ASTR 792 Syllabus
Fall 2020
Professor Mills

Applied Physics of the Interstellar Medium
2:30- 3:45 TR

Office Hours:
- **Thursdays at 11 AM** on Slack
- Additional one-on-one hours on Zoom/Slack can be scheduled by appointment here

Class Github: https://github.com/eacmills/ASTR-792

Class Slack group: kuphysicsandastronomy.slack.com

Anonymous Feedback: Form here

Course Philosophy:

Graduate school is a time of change, when you must transition from achieving subject mastery in the classroom to becoming an independent researcher. This can feel like "moving the goalposts", as up to this point you have been primarily assessed based on your academic performance, but now you must pivot to achieve research proficiency. Despite the importance of successfully navigating this transition, uniform training in the skills necessary to do this are rarely provided, as historically this guidance is expected to come from your individual advisor. The goal of this course is to better prepare you for this transition by not only providing a strong theoretical foundation in astrophysics but also guiding you to apply these skills and concepts to your research practice, particularly focusing on areas of coding and project management.

Overview:

This course will cover topics including:

- The theory of radiative processes relevant to astrophysical situations, including those acting on atoms, ions, and molecules and especially those relevant to material exterior to stars.

- The physics of the interstellar medium in and between galaxies, including fluid dynamics, the quantum mechanics of atomic and molecular spectra, and equilibrium and non-equilibrium thermodynamic processes.
- Observational diagnostics of interstellar gas, including microwave spectroscopy and radiative transfer modeling.

Throughout this course we will work to develop a theoretical understanding of these topics that can be applied to the practice of astrophysics research. The theoretical understanding of course concepts will be assessed through regular problem sets. The ability to transfer these skills and concepts to a research setting will be assessed through a strong emphasis on Python notebooks in weekly lectures, with coding-based activities and challenges involving real data sets.

Course Goals:

As an instructor:

- Adapt to the challenges of a remote learning environment by working with students to provide responsive and individualized solutions to help students engage with course content and to maintain social connections
- Maintain a supportive and welcoming classroom environment where students are comfortable asking questions, discussing topics, and solving problems
- Foster a community of learning in which students and professor support each other and challenge each other to listen, grow and succeed
- Listen to student needs and provide resources, guidance, and feedback that helps each student achieve their individual goals

For students:

- Practice and improve physics problem solving techniques, including recognizing when a challenging problem or concept has you stuck, and responding by finding and utilizing resources to get unstuck.
- Apply the methods and topics covered in this class to new scenarios, including current research problems.
- Improve your communication skills for working as part of a team, including listening to and validating classmates, and sharing your opinions and input.
- Build project management skills, including defining goals, prioritizing individual tasks, and employing time management and organization strategies to deliver a final product.

Textbooks:

(1) Bruce T. Draine, ‘Physics of the Interstellar and Intergalactic Medium’.
(2) Charles H. Townes & Arthur L. Schawlow, ‘Microwave Spectroscopy’.

Draine is required, and will be the primary text for the course. For a more detailed treatment of molecular spectra I will also refer to Townes and Schawlow, and I recommend but do not require this text. Draine is currently in print, and there are many ways to obtain this text including the campus bookstore and online book vendors. Townes & Schawlow is not in print, however used copies are available, and an ebook version is available for $10. I will also provide scanned excerpts of sections listed in the course readings.

Classroom Environment:

Learning is not a competition, but rather a mutual endeavor where we all work to succeed together. Everyone in this classroom, including myself as a professor, is here to learn. Ignorance is a natural part of this process. During the semester we will all encounter situations that make us feel confused or lost. We may initially fail at something. We can support each other by asking questions, sharing our own understanding, respecting each other when we struggle with a new idea or concept, and celebrating when we eventually ‘get it’. Listening to each other is key to learning, and as a professor I will regularly solicit student opinions and feedback about the course, in addition to the anonymous feedback form.

If you have any concerns about the class that you feel are not being addressed, please contact me by e-mail or in person. I will be available for regular office hours when you can talk to me about any topic (grades, homework, class structure, issues outside of the classroom, research, etc). Additionally, if you ever feel that you have been subjected to sexual harassment (or any other kind of bullying) in this class and do not wish to discuss it with me directly, please talk to the Department Chair (Dr. Feldman) as soon as possible.

Weekly Class Structure:

This class will be highly interactive with a mix of lecturing and group work, so I expect you to familiarize yourself with the assigned reading before coming to class. To encourage this, I require that for each class meeting students (1) post at least one question about the assigned reading on the slack channel and (2) interact with a question posted by another student.
Each week, the goal is to devote the first 45 minutes of class to lecturing, with the last 30 minutes reserved for group problem solving. I expect students to attend class regularly in order to participate in all these activities.

Course Webpage:

Class materials, including problem sets and lecture notes, will be available in a shared Github repository. Please contact me if you encounter any difficulty accessing these materials.

Homework:

There will be a series of problem sets assigned over the course of the semester. You are encouraged to work together, however each student must turn in their own version of solutions. I strongly prefer that homework assignments be typed: typed homework is easier for me to read and grade, can more easily be revised in the future by you, and allows for additional self-assessment and reflection as it is transcribed from your original notes. Ultimately however I leave it to your discretion. Unless otherwise specified in class, ***homework is due at midnight on the date shown in the lecture schedule.*** If you cannot make a deadline, please contact me in advance. In the second half of the semester, the problem sets will transition to a single problem, due weekly.

Final Project:

There will be no traditional exams in this course. Instead, a project will take the place of a Final exam.

For the final project, students in the class will work together to make a solution guide for 6 problems from the problem sets that accompany the Draine textbook. Three of these problems can be from the first two problem sets. Using a team-editing software (overleaf, google drive, or github) you will work as a team to compile individual solutions for each problem set into a single document. These solution sets should include:

- A detailed, step-by step solution to each problem
- Examples of alternative solutions or approaches, if they exist
- Examples of common mistakes or pitfalls to watch out for
- Helpful sources (texts, webpages, etc) used for solving these problems

Everyone should have an opportunity to contribute substantially to this final project. The more you have worked together already, the easier this should be. All resources are allowed, including the internet, other students and professors. A final grade will be awarded to the class as a whole. Each student should write a brief description of your contribution to the final document (examples: contributing a mistake you made on problem 1, formatting equations for problem 2, proofreading problem 3, or finding a helpful source for problem 4 online).

Grades and Assessment:

Your performance in this course will be assessed using multiple methods.

Formative Assessment: 60% of the course grade will be determined from the ***completion*** of work, including twice-weekly reading questions, in-class activities, and the first two problem sets. This is low-stakes work that will ***not be graded on correctness***, but instead will be graded based on the completeness of the work you have done and the effort you have put in.

Summative assessment: 40% of the course grade will be determined from your grades on the midterm, the weekly problems from the second half of the semester (these will be graded normally, and solutions will be made available), and the final project. As previously described, the final project will consist of students in the class working as a group to create a set of solutions for problems from Draine.

All together, the detailed weighting scheme for final grades is:

Reading questions	20%
In-class work	20%
Problem sets (ungraded, effort-based)	20%
Weekly problems (graded)	20%
Final project	20%

Final grades in the class will be assigned based on percentages, as follows:

A+	97% and above	**B+**	87% - 89.9%	**C+**	77% - 79.9%	**D+**	67% - 69.9%
A	92% - 96.9%	**B**	82% - 86.9%	**C**	72% - 76.9%	**D**	62% - 66.9%
A-	90% - 91.9%	**B-**	80% - 81.9%	**C-**	70% - 71.9 %	**D-**	60% - 61.9%

How to Succeed in this Class:

A successful student in this class looks like you! I have high expectations about what we can learn and accomplish this semester, and I believe each of you has the ability to meet these expectations and succeed. Some tips:

- Take notes on reading & lectures, and spend some time outside of class summarizing them (daily or weekly). Try to make connections in your notes to topics from other lectures (have we discussed anything similar already in this class?)
- Ask questions! If you encounter a question you really don't want to ask in the lecture, or on Slack, submit them anonymously through the google form, or send me an e-mail!
- Take advantage of your classmates: we can all learn from each other, and sharing our questions and ideas will make all of us better problem solvers.
- Don't leave problems blank on homework or in-class work-- always try something and write a description of your thought process (if you think you are doing something wrong or have the wrong answer, say why. Reflecting on problems is a valuable skill!)
- If something isn't working for you, let me know! I value your perspective and feedback, and while I can't fix or change everything, I will be working to improve the class over the course of the semester.