Syllabus

ASTR 3730 Astrophysics I: Fall 2019

Class: Tu, Th 12:30 – 1:45 PM : ***Chemistry 142***

Instructor: *John Bally* John.Bally@colorado.edu Duane D349
Office Hours: Wed & Thurs 2:00 PM in Duane D349, or by appointment
T.A.: Justus Gibson Justus.gibson@colorado.edu
Office Hours: TBD
Grader: John (Jack) Faulhaber John.Faulhaber@Colorado.edu
Text Book: *Introduction to Modern Astrophysics*, Bradley W. Carroll, Dale A. Ostlie
Course Materials: http://casa.colorado.edu/~bally/Current_Course/

Course Description:

We live in remarkable times. We are part of the first generation that can see the Universe and its contents in all wavelengths of the electromagnetic spectrum. We are opening new windows on the cosmos using gravitational radiation, neutrinos, and particles. These developments are made possible by access to space and development of solid-state electronic sensors.

This is a course in Astrophysics, designed to approach the subject in greater depth than is provided by the elementary, introductory courses. Emphasizes will be on the properties of stars, star formation, stellar evolution, the formation of planets, multiple-star systems, and star clusters, and the physics of galactic interstellar media. We will cover energy generation by nuclear fusion, the transfer of energy from the stellar core to the surface. We will discuss exotic objects such as white dwarfs, neutron stars, black holes, supernovae, and mass transfer binaries. We conclude with a discussion of the Milky Way galaxy and its interstellar medium, which provides an natural link to the following course in extragalactic astronomy.

Basic astronomy, introductory physics, and calculus knowledge at the lower division level is required. Physics and mathematical formulae are used extensively. Students will develop skills in estimation - doing "back-of-the-envelope" calculations - using basic formulae and the constants of nature (see *Constants_and_Formulae_for_majors.pdf*) to gain an intuition for the physics and a sense for the orders of magnitude of quantities. Some knowledge of computer programming in environments such as Python will be useful.

Each week, I will assign reading from the text - typically one chapter per week (not necessarily in the order of chapters in the book). On Tuesday following, we will use most of the class time to discuss the key ideas, work example problems, and answer student questions. I expect all students to come to class with questions to discuss. On Thursday, I will introduce the topic of the reading for the following week.

We will meet in Fiske Planetarium on Tuesday, 12 November for a special treat.

Grading:

The grade will be based on problems sets (50%), one midterm (15%), and a comprehensive final (25%). The remaining 10% of your grade will be determined by participation in discussions in class and lab. All students are expected to do their own work. Cheating, copying, or use of material without proper referencing or attribution is unacceptable.

Absences and Late Work:

If you must miss two consecutive classes in a row, please call or email and let us know what is happening. Late work is not accepted without prior permission.

Campus policy regarding religious observances requires that faculty make every effort to reasonably and fairly deal with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance.. See full details at http://www.colorado.edu/policies/fac_relig.html

CU Honor Code and Other Policies:

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code. Violations of the policy may include: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty. All incidents of academic misconduct will be reported to the Honor Code (honor@colorado.edu); 303-492-5550). Students who are found responsible for violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code as well as academic sanctions from the faculty member. Additional information regarding the Honor Code academic integrity policy can be found at the Honor Code Office website (https://www.colorado.edu/sccr/).

The University of Colorado Boulder (CU Boulder) is committed to fostering a positive and welcoming learning, working, and living environment. CU Boulder will not tolerate acts of sexual misconduct intimate partner abuse (including dating or domestic violence), stalking, protected-class discrimination or harassment by members of our community. Individuals who believe they have been subject to misconduct or retaliatory actions for reporting a concern should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2127 or cureport@colorado.edu. Information about the OIEC, university policies, anonymous reporting, and the campus resources can be found on the OIEC Website (https://www.colorado.edu/oiec/). Please know that faculty and instructors have a responsibility to inform OIEC when made aware of incidents of sexual misconduct, discrimination, harassment and/or related retaliation, to ensure that individuals impacted receive information about options for reporting and support resources.

Students and faculty each have responsibility for maintaining an appropriate learning environment. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. Class rosters are provided to the instructor with the student's legal name. I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records. For more information, see the policies on classroom behavior and the Honor Code (https://www.colorado.edu/sccr/honor-code).

If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the Disability Services website (https://www.colorado.edu/disabilityservices/faculty-staff). Contact Disability Services at 303-492-8671 or dsinfo@colorado.edu for further assistance. If you have a temporary medical condition or injury, see Temporary Medical Conditions under the Students tab on the Disability Services website.

Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class, I ask that students to review the draft schedule immediately, and contact us within the first two weeks of the semester to discuss possible conflicts.

Course Outline:

Note on my absences: I will be absent during the week of 26 - 30 August & 23 - 27 September due to international meetings. Our TA, **Justus Gibson** will assist with the 1st class on 27 August. I will talk to you remotely using Zoom (a teleconference tool) from the James Web Space Telescope (JWST) meeting in Courmayer, Italy. I will provide information about the other three lectures I will miss on Tuesday, 27 August. In brief, **Justus Gibson** will run class on 29 Aug, 24 & 26 Sept.

Visit to Fiske: On Tuesday, 12 November, class will meet in the Fiske Planetarium to take advantage of its all-sky visualization capabilities to show inter-relationships between multi-spectral data using "most-of-the-sky" surveys & "zoom-ins" to specific regions of interest.

The schedule is meant to be flexible. The topics to be covered are listed below.

- Intro to class and logistics. Class overview. Review the properties of electromagnetic waves.
- Telescopes in space and on the ground. Single aperture vs. interferometry. From γ-rays to radio.
- The magnitude scale and photometric systems. Doppler Effect: The measurement of radial velocity & proper motion.
- Gravitation, Newtonian mechanics, orbits, Kepler's laws, Virial Theorem. Measuring stellar distances, masses, sizes, & other properties.
- Quantization of energy; transitions in atoms and molecules. Overview of quantum-mechanical concepts. Interaction of light with matter, blackbody radiation, the formation of spectra.
- Overview of the fundamental forces (gravity, E&M, weak & strong nuclear forces). How we measure the cosmos with EM waves, neutrinos, & gravitational waves.
- Multiple stars, stellar mass determination. Overview of stellar properties.
- Stellar spectroscopy. Measuring distance, luminosity, and temperature; the H-R diagram.
- Stellar atmospheres. Opacity, radiative transfer, spectral line formation.
- Stellar interiors. Equations of stellar structure.
- Nuclear fusion in stellar interiors, origin of the elements.
- The Sun. Interior, energy transport, surface phenomena. Space weather.
- The Interstellar Medium (ISM). From hot plasmas to cold molecular clouds.
- Star formation and planet formation. Feedback and self-regulation; the "Galactic ecology" and the cycling of matter from the ISM into stars and back into the ISM.
- Stellar evolution: Pre-main-sequence, main-sequence, and post-main-sequence stellar evolution.
- Pulsating stars.
- Massive stars. Core-collapse supernovae (Type II). Formation of neutron stars, black holes, gamma-ray bursts, transients.
- Stellar winds, binaries, mass transfer, and symbiotic systems. Wolf-Rayet stars, luminous blue variables, supernova impostors, luminous transient phenomena.
- Degenerate stars. White dwarfs, Chandrasekhar limit, Type Ia supernovae , pulsars & neutron stars, X-ray pulsars, and stellar exotica
- General Relativity and black holes. LIGO & gravity waves. Multi-messenger astrophysics.
- The structure of the Milky Way Galaxy & the Local Group.
- Overview of the Solar System, Planetary system formation & evolution. Exo-planets.