AST501 Stellar Interiors and Evolution

Course outline Fall Term 2024

Calendar entry: The physics of stars and stellar explosions. Interior structure and evolution including the origin of the elements. Stellar properties as a function of mass and metallicity. Computational simulations of stars and stellar physics processes, such as mixing, and corresponding observables.

Instructor: Falk Herwig (fherwig@uvic.ca)

Course repository: https://arc-gitlab.phys.uvic.ca/fherwig/astr-501-2024

Course on ARC Mattermost: http://206.12.91.127:8066/arc-news/channels/a501-24

Class times: Mon, Wed 9:00-10:30am (this may likely be changed in first class)

Course content

The structure and evolution of stars is the result of intricate interaction of different types of physics processes, such as

- Conservation laws of fluid dynamics and the macro physics of convection and rotation
- Atomic physics of radiation-matter interaction and the physics of radiation transport,
- Thermodynamics and the equation of state of a wide variety of conditions from the dilute atmospheres of stars to the extreme high-energy-density conditions in the cores of late phases of stars, such as white dwarfs and neutron stars
- Nuclear physics of element formation and energy generation that fuels the life of stars

This interaction of a multitude of different physics components is quite typical for astrophysics, and the presentation in this course seeks to be general enough to applicable to non-stellar research problems in astronomy. For each physics topic we cover we will not go into too much depth. The emphasis is on developing an understanding of how the different physics components are interacting with each other in the context of stellar objects.

We will apply the physics principles to a selection of the most interesting phenomena and stellar evolution phases, such as

- The evolution from the main sequence through subsequent stages, ending in white dwarfs, neutron stars or black holes

- Nuclear energy generation and the formation of the elements, neutron-capture nucleosynthesis to create heavy elements, the s, i and r process
- Supernova
- Binary stars
- Asteroseismology and stellar pulsation

Emphasis will be guided by student interest.

In addition to the physics of stars and the specific stellar phenomena and evolution phases the course will familiarize students with several of the research tools astronomers often use. Students are required to carry out mini-projects and computationally-based assignments requiring basic progaming skills in Python. We will be using tools like Git, MarkDown, Jupyter. A key element of the course is a student project in the second half of the course.

Course structure

This course will broadly consist of two parts. In the first half regular lectures will provide a formal introduction into the course material. During this time there will be two assignments. At the end of October there will be a midterm exam based on the formally taught first part of the course. In the second half each student will select and carry out a mini-research project. During this phase class time will be devoted approximately one half to discuss the student projects as a group. Each student is expected to give an updated on their project by sharing a slide or plot with the class during that part of the course. During the remaining class time additional lecture-style elements will provide additional information relating to the specific project topics students have selected. Students will provide a presentation and a final project report in the form of a mini paper at the end of the term.

Final Grade

Specifics of the format and expectations regarding the graded items related to the project will be given in class.

Grade item	Due	Percent
Assignment 1	Sep 23	10
Assignment 2	Oct 07	10
Mid-term	Oct 23	30
Student project proposal	Oct 30	5
Project presentation	Week Nov 25	10
Project report	Dec 17	35

These dates are approximate at the time of writing and may be adjusted in consultation with students.

Policies

- Important dates: https://www.uvic.ca/calendar/dates
- Graduate calendar: https://www.uvic.ca/calendar/grad/index.php#/home
- Uvic's policy of academic integrity applies:
  - https://www.uvic.ca/students/academics/academic-integrity/
  - https://www.uvic.ca/calendar/undergrad/index.php#/policy/Sk_0xsM_V?bc=true&bcCurrent=08%20%E2%80%90%20%20Policy%20on%20Academic%20Integrity&bcGroup=Undergraduate%20Academic%20Regulations&bcIte%20mType=policies
- The Libraries' guide on plagiarism: https://www.uvic.ca/library/research/citation/plagiarism
- All lecture notes and course materials that are made available to you, and all exams and assignments are the instructor's intellectual property, and are made available to students for instructional purposes only. The material is protected under copyright law, even if not marked with a ©. You may not distribute your lecture notes or any exams or assignments from the course without permission, and to do so, through note-sharing sites or other means, violates the Policy on Academic Integrity.