Modern Astronomy: Observing the Physics of Our Mysterious Universe
Summer 2020

Course Coordinator:
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Meetings:
January 13 – 31, 2020
Monday - Friday
10:30 - 11:30 EDT: Lecture
11:30 - 12:15 EDT: Lab Introduction
14:00 - 16:00 EDT: Lab
16:00 - 17:00 EDT: Optional Slack TA hours

Course Website: www.people.umass.edu/sbetti/summer2020

Course Description:
This three-week program will build a ground-up understanding of observational astronomy, exploring the basis of human extraterrestrial observation and the art of turning astronomy into a science. We'll use the foundations of astrophysics to explain the implications of modern observations, supplementing data with observations from optical telescopes. To learn how astronomers analyze data, we'll introduce basic computer programming using Python, and learn how to extract information from images. These images reveal galaxies, stars, and the Universe itself in the midst of slowly-changing, billion-year long processes. We will learn the astrophysics underlying these long processes.

Prerequisites: None. However, if you would like to start learning python, we recommend free online websites such as code academy: www.codecademy.com.

Computer software:
Students are expected to have access to a computer and be able to communicate via a webcamera. For this course, we require students to download and install the following free software, if they do not have it already:
zoom: https://zoom.us/
slack: https://slack.com/ (we will provide the slack channel once the session begins)
anaconda python: *PLEASE INSTALL PYTHON 3.7!*
https://www.anaconda.com/products/individual/
https://docs.anaconda.com/anaconda/install/ (installation guide)
(optional) SAO DS9: https://sites.google.com/cfa.harvard.edu/saoimageds9 (image viewer for astronomical images)

Goals and Expectations:
Below are some of the specific skills we hope you will obtain in this course:

- You will gain an understanding of astrophysical processes, from planet formation to the Big Bang.
- You will learn how astronomers analyze data and apply the theory to the applications to interpret your data
- You will develop programming skills sufficient to comfortably read/write data, manipulate arrays, write functions, iterate, and produce plots and images in Python

- You will understand how to create an H-R diagram of a star cluster from raw data, determine the cluster age, and connect your data to the theory of star formation

What We Expect from You

1. That you respect your instructors and fellow students.
2. All of the learning in this course will happen via Zoom. We expect that you'll come to every zoom session on time and prepared to actively engage with the material and your classmates (except in the case of an emergency or situation beyond your control, including internet connectivity issues).
3. That you respect your instructors and fellow students by listening when others are talking.
4. That you work collaboratively with your classmates and aim to contribute equivalently (if not equally) to both lectures and labs.
5. That you participate actively and conscientiously. If you come to this class with a lot of prior knowledge about the subject, please take a step back and try not to over-participate in lectures or labs. If you are less comfortable with the course material or format, please challenge yourself to actively participate. Active participation may take many forms. For example:
    - Asking a clarifying question to the instructor or a classmate
    - Speaking up in a large group discussion
    - Coming to optional TA hours
    - Asking thoughtful questions via the slack channel

Schedule

The class is structured into two sessions per day: a morning lecture that builds our knowledge from Earth out to the farthest reaches of the Universe, and an afternoon lab that explores the fundamentals in astronomical data processing and analysis.

Day	Lecture	Lab
1	Introduction	Intro to python
2	Scientific Methods and Brief History of Astronomy	Mapping the Universe - LSS
3	EM/Light/Telescopes	Characterizing stars, Magnitudes system, Telescope Filters
4	The Sun and Stars	The HR diagram
5	Milky Way and ISM and Local Star formation	Creating three-color astrophysical images
6	Energy and Newtonian Gravity	What is astronomical data reduction?
7	Galaxies I	Making Master Biases and Darks
8	Galaxies II	Flat Fielding
9	Gravity and GR, Black Holes and AGN	Calibrating and aligning images
10	Dark Matter and Dark Energy	Stacking images
11	LSS and Cosmology, Time and the Universe	Aperture Photometry

12	Planet Formation and Exoplanets	From ADU to flux
13	Career Paths, A Day in the Life of an Astronomer, and Q&A	Color-Magnitude Diagrams
14	Special Topic TBD!	Working with GAIA
15	Presentations	

Final Project

One of the most revolutionary discoveries of modern astronomy was that we could quantify the age and evolutionary stage of stars using only two properties: their luminosity and their temperature. Known as the Hertzsprung-Russell diagram, the plot of luminosity vs. temperature (measured observationally as brightness vs. color) is essentially a *family portrait*, showing stars of different types, ages, and mass—and where our Sun fits in the picture. For our final project, we will work with observations of star clusters and place each star on the family portrait. Working together, students will design a project based on an outstanding question in astronomy, then use computer programming skills (taught during the class!) to begin answering the question. Each group will give a presentation of their findings to the class at a zoom seminar open to the Astronomy department and parents on the last day.

Course Expectations

This course will be taught through *zoom*, a cloud-based video communications app, *slack*, a messaging app, and the course website. Due to the online nature of the course, students are required to attend all zoom sessions, while slack is available for students to message the instructors and each other in order to work on labs or ask questions outside of the designated "in-person" class hours. However, we understand that due to the COVID-19 pandemic and the nature of online classes, issues and responsibilities beyond your control, including unstable Internet connections, could prevent you from attending the zoom calls. We ask that you keep us informed so that we can work to find a solution to make sure you remain caught up with the rest of the class.

There are no homework assignments, required textbooks, exams, reading assignments, or quizzes. Each session will consist of a lecture—which will include questions, discussions, and problem solving—and a lab section focused on using computers for data analysis.

Evaluation

Evaluation will be on the basis of attendance (to all labs/lectures), participation (which will consist of participating in lab/lecture discussions AND completion of lab/lecture in-class assignments) and effort for the final project. Each student will receive feedback on their work.

Accommodations for Disabilities

If you have any kind of disability, whether apparent or non-apparent, learning, emotional, physical, or cognitive, and you need some accommodations or alternatives to lectures or labs, please feel free to contact the course instructor or the pre-college program to discuss reasonable accommodations for your access needs.