Astronomy 74: Astrophysics

Prof. Emily Boudreaux

Compiled: August 25, 2024

Class: MWF 12 block (12:50 - 1:55), Wilder 102 Office hours: TBD

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.

There will not be lectures in class. Instead, you will be asked to learn the material through self-study. The textbook is very good and is the basis for the course. I also have detailed lecture notes (which are nearly a transcript of lectures I have given previously). You should use the textbook and lecture notes in tandem. Our synchronous class time will be a mix of activities: (1) address the questions that you will inevitably have on the material (email me about them); (2) examples both to solidify your basic understanding, and to highlight some astrophysical applications; (3) office hours/co-working on computational worksheets.

After class, each worksheet should be written up independently and submitted to Canvas.

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. 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 (many)	15%
Paper reviews (3)	9%
Computational projects (3.5)	18%
Final paper	18%

Late Policy: Late assignments will be accepted without penalty for three days. If you are struggling with that timeline please contact Prof Boudreaux 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.

Students with Disabilities: Students with disabilities who may need disability-related academic adjustments and services for this course are encouraged to see me privately as early in the term as possible. Students requiring disability-related academic adjustments and services must consult the Student Accessibility Services office (205 Collis Student Center, 646-9900, Student.Accessibility.Services@Dartmouth.edu). Once SAS has authorized services, students must show the originally signed SAS Services and Consent Form and/or a letter on SAS letterhead to their professor. As a first step, if students have questions about whether they qualify to receive academic adjustments and services, 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.

Course Schedule (tentative)

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

Monday Sep 16	Intro + Workday (CP #0)	1.3
Wednesday Sep 18	Radiation Fundamentals, Intensity (WS 1a)	1.1-1.3
Friday Sep 20	Radiative transfer (Lec)	1.4
	Due: CP #0 (F)	
Monday Sep 23	Thermal radiation (WS 1b)	1.5
Wednesday Sep 25	Work day (HW #1)	
	Due: HW #1 (W)	
Friday Sep 27	Paper discussion 1	
Monday Sep 30	Boltzmann & Saha, Line broadening (WS X)	9.5,10.6
Wednesday Oct 2	Einstein coefficients (WS 1c)	1.6-1.8
Friday Oct 4	EM Fields, Stoke's parameters	2.1-2.5
	Work day (CP #1)	
	Due: CP #1 (F)	
Monday Oct 7	Work day (HW #2)	
Wednesday Oct 9	Moving charges (WS 3a)	3.1-3.3
	Due: HW #2 (W)	
Friday Oct 11	Thomson scattering (WS 3b)	3.4-3.6
Monday Oct 14	Relativity (WS 4)	4
Wednesday Oct 16	Work day (HW #3)	
	Due: HW #3 (W)	
Friday Oct 18	Fourier review, Bremsstrahlung (WS 5a)	5.1
Monday Oct 21	Thermal bremsstrahlung (WS 5b)	5.2-5.3
Wednesday Oct 23	Paper discussion 2	
Friday Oct 25	Work day (CP #2)	
	Due: CP #2 (F)	
Monday Oct 28	Synchrotron radiation (TBD)	6.1-6.2
Wednesday Oct 30	Work day (HW #4)	
	Due: HW #4 (W)	
Friday Nov 1	Synchrotron radiation (WS 6)	6.3,6.8
Monday Nov 4	Compton scattering 1	7
	Paper discussion 3	
Wednesday Nov 6	Compton scattering 2 (WS 7a)	7
Friday Nov 8	Work day (CP #3)	
	Due: CP #3 (F)	
Monday Nov 11	Sunyaev Zel'dovich effect (TBD/WS 7b?)	7
Wednesday Nov 13	Plasma physics (WS 8)	8.1-8.2
Friday Nov 15	Back up day	
	Due: Paper draft (F)	
Monday Nov 18	Work day (HW #5)	
	Due: HW #5 (T), Final paper	