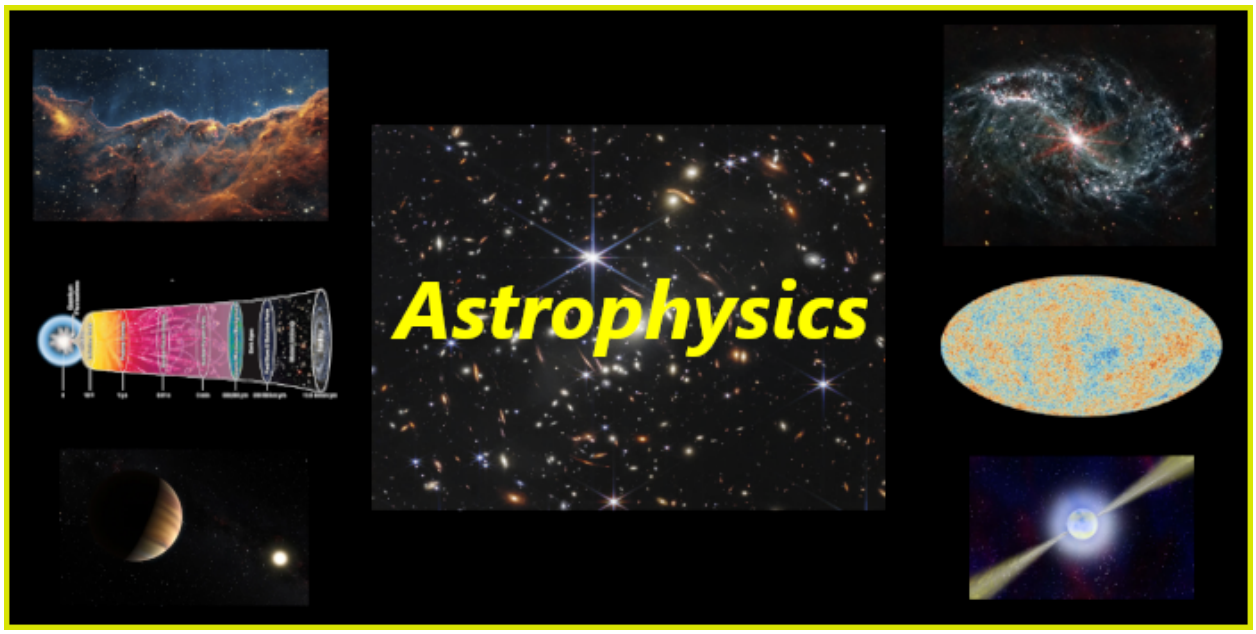

Astrophysics (PHYS 308)
Fall 2023

Instructors

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David Nice is the primary instructor in the first half of the semester (stellar astrophysics). Brooks Thomas is the primary instructor in the second half of the semester (cosmology).

The primary instructor in each half of the course will teach classes, arrange homework sets, organize in-class student presentations, hold office hours, etc.

General Course Information

Astrophysics is the study of how astronomical phenomena that we observe in the Universe arise from physics principles. This is a very broad area, and we must select specific topics within astrophysics to make a tractable one-semester course. This semester, we will have two themes: stellar astrophysics—the structure and evolution of stars—and cosmology—the study of how our universe evolved over time to appear the way it does to us today.

Objectives and Learning Outcomes

We have a rewarding semester ahead of us. Over the course of the next fourteen weeks, we'll not only explore some of the fascinating astrophysical phenomena that we observe in our universe today, but also examine how we can use the information we glean from such observations in order to deduce how our present-day universe came to look the way it does in the first place.

In this course, you will not only learn a great deal about our universe, but will also get a chance to develop some of the skills that physicists and astronomers use in order to extract information from data. In particular, by the end of this course, you'll be able to…

- understand how properties of stars are measured.
- model the generation and propagation of light within stellar atmospheres
- apply thermodynamic principles to the interior structures of stars, particularly the Sun
- understand the properties of compact objects: white dwarfs, neutron stars, and black holes
- identify the sequence of events and epochs which are believed to have taken place during the history of the Universe and justify why, based on observations of the present-day universe, we believe each of these events or epochs occurred.
- identify the gaps in our knowledge about our universe's history and be able to evaluate cosmological models based on the knowledge that we *do* have.
- understand the differences between the various measures of distance used in cosmology and be able to apply each one in order to extract information from observational data.
- apply the Friedmann equations in order to determine how a universe consisting of different energy components will evolve at any given time.
- explain why our Universe is believed to contain both dark matter and dark energy and explain the difference between the two.

Prerequisites

The prerequisites for this course are an understanding of Newtonian mechanics at the level of PHYS 131 or PHYS 151 and an understanding of electricity and magnetism at the level of PHYS 133 or PHYS 152.

Components of the Course

The course will consist of class meetings, reading assignments in the text, weekly problem sets, and two in-class presentations. These are described more fully below.

Class Meetings:

Class meetings will be held from **2:45 – 4:00 PM** in Hugel 017 each Tuesday and Thursday during the semester. Regular attendance at these class meetings is expected. A schedule of topics to be covered each day is listed on the course web page. Much of the material covered in this course – and many of the homework problems that you'll be working through –

are quite challenging. It is therefore important that you come to class prepared to ask questions and to engage in discussions. You should be aware that class meetings will involve not only our lecturing to you about the material covered in the readings (which is not necessarily the best way for me to help you learn the material), but a variety of other activities as well – the benefit you get out of which is directly proportional to the effort you put in.

Textbook:

There are two required texts for this course, listed below. For both of these texts, any format of the text will do: a physical copy, an eBook, or a pdf if available. Get them in whatever format you prefer. A copy of the Carroll and Ostlie text is also available at the reserve desk in Skillman Library, and a copy of the Ryden text is on order at the Library.

- Bradley W. Carroll and Dale A. Ostlie, *An Introduction to Modern Astrophysics*, 2nd Ed. (Cambridge University Press, 2017), ISBN 9781108422161
- Barbara Ryden, *Introduction to Cosmology*, 2nd Ed. (Cambridge University Press, 2017), ISBN 9781107154834.

Homework Assignments:

Working through problems is an essential part of this course. There's no way of truly understanding quantum mechanics without delving in and *doing* astrophysics calculations. For this reason, we will be assigning a number of homework problems each week which we feel provide practice with the most crucial aspects of the material we're covering in the course. A list of the problems included in each problem set will be provided on the course Moodle.

Each homework assignment is due at 5:00 PM on the day indicated on the assignment. Each assignment will specify whether your work should be submitted on paper or submitted online (as a PDF on Moodle). In any case, you do not need to typeset your homework in a fancy way. Write your work out by hand on paper. If we request online submission of a given assignment, scan or photograph the pages and convert them to a single pdf for submission. Late homework may be penalized by 10% per day. If you are having difficulty completing an assignment on time, please contact the instructor. We can make accommodations in cases of illness, personal difficulties, etc.

We encourage you to work together on homework problems with other students in the class. This can be a very productive way of expanding your own knowledge, and working with other people to solve problems is a big part of how science is really done. However, the work that you turn in must be your own: it should reflect your own understanding and should be written up independently after all discussion between you and your peers is complete.

In-Class Presentations:

In addition to the homework assignments, you will also be delivering two short presentations (approximately 8 minutes and certainly no more than 10 minutes in length) to the class this semester. These presentations will give you the opportunity to explore your own interests in astrophysics and cosmology and to communicate the results of that exploration to your peers. Public presentations are a part of just about every career in science and engineering – and in a lot of other situations in life as well – so getting practice preparing and giving one will be valuable no matter what you want to do.

Details of content and scheduling will be given in class. You will deliver one of these presentations sometime during the first half of the semester (on or before Oct. 17th) and the other sometime during the second half. The presentation you deliver during the first half of the semester should focus on a topic related to stars or galaxies, while the one you give during the second half should focus on a topic related to cosmology. If you're not sure what topic you'd like to pursue, we would be happy to meet with you and discuss possible ideas.

The format of your presentation should be whatever is appropriate for communicating your intended message to your audience. For example, if you intend on displaying and discussing images, figures, or plots, your presentation should probably be slide-based (created using PowerPoint, Keynote, OOImpress, Beamer, etc.). However, if your presentation consists primarily of a mathematical derivation, your presentation could also take the form of a blackboard talk. In any case, you should make it clear to your audience what sources you're using.

No Exams in this class:
There will be no exams in this class.

Instructor Drop-In Hours:

Drop-in hours (sometimes referred to as "office hours") are times that your instructors have set aside for you to ask us questions, get homework help, or discuss any other aspect of this course. Prof. Nice's official drop-in hours this semester will be held in Hugel 030 (his Department office). Prof. Thomas's drop-in hours will be held in Hugel 125 (*not* his Department office) on **Tuesdays from 1:00 – 2:00 PM**, on **Wednesdays from 1:30 – 3:00 PM**, and on **Fridays from 1:30 – 3:00 PM.** Prof. Nice's drop-in hours will be in Hugel 030 on **Mondays and Tuesdays from 11:15 am to Noon** and **Mondays from 3:10 to 4:00 PM**. These hours may change as the semester evolves. Up-to-date hours will always be posted on Moodle. If you and other students in the course have the same question, you are welcome – and in fact encouraged – to meet with us during our drop-in hours as a group.

If you are unable to make it to these official drop-in hours, you may also email us to make an appointment to meet at some other time. However, please do this as far in advance as possible in order to ensure that we can find a time to meet.

Grading and Intellectual Honesty

Course Grade:

Your grade in the course will be determined by the following criteria:

Homework	80%
Presentations	20%

Intellectual Honesty:

When studying, or working on homework problems, we encourage you to work with each other. However, you may not consult a solutions manual or any other source for answers to the problems, and the final problem write-ups should be your own work. As always, you are expected to abide by the principles of intellectual honesty and academic integrity outlined in the Lafayette Student Handbook, which can be found at

- https://conduct.lafayette.edu/student-handbook/

Other Useful Information

Accessibility Services:

In compliance with Lafayette College policy and equal access laws, we are available to discuss appropriate academic accommodations that you may require as a student with a disability. If you are requesting accommodations, you must register with the Accessibility Services Office (administered by the Academic Resource Hub) for disability verification and for the determination of reasonable academic accommodations. Accessibility Services will then provide me with a document which outlines what those accommodations are. We cannot provide accommodations until we receive such a letter. Requests for academic accommodations must be made within the first two weeks of the semester, except in unusual circumstances, so that suitable arrangements can be made in a timely manner.

Course Communication:

Throughout the semester, we will use the Moodle page for this course in order to distribute course materials, communicate with the class, etc. The Moodle page can be found at

- https://moodle.lafayette.edu/course/view.php?id=25683

Occasionally, it may be necessary for us to communicate additional information (scheduling changes, clarifications about homework problems, etc.) to the class as a whole. When we do so, we will use your official Lafayette email addresses for all course-related correspondence, so make sure to check your Lafayette email regularly.

COVID-19 Protocols:

Masking is not required during class meetings or during instructor drop-in hours this semester, although this policy may change if the situation warrants it. That said, Prof. Thomas will be wearing a mask in the classroom at all times, and we both encourage you to do likewise if it makes you feel more comfortable.

If you are experiencing COVID-19 or flu symptoms (cough, chills, fever, sore throat, etc.), inform that week's instructor of the situation by email and get a COVID-19 test as soon as possible. Consult with the instructor on masking expectations. In any case, if you have active symptoms (whether or not they are COVID-19), please do not come to class! We want everyone to be healthy. If you have a positive COVID-19 test, you are required by Lafayette College protocols to isolate for 5 days and may not attend class meetings or instructor drop-in hours until the isolation period is over. You are also required to wear a mask for an additional 5 days after this isolation period ends. If you test positive for COVID-19, inform me immediately so that we can discuss how you will keep up with your work in this class during the isolation period.

Privacy Statement Concerning Course Materials and Classroom Recordings:

At Lafayette College, all course materials are proprietary and for class purposes only. This includes posted recordings of lectures, worksheets, discussion prompts, and other course

items. Reposting such materials or distributing them through any means is prohibited. Such materials should not be reposted or distributed through any means. You must request my permission prior to creating your own recordings of class materials, and any recordings are not to be shared or posted online even when permission is granted to record. Permission will be granted only when sanctioned as an academic accommodation in an official letter from the Accessibility Services Office. If you have any questions about proper usage of course materials please ask me. Please also be in contact with me if you have any concerns with being recorded during the course.

Online discussions in Moodle occurring during synchronous class sessions should also remain private and not be shared outside of the course. Courses using Moodle will make student information visible to other students in this class. Student information in courses is protected by the Family Educational Right to Privacy Act (FERPA). Disclosure of student information to unauthorized parties violates federal privacy laws and it must not be shared with anyone outside the class. Questions can be referred to the Registrar's Office.

Mandatory Credit-Hour Statement:

The student work in this course is in full compliance with the federal definition of a four-credit-hour course. The full policy and practice statement can be found on the Registrar's Office website at

- https://registrar.lafayette.edu/wp-content/uploads/sites/193/2022/07/Federal-Credit-Hour-Policy-Web-Statement.pdf

Course Schedule

The full, up-to-date schedule for the course, including due date for all assignments is available on the course Moodle.

Week	Topics and Readings	Due Dates
Week 1 8/28 – 9/1	**Tools of Astronomy; Binary Systems** Carroll & Ostlie: Ch. 3, 7	
Week 2 9/4 – 9/8	**Stellar Spectra** Carroll & Ostlie: Ch. 8	HW1 (Due 9/5)
Week 3 9/11 – 9/15	**Stellar Atmospheres** Carroll & Ostlie: Ch. 9	HW2 (Due 9/12)
Week 4 9/18 – 9/22	**Stellar Interiors** Carroll & Ostlie: Ch. 10	HW3 (Due 9/19)

Week 5 9/25 – 9/29	**The Sun; Stellar Evolution** Carroll & Ostlie: Ch. 11, 13	HW4 (Due 9/26)
Week 6 10/2 – 10/6	**Stellar Evolution (continued)** Carroll & Ostlie: Ch. 13, 15	HW5 (Due 10/3)
Week 7 10/9 – 10/13	**Compact Objects** Carroll & Ostlie: Ch. 16	
Week 8 10/16 – 10/20	**Comp. Obj. (Cont'd); Fundamental Observations** Carroll & Ostlie: Ch. 16; Ryden, Ch. 1 - 2	HW6 (Due 10/17)
Week 9 10/23 – 10/27	**Particles, Gasses, and Relativity** Ryden: Ch. 2 - 3	HW7 (Due 10/22)
Week 10 10/30 – 11/3	**Special and General Relativity** Ryden: Ch. 3 - 4	HW8 (Due 10/31)
Week 11 11/6 – 11/10	**The Friedmann Equations** Ryden: Ch. 4	HW9 (Due 11/7)
Week 12 11/13 – 11/17	**Cosmological Epochs** Ryden: Ch. 5	HW10 (Due 11/14)
Week 13 11/20 – 11/24	**Dark Matter and Dark Energy** Ryden: Ch. 6 - 7	HW11 (Due 11/21)
Week 14 11/27 – 12/1	**The Cosmic Timeline I, Part I** Ryden: Ch. 10 - 11	
Week 15 12/4 – 12/8	**The Cosmological Timeline, Part II** Ryden: Ch. 8 - 9	HW12 (Due 12/5)
Final Exam Week		