

PHYS 4720 – Galaxies and the Interstellar Medium (undergraduate)

PHYS 6720 – Galaxies and the Interstellar Medium (graduate)

Course Syllabus, Spring 2021

This online syllabus will be an evolving document (removed from public version) that will be updated throughout the semester.

Course and Instructor Information

Instructor: Professor/Dr. Cara Battersby

Virtual Office: *(removed from public version)*

Office: Gant South S113F

Email: cara.battersby@uconn.edu

Office Hours: Tuesdays 9-10am on WebEx or by appointment, just ask me or try: *(removed from public version)*

Class Meeting: Mon/Wed 1:00-2:15pm

Class Location: *(removed from public version)*

Class Slack Group: *(removed from public version)*

Class Google Drive Folder: *(removed from public version)*

*Please join the WebEx and slack group¹ with your **preferred full name** and **gender pronouns** in parentheses. E.g. "Cara Battersby (she/her)" If your preferred name is different from your name on student admin, please send me a quick email.*

Course Materials

This is a dynamic course, spanning the detailed physics of our Galaxy's Interstellar Medium as well as Galaxies into the distant Universe. Unfortunately, there is no one textbook that covers all of this material at the same level it will be taught in our course.

*Therefore, I recommend the following textbooks as good references for you to consult as needed. **These are all freely available to you online (except 1 which you probably already have, but if you don't, you don't need to buy it).***

1. **An Introduction to Modern Astrophysics** by Carroll & Ostlie, 2nd edition, published by Pearson. Also known as the BOB (Big Orange Book). The same textbook is used in

¹ *(To change your display name in **WebEx**, log in to webex in your browser, click your account in the top right, selected "My Profile," then click "Edit My Profile," then change your display name. To change your display name in **slack**, open slack, click on your profile picture on the top right, click "Edit Profile," then change your display name.)*

PHYS 2701 and 2702. The material for this course is mainly restricted to Chapters 12, 24, 25, 26, 27, and 28.

2. ***Dynamics and Astrophysics of Galaxies*** by Jo Bovy. Online textbook (with coding exercises and examples!) available here: <http://astro.utoronto.ca/~bovy/AST1420/notes-2019/index.html> Awesome resource. Available as PDF in our “Textbooks” folder.
3. ***Extragalactic Astronomy and Cosmology : An Introduction*** by: Peter Schneider, 2nd Edition, 2014. Available as an ebook at the UConn library (details to be added)
4. ***Galaxies in the Universe : An Introduction*** by L. S. Sparke and J. S. Gallagher, III, 2nd edition. Available as PDF in our “Textbooks” folder.
5. ***Radiative Processes in Astrophysics*** by George B. Rybicki and Alan P. Lightman. A classic! Will be available at UConn library (link to be added).
6. ***ISM and Star Formation*** curated by Prof. Alyssa Goodman for a Harvard graduate class. Here: <https://ay201b.wordpress.com/>
7. ***Physics of the Interstellar and Intergalactic Medium*** by Draine. Available as PDF in our “Textbooks” folder.
8. ***Galaxy Formation and Evolution*** by Mo, van den Bosch, and White. Available as PDF in our “Textbooks” folder.

We will also be relying heavily on the current scientific literature. You can search for papers on ADS (<https://ui.adsabs.harvard.edu/>). You can download the publisher’s PDF if you are logged in with your UConn VPN or many are freely available on the arxiv.org.

Reminder: *Do not share any of the materials for this course (including textbook copies linked here, but also assignments, projects, notes, etc.) outside of this course. These are all copyrighted materials.*

Course Objectives

This is an advanced course for students looking to dive deeper into astrophysics. This course contains both a theoretical and observational overview of topics concerning Galaxies and the Interstellar Medium (ISM), as well as a chance to engage with the practical elements of how astrophysics research in these areas is conducted. If you seeking to pursue astrophysics professionally, this course will help prepare you for serious research endeavors. If you are not, this course is an opportunity to apply physics concepts to a new regime and become familiar with practical skills. The course objectives are to:

1. Solidify a **foundational understanding** of modern astrophysics.
2. Become familiar with the **tools of modern astrophysics**: coding in python, writing in LaTeX, collaboration, reading and engaging with the scientific literature.
3. Build **science communication** skills.
4. Become familiar with **key topics in Galaxies and the ISM** as well as to appreciate the open questions in the field.
5. **6720 only**: Develop self-learning and teaching skills. Develop a detailed understanding of the current status of the field.

Pre-requisites

The course assumes a strong background in physics, math, and astrophysics.

PHYS4720 pre-requisites: Completion of PHYS2701, PHYS2702 and MATH2410Q. This course is designed for advanced astrophysics students interested in pursuing astrophysics research. This course counts toward an Astrophysics Minor.

PHYS6720 pre-requisites: Proficiency in calculus and physics, and recommended to have a strong background in astrophysics and coding. Co-taught with PHYS 4720 and not open for credit to students who have passed PHYS 4720.

Course Schedule

Tentative Course Schedule -- subject to change – shared here:
(removed from public version)*

Date	Unit	Topic	Activity	Assignment	6720 only
1/20/2021	I. Intro	Course Overview	Intro to Python	PS1 assigned	
1/25/2021		Review and Stellar Astrophysics		Paper 1 astrobite and coding handed out	
1/27/2021		Basic Galaxy Properties and History		PS1 due	
2/1/2021	II. The Milky Way	Overview and Radiative Processes		PS2 assigned	
2/3/2021		Radiative Processes / ISM			
2/8/2021		Paper #1 Discussion	Paper #1 discussion	Paper 1 prep due	
2/10/2021		Radiative Processes / ISM		PS2 due	Paper2 coding and astrobite due
2/15/2021		Star Formation		PS3 assigned	
2/17/2021		Galactic Structure			
2/22/2021		the Galactic Center		PS3 due	
2/24/2021		Paper #2 Discussion	Paper #2 discussion	Paper 2 prep due, PS4 assigned	
3/1/2021		Stellar Populations			Paper 3 coding and astrobite due
3/3/2021		Galactic Dynamics		PS4 due	
3/8/2021		Galactic Dynamics			
3/10/2021		the Milky Way in Context		Midterm PS due (assigned Friday 3/5?)	
3/15/2021		Paper #3 Discussion	Paper #3 discussion	Paper 3 prep due, PS5 assigned	
3/17/2021	III. A Universe of Galaxies	Normal Galaxies		Term project first draft due	Paper 4 coding and astrobite due
3/22/2021		Morphology and Spiral Structure			
3/24/2021		Gas in Galaxies		PS5 due	
3/29/2021		Star formation in galaxies		PS6 assigned	
3/31/2021		Paper #4 Discussion	Paper #4 discussion	Paper 4 prep due	
4/5/2021		Supermassive Black Holes and Active Galaxies		Term project reviews due	Paper 5 coding and astrobite due
4/7/2021		The High-redshift Universe		PS6 due, PS7 assigned	
4/12/2021		spring recess			
4/14/2021		spring recess			
4/19/2021		Galaxy Evolution		Term Project Due	
4/21/2021		Galaxy Evolution		PS7 due	
4/26/2021		Paper #5 Discussion	Paper #5 discussion	Paper 5 prep due	
				Take Home Final PS Due	

Grading and Course Work

This course is designed to reward hard work and in-class participation. Intelligence is fluid and learning to learn is an important component of this class.

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Grade Component	Weight	Grade Component	Weight
Problem Sets	35%	Problem Sets	35%
Take-Home Exams	20%	Take-Home Exams	20%
Term Project	25%	Term Project	20%
In-class Participation	5%	In-class Participation	5%
Journal Club (Preparation and Participation)	15%	Journal Club (Presentation, Coding Project, Astrobite)	20%

Grading	Scale	(%)	
93-100	A	73-76	C
90-92	A-	70-72	C-
87-89	B+	67-69	D+
83-86	B	63-66	D
80-82	B-	60-62	D-
77-79	C+	0-59	F

Problem Sets

Problem Sets (PSs) will be due roughly every 1-2 weeks. PSs will be a combination of traditional written problems and coding problems. Instructions on submission will be included on each assignment, but in general, PSs must be **highly legible** or **typewritten** and should be **submitted as a PDF file**. As an advanced astrophysics course, **I expect professional and serious work from each and every one of you.**

Collaboration on PSs is allowed (even encouraged!), but the final work must be your own. Clearly indicate with whom you worked on each PS, what resources you used, and how long the PS took you to complete. **Prof. Battersby has a zero-tolerance cheating policy.** You are absolutely forbidden from seeking problem set solutions online, posting the problem set questions online, copying from anyone, or any other form of cheating. If you do so, the incident will be reported to academic misconduct, and I will recommend failure of the course.

Problem Sets will be discussed in class the day that they are due, so no late assignments can be accepted. However, **you can re-do problems (as many as you like) on two problem sets** for up to 65% credit on the redone problems within two weeks of the original due date. **The lowest problem set score will be dropped.** Students should contact the instructor at least one week in advance to make up work associated with planned absences (like religious observances or extracurricular activities).

The expectation for problem sets is that you clearly state the problem, demonstrate what you are calculating and why, clearly outline the steps and process for solving the problem, box your final answer, include appropriate units and significant figures for your answer, and assess the reasonableness of your answer. The focus is on problem-solving skills, not getting the right numerical answer, and the clearer your work is, the easier it is to assign partial credit. A “reality check” on your numerical answer is expected (does this answer make sense? Why or why not?).

The PSs will be “spot-graded” meaning that I will only grade a few questions. We will have time to discuss the solutions and any questions in class and of course in office hours.

Exams

We will have two 24-hour take-home exams during the semester. These will be very similar in style to the problem sets (with both traditional written and coding components) but are to be completed individually with no collaboration and in a limited 24-hour time window. They will be open notes but not open collaboration.

Term Project (in groups of 2?)

You will complete a term project which is an **8-10 page research paper on a topic in Galaxies and ISM of your choice**, to be approved by the instructor. This paper will be written in LaTeX and cite original references from the astronomical literature, as well as textbooks, and other resources. You will review a topic of your choice in detail. As part of writing your review paper, you must also **construct an original figure for the paper, or perform a new calculation, or apply a new model**, which will be included in your review. You will also **present your findings** in class. More details to follow.

Class Participation

This class will be an active learning experience with in-class work and participation expected. By default, *3 missed days of participation will be forgiven*, any more will detract from the in-class participation grade. Each day, you can earn 0, 1, or 2 points for no participation, distracted participation, or full participation, respectively.

Journal Club

We will engage with the scientific literature in this class through five (?) journal club style discussions. A journal club is generally a gathering where a paper from the scientific literature, and associated background, other relevant papers, future prospects, and so on are discussed. Typically, one or two people present an overview of the paper and lead the discussion but everybody involved has read the paper and participates actively in the discussion. Journal clubs are a staple of modern astrophysics. The undergraduate (4720) and graduate (6720) students will have different responsibilities for these discussions.

Graduate student (6720) Journal Club responsibilities: There will be four graduate student groups made of 2-3 people. All students will read each paper in detail. For each paper day, one group will do the **Journal Club presentation and lead the discussion**. A different group will write an **Astrobite** (astrobites.org for examples) on the paper, to be distributed to the full class **two weeks** prior to the Journal Club. A third group will write a short **coding project** in Google Colab related to the topics of the paper (e.g. “read in this data table and make this figure,” “re-do this model fit with this other data”) to be distributed to the full class **two weeks** prior to the Journal Club. The fourth group will rest. We will rotate what each group does each Journal Club so that each group fulfills each role at some point during the semester. In addition, the graduate students have the same preparation and participation responsibilities as the undergraduate students, outlined below.

Undergraduate student (4720) Journal Club responsibilities: The undergraduate students will: 1) read the Astrobite associated with each paper, 2) read the full paper, 3) complete the coding project associated with the paper, 4) submit a form about the paper including two questions for the discussion, and 5) participate actively in the discussion.

Seminars and Colloquia

Astronomy seminars happen most Wednesdays at 11am and Physics Colloquia occur some Fridays 3:30pm (see <https://physics.uconn.edu/> for calendar of talks).

Graduate students (6720) are strongly encouraged to attend every astronomy seminar and Astronomy-related Physics Colloquia. If you attend at least five of these and hand in a short, 1 paragraph summary of each, you will be awarded extra credit, up to an additional 10% of your final exam.

Undergraduate students (4720) will get extra credit for attending astronomy seminars and colloquia. If you attend at least three of these and hand in a short, 1 paragraph summary of each, you will be awarded extra credit, up to an additional 10% of your final exam.

Extra Credit

You can earn extra credit on your problem sets by suggesting improvements to the code that I share with you. I'm still learning too and will appreciate the help!

General Rules of Conduct in an Online Environment

The COVID-19 situation is unusual. Online learning may be especially challenging for many of you. Teaching online is new to me. I encourage open communication and regular check-ins about how things are going. I will encourage structured group work, both in class and out, to improve interactivity and to hopefully help feelings of isolation during this pandemic. Please adhere to these guidelines for online participation:

- *Please join the WebEx and slack group with your **preferred full name and gender pronouns** in parentheses. E.g. "Cara Battersby (she/her)" If your preferred name is different from your name on student admin, please send me a quick email.*
- Cameras are *optional* for the lecture period and *required* (if not possible let me know) during breakout sessions and Journal Clubs.
- To avoid sound feedback, students should be muted when not speaking in the main WebEx room.
- You can use a virtual background if you like, but please be sure there is nothing inappropriate in your virtual or real background.
- All classroom norms apply to our online class. If you wouldn't do it in a physical class setting, don't do it in our online classroom.
- I welcome questions and interactions during class. You can unmute yourself to ask a question, you can "raise your hand," you can use the weird WebEx emoticons, or you can say something in the chat window. These are all encouraged.

Academic Integrity

Don't cheat. Not even once, not even a little bit. Academic honesty is a fundamental tenet of education. Copying someone else's work, letting someone copy yours, seeking or using homework solutions or old exams (found online, from a friend, *anywhere*) is cheating. If any of you are caught cheating in any way, I will report the incident to Academic Misconduct and recommend failure of the course.

Take responsibility for your learning process and be a part of the community of scholars at UConn. Similarly, plagiarism in any form, meaning the failure to adequately document the source(s) of one's work, is wrong. Both copying and plagiarism violate the UConn Student Code. See Appendix A: Academic Integrity in Undergraduate Education and Research:

<http://community.uconn.edu/the-student-code-appendix-a/>

Instances of copying or plagiarism will be handled under the guidelines specified in the Student Code (<http://community.uconn.edu/the-student-code-preamble/>). You are responsible for acting

in accordance with this code. Review and become familiar with these expectations. “I didn’t know” is not an excuse. Please note that copying another student’s assignment is not the same as sitting down in a study group and discussing the assignment. As long as you maintain the boundary of *doing your own work* following discussion, there should not be a problem.

All lectures, notes, handouts, homeworks, exams, quizzes, and displays are copyrighted by state and federal law. You are welcome to take notes and share them with other students in the class. You are not authorized to share course materials outside our class, and are expressly forbidden from commercial use of course materials.

UConn policies

Full UConn policies can be found on the web, here is a good place to start:

<http://provost.uconn.edu/faculty-and-staff-resources/syllabi-references/>

Resources for Students Experiencing Distress

The University of Connecticut is committed to supporting students in their mental health, their psychological and social well-being, and their connection to their academic experience and overall wellness. The university believes that academic, personal, and professional development can flourish only when each member of our community is assured equitable access to mental health services. The university aims to make access to mental health attainable while fostering a community reflecting equity and diversity and understands that good mental health may lead to personal and professional growth, greater self-awareness, increased social engagement, enhanced academic success, and campus and community involvement.

Students who feel they may benefit from speaking with a mental health professional can find support and resources through the Student Health and Wellness-Mental Health (SHaW-MH) office. Through SHaW-MH, students can make an appointment with a mental health professional and engage in confidential conversations or seek recommendations or referrals for any mental health or psychological concern.

Mental health services are included as part of the university’s student health insurance plan and also partially funded through university fees. If you do not have UConn’s student health insurance plan, most major insurance plans are also accepted. Students can visit the Student Health and Wellness-Mental Health located in Storrs on the main campus in the Arjona Building, 4th Floor, or contact the office at (860) 486-4705, or <https://studenthealth.uconn.edu/> for services or questions.

Accommodations for Illness or Extended Absences

Please stay home if you are feeling ill and please go home if you are in class and start to feel ill. If illness prevents you from attending class, it is your responsibility to notify your instructor as soon as possible. You do not need to disclose the nature of your illness, however, you will need to work with your instructor to determine how you will complete coursework during your absence.

If life circumstances are affecting your ability to focus on courses and your UConn experience, students can email the Dean of Students at dos@uconn.edu to request support. Regional campus students should email the Student Services staff at their home campus to request support and faculty notification.

Policy Against Discrimination, Harassment and Related Interpersonal Violence

The University is committed to maintaining an environment free of discrimination or discriminatory harassment directed toward any person or group within its community – students, employees, or visitors. Academic and professional excellence can flourish only when each member of our community is assured an atmosphere of mutual respect. All members of the University community are responsible for the maintenance of an academic and work environment in which people are free to learn and work without fear of discrimination or discriminatory harassment. In addition, inappropriate amorous relationships can undermine the University's mission when those in positions of authority abuse or appear to abuse their authority. To that end, and in accordance with federal and state law, the University prohibits discrimination and discriminatory harassment, as well as inappropriate amorous relationships, and such behavior will be met with appropriate disciplinary action, up to and including dismissal from the University. Additionally, to protect the campus community, all non-confidential University employees (including faculty) are required to report sexual assaults, intimate partner violence, and/or stalking involving a student that they witness or are told about to the Office of Institutional Equity. The University takes all reports with the utmost seriousness. Please be aware that while the information you provide will remain private, it will not be confidential and will be shared with University officials who can help. More information is available at equity.uconn.edu and titleix.uconn.edu.

Students with Disabilities

The University of Connecticut is committed to protecting the rights of individuals with disabilities and assuring that the learning environment is accessible. If you are a student with approved academic accommodations through the Center for Students with Disabilities (CSD), please let me know immediately so we can discuss implementation. If you anticipate or experience any physical or academic barriers based on disability or pregnancy, you should contact the CSD to request accommodations at csd@uconn.edu or (860) 486-2020. Information about requesting accommodations is available on the CSD website at <http://csd.uconn.edu/>

Inclement weather and emergency preparedness

In case of inclement weather, a natural disaster, or a campus emergency, the University communicates through email and text message. Students are encouraged to sign up for alerts through <http://alert.uconn.edu>. Students should be aware of emergency procedures, and further information is available through the Office of Emergency Management at <http://publicsafety.uconn.edu/emergency/>

Sexual Assault Reporting Policy:

To protect the campus community, all non-confidential University employees (including faculty) are required to report assaults they witness or are told about to the Office of Diversity & Equity under the Sexual Assault Response Policy. The University takes all reports with the utmost seriousness. Please be aware that while the information you provide will remain private, it will not be confidential and will be shared with University officials who can help. More information is available at:

<http://sexualviolence.uconn.edu/>