ASTRONOMY 601
RADIATIVE PROCESSES
Fall 2022

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Lectures: T/Th 12:30-1:45 PM • ATL 0201

"The most incomprehensible thing about the universe is that it is comprehensible."
– Albert Einstein

Course Summary & Goals

The primary way in which we learn about astronomical objects is by intercepting the radiation that they give off. It is therefore of key importance for astronomers to be intimately familiar with the processes that govern radiative transport and the interactions between radiation and matter. This course will survey astrophysical applications of radiative processes. Topics covered include emission, absorption, and scattering of radiation by matter, radiative transfer, thermal equilibrium, ionization, atomic and molecular radiation, plasma radiation and transfer, bremsstrahlung, synchrotron emission, and Compton scattering. An undergraduate background in thermal physics, electricity and magnetism, and quantum mechanics is assumed. The principle goal of this class is to equip you with the tools to understand and address the propagation of radiation in a wide variety of astrophysical contexts. A secondary goal of this class is to prepare you for making scientific presentations during the remainder of your graduate career, and beyond. To that end, the final week of the class will be devoted to in-class presentations, in which each member of the class will present on a journal article of their choice and its usage of the topics studied during the semester.

Text

Required:
Radiative Processes in Astrophysics, Rybicki, G. B. & Lightman, A. P., Wiley-VCH, 2004

Other useful texts (not required):
The Physics of Astrophysics Volume 1: Radiation, Shu, F., University Science Books, 1991

Office Hours

There is no official office hour for ASTR 601, but please feel free to stop by my office or send me an email to schedule a time to chat.

Class Format

Class sessions will be conducted in a "flipped classroom" style. This approach has been shown by many studies to enhance student engagement and improve learning outcomes. The way that this will play out in ASTR 601 is we will have one student at a time serving as the class "scribe" at the board. This student will be responsible for writing the class notes on the chalkboard (e.g. derivations, diagrams, and definitions) with prompts from the professor and with the help of their peers. All members of the class are expected to engage with the class scribe, and to help them to write correct statements while at the board. For this system to work, it is key that we all endeavor to create a supportive classroom environment. Science is done in teams, and when we strive to elevate each member of the team we will all find success.

To reinforce our in-class work, please come to class having completed all assigned readings. The textbook reading is important preparation for supporting and acting as the class scribe. Please also review the class notes that I distribute after class. I will make my own notes available to the class following each class session to help synthesize what we covered on a given day.

Collaboration Policy

I encourage you to collaborate ***in class*** and on the ***homework assignments***. The course is graded on an absolute scale, so you won't reduce your grade by helping others. Your fellow classmates are an important resource to help you understand the course material in order to complete the homework. The best strategy is to first attempt to complete an assignment on your own, before consulting with your fellow students. If you are having trouble completing a homework problem, you may wish to consult with any of the following resources: your textbook, your class notes, your professor, or your classmates. **Other resources are not allowed unless I specifically approve them.** If you have any questions about appropriate use of outside resources, please come speak with me directly. If you collaborate on a homework assignment, you must (1) state the names of the students with whom you collaborated, and (2) submit your own individual, original solutions, which you write without consulting someone else's solutions.

It is very important that you do **NOT** collaborate with each other on the ***midterm*** or the ***final exam***. Any suspected violation of the collaboration policy will be forwarded to the Student Honor Council. (For more information, the UMD Code of Academic Integrity is outlined here: https://www.president.umd.edu/sites/president.umd.edu/files/documents/policies/III-100A.pdf)

Grading

Class Participation 10%

While I can present material, I cannot make you learn, and without your help this class will not be a success. Because of this, I will be grading on participation. Students who receive an "A" in participation will do many of the following things:

- Attend class
- Ask questions (before, during, or after class)
- Answer questions (being correct is not important)
- Help the class "scribe" and participate in this role when called upon
- Work effectively and collegially with their fellow classmates

Homework Assignments 25%

Homework assignments will generally be handed out in class on Thursdays and will be due two weeks after they are assigned. Homework assignments are to be handed in prior to the start of class on their due date. Well-motivated requests for homework extensions must be received by 48 hours prior to the homework submission deadline. Otherwise late homework will not be accepted. There will be no extra credit or dropping of the lowest grade.

Class Presentations 15%

In addition to expanding your understanding of radiative processes this semester, this class also aims to develop your scientific presentation skills. To that end, each student will complete an independent project in which you will present to the class on a recent paper from the scientific literature, focusing on the use of radiative processes in deriving the results of that work. Additional handouts and discussion of this project will be provided at a later date.

Midterm Exam 20%

The in-class midterm exam will occur on Tuesday 10/18. It will cover material from the first 6 weeks of lecture and the first 3 problem sets. All students are expected to take this exam. I will allow for alternate arrangements only in exceptional circumstances, and such arrangements must be made well in advance of the exam date.

Final Exam 30%

The final exam will occur on Monday 12/19 at 1:30 PM. The exam will be 2 hours in duration. It will be a cumulative final exam, covering all course content from the semester with a weighting toward new material that was not covered on the midterm.

Grading

The course will be graded on an absolute scale, with the following letter grade assignments. I reserve the right to revise the dividing line between letter grades downward. I will not revise them upward.

90-100%: A (+/-)
78-89%: B (+/-)
66-77%: C (+/-)
56-65%: D (+/-)
55% or less: F

Approximate Course Schedule

Date	Topic (approximate)	Textbook Chapters
8/30 9/1	Introduction, problem solving strategies, basics of radiation Radiative flux and intensity	Syllabus Ch 1.1 - 1.3
9/6 9/8	The radiative transfer equation, emissivity, opacity, and optical depth Thermal radiation and the Planck spectrum	Ch 1.4 Ch 1.5
9/13 9/15	Thermal radiation (cont'd), Einstein coefficients ***(HW1 due)*** Einstein coefficients	Ch 1.6
9/22 9/24	Scattering effects and random walks Moment equations, the gray atmosphere	Ch 1.7 Ch 1.8
9/27 9/29	Maxwell's equations ***(HW 2 due)*** E&M basics, plane parallel waves	Ch 2.1 - 2.2
10/4 10/6	Polarization & Stokes parameters Liénard-Wiechart potentials ***(HW 3 due)***	Ch 2.3 - 2.4 Ch 3.1
10/11 10/13	Radiation from moving charges Dipole radiation	Ch 3.2 Ch 3.3
10/18 10/20	**Midterm Exam** Thomson and Rayleigh scattering	 Ch 3.4 - 3.6
10/25 10/27	Thermal Bremsstrahlung Bremsstrahlung (cont'd) ***(HW 4 due)***	Ch 5

Date	Topic (approximate)	Textbook Chapters
11/1 11/3	Compton scattering Compton scattering (cont'd)	Ch 4 (relativity review) Ch 7
11/8 11/10	Synchrotron radiation Synchrotron radiation (cont'd)	Ch 8
11/15 11/17	The Schrödinger Equation, energy levels ***(HW 5 due)*** Spin-orbit coupling, the Zeeman effect	Ch 9.1 - 9.4
11/22 11/24	Thermal distribution of energy levels and ionization ***** Thanksgiving *****	Ch 9.5
11/29 12/1	Dipole Transitions, line broadening mechanisms *Student presentations*	Ch 10
12/6 12/8	*Student presentations (cont'd)* ***(HW 6 due)*** ***No Class***	
12/19	**Final Exam: 1:30-3:30 PM**	