

**PHYS 4720 – Galaxies and the Interstellar Medium (undergraduate)**

**PHYS 6720 – Galaxies and the Interstellar Medium (graduate)**

**Course Syllabus, Spring 2023**

*This online syllabus will be an evolving document*

*(<https://docs.google.com/document/d/1A2E4iv3HYkk7PSq7hdCcFPI6soFA1ecuMjdAFtLYZZk/edit?usp=sharing>) that will be updated throughout the semester.*

**Course and Instructor Information**

**Instructor:** Professor/Dr. Cara Battersby

**Office:** Gant South S113F

**Virtual Office:** <https://uconn-cmr.webex.com/meet/cab16109>

**Email:** [cara.battersby@uconn.edu](mailto:cara.battersby@uconn.edu)

**Office Hours:** Mondays 2-3pm (in person) or by appointment, just ask me or try:  
<https://calendly.com/battersby>

**Class Meeting:** Mon/Wed 12:30-1:45pm

**Class Location:** GS 119

**Class Google Drive Folder:**

<https://drive.google.com/drive/folders/1RtgbWLkp7ieMdYeQ5wvIKHdiPCB0Pgjq?usp=sharing>

**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. We will use one primary textbook, but recommend a number of others as resources.*

**Main Textbook:**

1. ***Extragalactic Astronomy and Cosmology : An Introduction*** by: Peter Schneider, 2nd Edition, 2014. Available as an ebook at the UConn library and available as a PDF in our shared Google folder under "Textbooks."

**Useful secondary textbooks:**

2. ***Galaxies in the Universe : An Introduction*** by L. S. Sparke and J. S. Gallagher, III, 2nd edition. Available as a PDF in our shared Google folder under "Textbooks".
3. ***An Introduction to Modern Astrophysics*** by Carroll & Ostlie, 2<sup>nd</sup> edition, published by Pearson. Also known as the BOB (Big Orange Book). The same textbook is used in PHYS 2701 and 2702. The material for this course is mainly restricted to Chapters 12, 24, 25, 26, 27, and 28.

### Additional helpful resources:

4. **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.
5. **Radiative Processes in Astrophysics** by George B. Rybicki and Alan P. Lightman. A classic! Used for graduate radiative processes as well.
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](https://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 galactic astrophysics.
2. Become familiar with the **tools of modern galactic 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:*

[https://docs.google.com/spreadsheets/d/10wjV01fejKLJoC0Yskun\\_Zrlca9p0wSMKn1OJXZGVlU/edit?usp=sharing](https://docs.google.com/spreadsheets/d/10wjV01fejKLJoC0Yskun_Zrlca9p0wSMKn1OJXZGVlU/edit?usp=sharing)

Date	Unit	Topic	Reading Due	Activity	Assignment - all	Assignment - 6720 only
1/18/2023	I. Overview of Galactic Astronomy	Course Overview	--	Distance to Andromeda	PS1 assigned	
1/23/2023		ISM and Milky Way overview	Ch. 1.1; Appendix A/B/C; background material	background quiz		Sign up for astrobite, journal club, and term paper slots
1/25/2023		Basic galaxy properties and history	Ch. 1.2			
1/30/2023	II. The Milky Way	Milky Way overview, galactic coordinates, MW distance ladder	Ch. 2.1-2.2		PS1 due, PS2 assigned	
2/1/2023		distance ladder, extinction, dust	Ch. 2.2.4 and C+O Ch. 12.1			
2/6/2023		Galactic structure, metallicity, stellar populations	Ch. 2.3			
2/8/2023		Galactic structure, bulge, bar, spiral				
2/13/2023		Galactic dynamics	Ch. 2.4		PS2 due, PS3 assigned	Astrobite #1 due
2/15/2023		Galactic rotation curves, dark matter				
2/20/2023		Paper #1 discussion + term-paper presentations	Paper #1		Paper #1 prep due	term paper presentations #1 due
2/22/2023		Galactic Center	Ch. 2.6			Astrobite #2 due
2/27/2023		star formation			PS3 due	
3/1/2023		Paper #2 discussion + term-paper presentations	Paper #2		Paper #2 prep due	term paper presentations #2 due
3/6/2023	III. A Universe of Galaxies	The Milky Way in context, Hubble sequence	Ch. 3.1			
3/8/2023		Exam #1			Exam #1, PS4 assigned	
3/13/2023		Spring Recess				
3/15/2023		Spring Recess				
3/20/2023		Elliptical and spiral galaxies	Ch. 3.2, 3.3			
3/22/2023		Scaling relations	Ch. 3.4		PS4 due, PS5 assigned	
3/27/2023		Paper #3 discussion + term paper presentations	Paper #3		Paper #3 prep due	term paper presentations #3 due
3/29/2023		Scaling relations (luminosity function and stellar populations)	Ch. 3.6, 3.7			
4/3/2023		Population synthesis	Ch. 3.9			
4/5/2023	Guest Lecture: TBD	new JWST results on Galaxies! Galaxy Evolution			Paper #4 prep due	term paper presentations #4 due
4/10/2023		Paper #4 discussion + term paper presentations	Paper #4		PS5 due, PS6 assigned	
4/12/2023	IV. The Early Universe	Supermassive Black Holes and Active Galaxies	Ch. 3.5			
4/17/2023		finding distant galaxies	Ch. 9.1-9.3		Term Paper due	
4/19/2023		Paper #5 discussion + term paper presentations	Paper #5		Paper #5 prep due	term paper presentations #5 due
4/24/2023		high redshift galaxy properties	Ch. 3.7, 9.4			
4/26/2023		galaxy evolution, cosmic star formation history	Ch. 9.6		PS6 due	
Date TBD		Final Exam			Final Exam	

### 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.

#### PHYS 4720:

#### PHYS 6720:

Grade Component	Weight	Grade Component	Weight
Problem Sets	25%	Problem Sets	25%
Midterm Exam	15%	Midterm Exam	15%
Final Exam	15%	Final Exam	15%
Term Project	25%	Term Project	25%
In-class Assignments, Quizzes, etc.	15%	In-class Assignments, Quizzes, etc.	5%
Journal Club (Preparation and Participation)	5%	Journal Club (Presentation, Astrobite)	15%

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 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 can be **submitted as a PDF file or handed in**. 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 or from other people, 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 exams for this class. A midterm on Wednesday March 8th and a Final exam during the assigned final exam period for the class. Please let me know immediately if you cannot attend one of the exam slots. Exam make-ups are reserved for only the most dire of circumstances, hopefully we don't encounter any of these!

### Term Project

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.

**4720** - this term project will be done in a group of size 1-3 people. You can choose your own group.

**6720** - this term project will be done individually. 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 assignments and quizzes. Active participation is expected. By default, *3 missed days of participation (assignments, quizzes, etc.) will be forgiven*, any more will detract from the in-class portion of your grade.

### 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 five graduate student groups made of 2 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 for about 45-55 min of class**. A different group will write an **Astrobite** ([astrobites.org](http://astrobites.org) for examples) on the paper, to be distributed to the full class **at least one week** prior to the Journal Club. A third group will present their term project presentations, two individual talks, taking about 10 minutes each. The other two groups will simply participate in the discussion. 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) submit a form about the paper including two questions for the discussion, and 4) participate actively in the discussion.

### Seminars and Colloquia

Astronomy seminars happen most Wednesdays at 3pm 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! Additional extra credit opportunities may be announced in class.

### 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](mailto: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](http://equity.uconn.edu) and [titleix.uconn.edu](http://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](mailto: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/>