Astronomy 74: Astrophysics

Prof. Emily Boudreaux

Compiled: September 13, 2024

Class: MWF 12(x) block (12:50 - 1:55, X-hour(Tuesday): 1:20-2:10), Wilder 102
Office hours: TTh (Time TBD), Wilder 224a

Objective: The radiation of light is the primary means by which astronomers learn about the Universe. The overarching goal of this course is to enable you to explain, using words and equations, the physics underlying the astrophysical phenomena that you will encounter in modern astronomy.

Overview: A74 is a survey of the processes that generate the radiation detected by astronomers, and how astronomers interpret observations to understand the Universe. Topics include radiative transfer, blackbody radiation, bremsstrahlung, synchrotron radiation, inverse Compton scattering, atomic and molecular spectra. Applications will include stellar and planetary atmospheres, emission from neutron stars, and interstellar gas.

Most classes will be lecture; however, there will be approximatly one work day a week. Sometimes the schedule notes that a worksheet is to be completed on these workdays. You are free to do those worksheets during the class period (they are all short enough you should be able to finish them during the course period); however, you are also welcome to finish them later **that same day** and work on other class-related work during the course (such as projects, your term paper, or homeworks). Worksheets solutions must be submitted the same day.

An important part of the course will be student-led discussions of papers from the astronomy literature. All students are expected to have read the paper and participate in the discussion. After each discussion, you will prepare a short write-up reviewing the astrophysics content of the paper.

There will be five written assignments (problem sets) given throughout the term. You are allowed (and encouraged) to discuss the problem sets with others, but 1) you should first attempt problems on your own and 2) your written submission must be your own work. If you consult published solutions to the problems, you must cite these solutions in your problem set. Use of published solutions is strongly discouraged.

We will also be doing computational exercises in Jupyter notebooks. You can either do these on your own computer, or on the class Jupyter hub (https://jhub.dartmouth.edu). These guided exercises will demonstrate astrophysical phenomena.

The cumulative assignment is a review paper on a topic of current interest in astrophysics. More details will be given later in the course.

Textbook: *Radiative Processes in Astrophysics* by Rybicki and Lightman. This textbook is old and there may be options other than buying it; ask your classmates. Note that there are some errors in the book, see the errata: https://sites.ualberta.ca/ heinke/RadProc/RLerrata.PDF

Grading:

Problem sets (5)	40%
Worksheets (8)	10%
Paper reviews (2)	10%
Computational projects (5)	25%
Final paper	15%

Late Policy: Late assignments will be accepted without penalty for three days. If you are struggling with that timeline please contact me so that we can together come up with a plan.

Academic Honor Principle: All work submitted for grading is to be the student's own unless the work is explicitly and clearly attributed to another source. Discussion of assignments and papers among students or with tutors is permitted and encouraged. Copying of one student's work by another student is NOT permitted. To repeat: you can freely discuss assignments with anyone; you may not simply copy another person's work and submit it for grading as your own work. Further details on Dartmouth's academic honor polity may be found here while additional information specific for Dartmouth undergraduates may be found here

Students with Disabilities: Students requesting disability-related accommodations and services for this course are required to register with Student Accessibility Services (SAS; Apply for Services webpage; student.accessibility.services@dartmouth.edu; 1-603-646-9900) and to request that an accommodation email be sent to me in advance of the need for an accommodation. Then, students should schedule a follow-up meeting with me to determine relevant details such as what role SAS or its Testing Center may play in accommodation implementation. This process works best for everyone when completed as early in the quarter as possible. If students have questions about whether they are eligible for accommodations or have concerns about the implementation of their accommodations, they should contact the SAS office. All inquiries and discussions will remain confidential.

Religious Observances: Some students may wish to take part in religious observances that occur during this academic term. If you have a religious observance that conflicts with your participation in the course, please meet with me before the end of the second week of the term to discuss appropriate accommodations.

Generative AI: An unavoidable fact of the day is the proliferation of generative AI tools such as ChatGPT or CodePilot. These use of these tools is not banned outright in this class. However, you must follow certain rules when using them in order to meet the pedagogical goals of this course. Fundamentally, you may break down appropriate vs. inappropriate use of generative AI tools by answering the question: Could I achieve a similar end using Google (with perhaps some time investment to parse through results). If the answer is yes then it is likely an appropriate use. For example asking a prompt-based generative AI tool "Can you explain how to use scipy's curve fitting routine" is perfectly acceptable. However asking "Can you explain how to solve the following problem (problem statement copied from a project or homework)" is not an acceptable use. Further, **all** use of AI must be cited (in a way which makes it clear what the specific use was). In general think of AI as an advanced, and extremely flawed, search engine. Finally, AI **may not** be used for either of the two paper discussions or for your final paper in this course. If you have any questions about what is acceptable use and what is not feel free to ask me. I recognize that the line can seem blurry and I would much prefer to have a conversation early to clarify points.

Course Schedule (tentative)

Readings are to be completed *prior* to the date listed.

Monday Sep 16	Radiation Fundamentals, Intensity	1.1-1.3
Tuesday Sep 17 (X-hour)	Work day (CP #0)	
Wednesday Sep 18	Intensity 2	1.3
Friday Sep 20	Radiative transfer	1.4
	Due: CP #0 (F)	
Monday Sep 23	Thermal radiation	1.5
Wednesday Sep 25	Work day (WS 1b)	
Friday Sep 27	Paper discussion 1	Rappaport et al. (2019)
	Due: HW #1 (F)	
Monday Sep 30	Boltzmann & Saha, Line broadening	9.5,10.6
	Due: Rappaport et al. Summary (M)	
Tuesday Oct 1 (X-hour)	Work day (WS X)	
Wednesday Oct 2	Einstein coefficients	1.6-1.8
Friday Oct 4	EM Fields, Stoke's parameters	2.1-2.2,2.4
	Due: CP #1 (F)	
Monday Oct 7	Moving Charges	3.1-3.3
Wednesday Oct 9	Workday (WS 3a)	
	Due: HW #2 (W)	
Friday Oct 11	Thomson scattering	3.4-3.6
Monday Oct 14	Relativity	4
Wednesday Oct 16	Work day (WS 4)	
Friday Oct 18	Fourier review, Bremsstrahlung	5.1
	Due: HW #3 (F)	
Monday Oct 21	Thermal bremsstrahlung	5.2-5.3
Tuesday Oct 22 (X-hour)	Work day (WS 5b)	
Wednesday Oct 23	Synchrotron radiation 1	6.1-6.2
Friday Oct 25	Work day (CP #2)	
	Due: CP #2 (F)	
Monday Oct 28	Synchrotron radiation 2	6.3,6.8
Wednesday Oct 30	Compton scattering 1	7.1-7.3
Friday Nov 1	Work day (WS 6)	
	Due: HW #4 (F)	
Monday Nov 4	Compton scattering 2	7.4-7.5
Tuesday Nov 5 (X-hour)	Paper discussion 2	Kao et al. (2023)
Wednesday Nov 6	Sunyaev Zel'dovich effect	7
Friday Nov 8	Work day (WS 7a)	
	Due: CP #3 (F) Paper Draft (F)	
	Kao et al. Summary (F)	
Monday Nov 11	Plasma physics	8.1,8.2
Wednesday Nov 13	Work day (Final paper)	
Friday Nov 15	Backup day	
	Due : HW # 5 (F)	
Monday Nov 18	Work day (CP #4)	
	Due: CP #4 (T) Final paper (T)	