ASTR 1250: Astronomical Techniques

James Aguirre, Spring 2022

Course Motivation

How is measurement is done in astrophysics?

- What are some basic techniques that are generally useful for scientific data analysis?
- What are some specific techniques that are commonly used to analyze to astronomical data?
- How is actual astronomical research done?

General philosophy

- Learn about key aspects of astrophysical measurement and analysis by taking measurements and doing analysis yourself
- Use class time to learn key ideas and work collaboratively on problems to under the application of these ideas using *in-class exercises*. Most class periods will involve at least some graded exercise; the balance of time spent on the exercise vs. more traditional “lecture” will vary from session to session. These are done collaboratively.
- The class sessions will present the material necessary to do the homework and projects but should also give us the flexibility to study some additional topics (in the second half of the course).
- Important ideas are focused on in homework assignments. These will be due about every two weeks and will help to make sure that you are proficient in doing the things necessary for the projects. You can confer with other students, but you should submit your own individual work (and it should be obvious that your work is your own).
- You will show mastery by doing two multi-faceted projects that require multiple skills and the interplay of data analysis and theory: a midterm and a final project. These are done individually, not as a group.

Questions

- I would like you to ask them! (in class, in office hours, in email)
- Help me by clarifying whether a question is narrow & technical, or broad & conceptual
- I tend to give long winded answers; I am trying to cut to the chase
- My overarching goal is to make sure your question does get answered

Feedback

- From me to you:
  - Answers in class
  - Homework grading: chance to earn back points
  - The midterm and final: enough time to grade midterm and final projects

- From you to me:
  - Questions and comments in class
  - Questions and comments in office hours
  - Midterm course evaluation (anonymous)
  - Final evaluation

Projects

Midterm: Measuring the Transit of an Extrasolar Planet
Key ideas:
• Observation planning
• Effect of the atmosphere
• Source finding and photometry

Final: Measuring the Properties of a Cluster of Stars
Key ideas:
• Filters and colors
• Error analysis
• Model fitting

Assignments

Assignments are weighted by group:

Group	Weight
In-class exercises	40%
Homework	20%
Midterm Project	20%
Final Project	20%
Attendance	0%
Total	**100%**

Course Outline

Getting Started

- Introduction to the Course
    - Installing Anaconda
    - Getting Set Up with Software
    - Observing: Weather, Getting Data, Etc
- Data Structures, Useful File Types, and Plotting
- In-Class Exercise: Working with Data from Files and Images

Acquiring Data

- Getting Acquainted with the Observatory
- More Data from the Observatory
- In-Class Exercise: Exploring CCD Images I
- In-Class Exercise: Exploring CCD Images II
- In-Class Exercise: Finding Sources in Images I
- In-Class Exercise: Finding Sources in Images II

Basic Observational Facts and Tools

- In-Class Exercise: Virtual Sky Exploration
- In-Class Exercise: Observation Planning
- In-Class Exercise: Observation Planning II
- A Bit About Exoplanets
- In-Class Exercise: Building an Exoplanet Transit Simulation
- In-Class Exercise: Finding an Observable Exoplanet
- Observing Exoplanet Transits
- Writing Research Papers
- In-Class Exercise 6: Using LaTeX to Write Reports (with an application to exoplanets)

Astronomical Imaging

- Light and Telescopes
- In-Class Exercise: How Many Photons?
- In-Class Exercise: Random Numbers, Noise, and the Central Limit Theorem
- Errors in Measuring Numbers of Photons
- Measuring Temperature with Color
- Cluster HR Diagram Preliminaries
- In-Class Exercise: Catalog Matching and Calibration