work units and groups, student organizations and groups, and classroom settings; it is also found with the delivery of services and activities, including, but not limited to, curriculum, teaching, events, advising, research, service, and community outreach.

Acknowledging that the attainment of diversity and inclusion are dynamic and continuous processes and that the larger societal setting has an evolving socio-cultural understanding of diversity and inclusion, Mason seeks to continuously improve its environment. To this end, the University promotes continuous monitoring and self-assessment regarding diversity. The aim is to incorporate diversity and inclusion within the philosophies and actions of the individual, group, and organization, and to make improvements as needed.

Course Information

Credit Hours: 4

Main Textbook:

- *Observational Astronomy* by Birney, Gonzalez, and Oesper

Recommended Texts:

- *Measuring the Universe: A Multiwavelength Perspective* by G. H. Rieke
- *An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurement* by J. R. Taylor
- *Handbook of CCD Astronomy* by S. B. Howell

Grade Distribution

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

Grade Scale

Letter Grade	Numerical Scale	Letter Grade	Numerical Scale
A+	96 – 100%	**C+**	72 – 75.99%
A	92 – 95.99%	**C**	68 – 71.99%
A-	88 – 91.99%	**C-**	64 - 67.99%

B+	84 – 87.99%	**D**	60 – 63.99%
B	80 – 83.99%	**F**	BELOW 60%
B-	76 – 79.99%		

Course Policies and Services

- **Course Materials and Student Privacy**
  - All course materials posted to Blackboard or other course site are private to this class; by federal law, any materials that identify specific students (via their name, voice, or image) must not be shared with anyone not enrolled in this class.
    - Video recordings – whether made by instructors or students – of class meetings that include audio, visual, or textual information from other students are private and must not be shared outside the class.
    - Live video conference meetings (e.g. Zoom) that include audio, textual, or visual information from other students must be viewed privately and not shared with others in your household or recorded and shared outside the class.
- **Disability Services**
  - George Mason University is committed to providing equitable access to learning opportunities for all students by upholding the laws that ensure equal treatment of people with disabilities. If you are seeking accommodations for this class, please first visit http://ds.gmu.edu/ for detailed information about the Disability Services registration process. The please discuss your approved accommodations with the professor. Disability Services is located in Student Union Building (SUB I), Suite 2500. Email: ods@gmu.edu | Phone: (703) 993-2474
- **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* (730-380-1434) or *Counseling and Psychological Services* (703-993-2380). You may also seek assistance from *Mason's Title IX Coordinator* (703-993-8730 | titleix@gmu.edu)
- **Email and Communication**

  - Students must use their GMU email account to receive important University information, including communications related to this class. I will not respond to messages from or send messages to a non-Mason email address.
  - It is your responsibility to stay current with all information either communicated through email or posted to Blackboard page. Please check you GMU email and the course pages regularly.
  - Email sent to the instructor is normally checked during business hours and a response sent out within one business day. If you do not receive a reply within that timeframe, please follow-up with a reminder email. Instantaneous responses, responses to emails past 10 PM, or during the weekends should not be expected.
  - All emails need to include your name and the course in which you are enrolled. Additionally, the email needs to include a greeting and be written in a professional manner. Emails that do not conform to these requirements may be ignored at the instructor's discretion.
- **Additional Services and Support**
  - George Mason has a wide variety of support services for students. Please visit the following website for information about on-campus resources: https://stearnscenter.gmu.edu/knowledge-center/knowing-mason-students/student-resources-on-campus/
- **Attendance and Absences**
  - From GMU Policy Statement 22: "Class attendance is the responsibility of the student. The student is expected to attend all classes. A student who finds it necessary to miss class assumes responsibility for making up examinations, obtaining lecture notes, and otherwise compensating for what may have been missed. The course instructor will determine the validity of a student's reason(s) for absences and will assist those students who have valid reasons."
  - Attendance will be taken each class to ensure in-class activities are completed in the classroom.
  - If you miss a graded assignment and believe that you qualify for an excused absence, contact the instructor within 48 hours and provide a copy of the absence excuse within one week, unless physically unable to do so. Failure to follow these deadlines will result in the absence being considered unexcused.
  - Note: if a class is missed, attendance of another section of the same course is not permitted.
- **Limit on Course Repeats**
  - There is a limit of three graded attempts for this course. A *W* does not count as a graded attempt. Please see AP. 1.3.4 in the University Catalog and consult with your academic adviser if you have any questions.
- **GMU Code of Student Conduct**

  - Students are expected to follow the George Mason University rules of student honor. As noted in the catalog: "George Mason University shares in the tradition of an honor system that has existed in Virginia since 1842. The Honor Code is an integral part of university life. On the application for admission, students sign a statement agreeing to conform to and uphold the Honor Code. Therefore, students are responsible for understanding the provisions of the code. In the spirit of the code, a student's word is a declaration of good faith acceptable as truth in all academic matters. Therefore, cheating, attempted cheating, plagiarism, lying, and stealing of academic work and related materials constitute Honor Code violations. To maintain an academic community according to these standards, students and faculty must report all alleged violations of the Honor Code to the Honor Committee. Any student who has knowledge of, but does not report, an Honor Code violation may be accused of lying under the Honor Code." (Source: http://www.gmu.edu/catalog/apolicies/index.html)
- **Instructor's Intended Purpose**
  - The student's work must match the instructor's intended purpose for an assignment. While the instructor will establish the intent of an assignment, each student must clarify outstanding questions of that intent for a given assignment.
- **Unauthorized/Excessive Assistance**
  - The student may not give or get any unauthorized or excessive assistance in the preparation of any work.
- **Authorship**
  - The student must clearly establish authorship of a work. Referenced work must be clearly documented, cited, and attributed, regardless of media or distribution. Even in the case of work licensed as public domain or Copyleft (See: https://creativecommons.org/) the student must provide attribution to that work to uphold the standards of intent and authorship.
- **Declaration**
  - Online submission of, or placing one's name on an exam, assignment, or any course document is a statement of academic honor that the student has not received or given inappropriate assistance in completing it and that the student has complied with the Academic Honesty Policy in that work.
- **Consequences**
  - An instructor may impose a sanction on the student that varies depending upon the instructor's evaluation of the nature and gravity of the offense. Possible sanctions include but are not limited to, the following: (1) Require the student to redo the assignment; (2) Require the student to complete another assignment; (3) Assign a grade of zero to the assignment; (4) Assign a final grade of "F" for the course. A student may appeal these decisions according to

the Academic Grievance Procedure (See the relevant section in the LSU Code of Student Conduct.). Multiple violations of this policy will result in a referral to the Conduct Review Board for possible additional sanctions.

- **Academic Dates and Deadlines**
  - Students must be aware of important dates during the semester. These dates are available at https://registrar.gmu.edu/calendars/spring_2021/
- **Smoking and Tobacco Products**
  - George Mason University is committed to providing a safe, healthful, and pleasant learning and working environment for Mason students, faculty, and staff. The purpose of this policy is to address the use of all tobacco products and electronic cigarettes, as well as ensure compliance with the Virginia Indoor Clean Air Act and Virginia Executive Order 41. Virginia Executive Order 41 states that smoking is not permitted within buildings, facilities, enclosed structures, or vehicles owned, leased or rented by the University.
    1. Executive Order 41 applies to parking garages, covered walkways, temporary enclosed structures, trailers, and tents, as well as structures placed on state-owned property by contractors or vendors.
    2. Smoking is not permitted outdoors within 25' of any building or facility entrance/exit (including parking garages, loading docks, etc.), outdoor air intake, operable window, or covered walkway. Smokers are requested to use ash urns to dispose of their smoking material waste and should not litter on state-owned property with smoking material waste.
    3. Smoking locations should not impede traffic flow in or out of buildings and should be in a location where smoke cannot drift into office, class or living spaces.
    4. Faculty, staff, student and visitor smokers are required to comply with Office of Housing and Residence Life policies and guidelines as they relate to smoking.
  - The use of electronic cigarettes (e-cigs) also known as vaping will follow the same guidelines as the use of all tobacco products.