Astronomy 601: Radiative Processes

Professor:

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Class web page: http://www.astro.umd.edu/∼miller/teaching/astr601

I will post lecture notes a few days before each class, and will assume you have read them before the actual lecture.

Schedule:

Lectures on Tuesdays and Thursdays from 12:30 to 1:45, ATL 0201.

Textbooks:

Required: *Radiative Processes in Astrophysics* by Rybicki and Lightman.
Recommended: *The Physics of Astrophysics Volume 1: Radiation* by Shu.

Course Grading

Feel free to discuss homework with other students, but you must work out and write up the solutions yourself. Web research is also okay unless specified otherwise in the problem (it's part of the learning process), but I do recommend that you work on the problems yourself first. You must indicate in your answer if any significant component came from a webpage or any other resource (see below for the special comment on AI tools such as, but not limited to, ChatGPT). I will grade each problem (in the homework and in the exams) on a four-point scale. One point is awarded if you demonstrate understanding of the physical issues associated with the problem. One point is awarded if you use the correct equations (assuming equations are needed). Two points are awarded for correct solution of the equations. If you come up with an answer that is obviously incorrect (e.g., a velocity 1000 times the speed of light!), but correctly say why it is incorrect and approximately what the right answer is, you will get one of those possible two points. If your answer is incorrect and this can be shown by simple units, limits, or symmetry arguments and you do *not* note this, more points might be taken off. You do need to take a stand: saying "I think this might be wrong" with no details won't help you, and might hurt you if your answer is actually right. The midterm and final will both be in-class, and will be closed-book and closed-notes.

Homework sets will be available on the class webpage, at least two weeks before the due date. Due dates will be Thursdays, typically two weeks apart (except for special cases such as Thanksgiving and the week of the midterm). Homework will be due right at the beginning of class, because I want it to be possible for you to absorb the content of that lecture instead of worrying about the problems! I will therefore enforce this policy strictly, and will take off points for, e.g., homework turned in at the end of class. I will do my best to return graded homeworks to you, with a solution set, by the next Tuesday.

Starting with the second homework, I will ask you to write computer codes as part of your homework. In addition to giving me the output of your code (in graph form, usually), I will require that

Table 1. Grade weights

Homework	25%
Midterm Exam	25%
Final Exam	35%
Individual Project	10%
Class Participation	5%

before the due date, you send me a copy of your code. This can be in any language that you want *provided* that the code compiles and runs on my departmental computer without my having to do anything but compile and run it (you can send me instructions about the compilation). Thus I will not install libraries or download anything to make your code run!

The individual project will be a report on one current topic in radiative processes in astrophysics. This will typically be represented by a single short paper in the literature, but it can be more extensive if you want. I'll want you to have selected the topic you'll discuss by the week after the midterm, so that we can talk about it and make sure it's a good project. The report will be both a written report (4-5 pages in double-spaced 12pt format with 1 inch margins) and an oral report, which will be given in class at the end of the semester. For this project you will be graded on both content and presentation in the oral and written reports; the presentation in the oral report will be judged based on the criteria in the guides to talks that I give on the webpage. The "class participation" portion involves both your questions to me and answers to my questions during class; I don't expect you to get the "right" answer every time but I do want you to try.

An additional component of the class participation grade is that by the night before a given class I want you to e-mail me (1) a short statement about an aspect of my notes and/or the Rybicki and Lightman reading for the class that you want elaborated or that you didn't understand, and (2) a short statement about something you *did* understand well. For the part that you want elaborated, you must indicate the point up to which you *did* understand. Thus something like "I didn't understand Equation (7)" is insufficient; you would need to indicate what parts of Equation (7) you did understand, and the nature of the elaboration you want. Moreover, in your e-mails reacting to the reading, I also want you to prompt an AI (for most of you that will probably be TerpAI, but please specify) with something like "Write one sentence on [topic] in an astrophysical context." As an example, it could be "Write one sentence on synchrotron radiation in an astrophysical context." I want you to include in your e-mail (1) which AI you used, (2) the exact prompt you used, (3) the exact answer you received, and most importantly, (4) an assessment from you about whether the answer was 100% accurate or whether there were important mistakes or omissions (and you would specify the mistakes or omissions). For part (4) you must commit completely one way or another; no weasel words ("maybe it was wrong", "I think it might be right"). I'm curious to see how that goes; my own tests show that sometimes it is 100% accurate, but other times it gets key points wrong.

ChatGPT and Other AI Tools

The rapid rise of ChatGPT and its competitors requires that we rethink our use of different tools to understand the universe, in classrooms and in our research. My point of view is that although artificial intelligence has the potential to improve our reach of information, in practice studies demonstrate that use of these tools risks reducing critical thinking and learning of material. I want you to think about the physics and astrophysics that we discuss in this course, from a critical standpoint, and I want to to check your answers and understanding at every point that you can. With that in mind, the policy for this class is:

1. You may not use any AI tools in any part of your homework; not to solve the homework, not to check your answer once you have a solution, nothing.
2. However, if you feel it is useful, you may absolutely use AI or any other tools (our book, my office hours, conversations with other students, etc.) to improve your understanding of a subject, including to study for exams.
3. My strong recommendation is that if you *do* use AI in our class, you do so with well-honed skepticism. My own examination of TerpAI (the free UMd version of ChatGPT, version 4o) responses regarding topics in our class shows that it often gets answers right, but also often will make mistakes. Thus uncritical reliance on AI answers will muddle your understanding of subjects. See above for how I would like you to incorporate AI into your readings.

Letter Grades

I will guarantee that you will receive no worse than the following letter grades for a given percentage of the total available points: A– for 85% to 100% of the points; B– for 70% to 85% of the points; C– for 55% to 70% of the points, and D– for 40% to 55% of the points. I may grade on a curve if the class average is significantly lower than suggested by the table; + and – additions to the letter grades will be determined based on the class distribution. There will be no extra credit.

Late Policy and Make-Up Policy

Partial credit for late homework assignments may be given if you give me a valid and documented reason by the Tuesday before the assignment is due. No credit will be given for homework turned in after the beginning of class the Tuesday after the due date, because I will hand out solution sets then. If you cannot make the midterm or the final exam, then we can arrange a different time if you tell me at least a week before the exam (to be fair to other students, the alternate time should be before the scheduled time).

COVID policies

I think that we are far enough away from the pandemic that this is no longer relevant, but in case it is we will follow the policies of the University of Maryland, which may change in response to CDC and State of Maryland guidelines. Please see https://umd.edu/4Maryland/health-plan for the current policies.

Academic Integrity

You know the drill by this time in your academic careers. If you have any questions, please talk with me and/or look at the University page http://www.studentconduct.umd.edu/

Some general guidelines:

1. I encourage you to work together, but you need to write things up separately. Copied materials, from each other, from previous students, from websites, etc., are a violation of our honor code. If for some reason you feel that it is essential to quote a particular source (this might come up in your term project), put quotes around the quoted part and cite the source there. For example: "If you don't make mistakes, you're not working on hard enough problems. And that's a mistake." (Frank Wilczek) My general advice is to do as much as you can yourself before talking with others or looking up references; that maximizes your learning and won't give you a reputation with others as a freeloader :)

2. No bullying, please! Grad school is tough enough as it is. You'll all do better if you cooperate constructively. Now, that doesn't have to mean that you agree with each other all the time; a major part of the cooperative aspect of science is the push and pull of robust discussion to get to better answers. But this can be done in a fun and civil way.

Tentative Course Outline
Sep 2–Sep 11: Overview, specific intensity, scattering and absorption.
Sep 16–18: Blackbodies and rate equations.
Sep 23–25: Quantum statistical mechanics and equilibria.
Sep 30–Oct 9: Electromagnetism applied to radiation, and relativity.
Oct 14: Fall break.
Oct 16: Midterm.
Oct 21–23: Thomson, Rayleigh, and Compton scattering.
Oct 28–Nov 4: Bremsstrahlung, cyclotron/synchrotron, plasma processes.
Nov 6: Statistics and interpretation of spectra.
Nov 11–20: Atomic structure, transitions, bound-bound and bound-free, line broadening.
Nov 25: Molecules.
Nov 27: Thanksgiving break.
Dec 2: Vibrational and rotational transitions.
Dec 4: Neutrino and gravitational radiation processes.
Dec 9: Class-selected topic.
Dec 11: Presentation of projects.
Dec 19: Final exam: 4:00-6:00 PM, normal classroom