Basic information

Title	ASTR 670 • Interstellar medium and gas dynamics
Website	ELMS/Canvas
Location	Atlantic 0201
Lecture times	Mon/Wed 2:00 – 3:15pm
Instructor	Benedikt Diemer (he/him)
Email	diemer@umd.edu
Office	PSC 1107
Office hours (on zoom)	TBD

Description

The effects of hydrodynamics are ubiquitous in the Universe, from the large-scale distribution of hydrogen to the atmospheres of planets. We will understand the equations of hydrodynamics and their basic consequences, such as waves, instabilities, and shocks. Rather than deriving the equations in detail, we will focus on hands-on exercises to solve them numerically. One particularly important gas system is the interstellar medium (ISM), the gas in galaxies. The ISM is composed of numerous phases that exhibit different temperatures and thus experience numerous different, complex physical processes; we will survey the most important ones.

By the end of the course, you will be able to…

- describe the physics of gas and fluids via the equations of hydrodynamics
- use numerical codes to solve and visualize complex hydrodynamic problems
- appreciate the numerous applications of hydrodynamics in astrophysics
- apply your knowledge to the specific problem of the interstellar medium
- understand the microscopic processes that determine the state of the ISM

General expectations

Given that this is a graduate course, I will not spell out detailed expectations and course policies in this syllabus. Most importantly, please bring your own initiative and curiosity! The goal is not to get a good grade but to develop a deep understanding of the subject that will serve you throughout graduate school and beyond.

Attending the lectures is key, of course. I ask that you put your phones away during class and actively participate; I will try to make the lectures as interactive as possible. The idea is to learn together, rather than for me to hold a monologue. Please feel free to reach out if you need help with the course material or with any other issue that might be preventing you from staying on top of the course.

This course contains a significant computing component. It's OK if you do not have the necessary foundation in python yet, but in that case you'll need to develop some programming skills along the way. While I am happy to discuss algorithmic and numerical issues, I hope you understand that I will not debug your code for you.

Course policies

Grading: Your grade will be composed of 5 homework sets, a hands-on numerical project, and two exams. Late homework will only be accepted for excused, documented absences. While you are encouraged to discuss with your peers, your homework and project need to be the result of your own work, thinking, and understanding. Please see shc.umd.edu for information on academic integrity and ugst.umd.edu/courserelatedpolicies.html for general UMD course policies.

Type of grade	Weight
Homework	35%
Semester project	15%
Midterm exam	20%
Final exam	30%

Learning environment: This course encourages scientific discussion and collaboration as a means of learning. Thus, we will find ourselves in disagreement or debate at times. It is important that we agree to conduct our conversations in a professional manner and to foster an environment in which everyone feels included and respected. I will make every reasonable attempt to create an atmosphere in which every student feels comfortable voicing their argument without fear of being personally attacked, mocked, demeaned, or devalued. Any behavior that threatens this atmosphere will not be tolerated, including harassment, sexual harassment, and derogatory language with respect to race, gender, nationality, or any other personal characteristic. Please let everyone speak and respect each other's point of view. Please alert me immediately if you feel threatened, dismissed, or silenced at any point during the semester or if your engagement in our discussions has been hindered by the learning environment in any way.

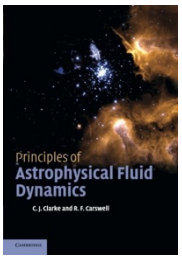
Possible changes due to COVID

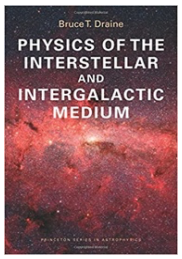
I have made my best effort to adjust the course to the current environment, but we live in quickly changing times! Our course might need to adapt, including the schedule and grading scheme. If the University closes the campus, we might need to switch to an online format on short notice.

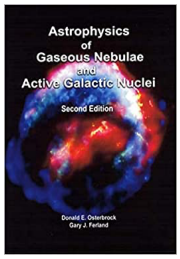
Textbooks

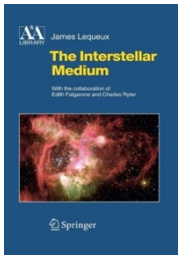
There is no one book that covers the full contents of this course. We will use a number of books; you do not need to purchase them, although Bruce Draine's text will be essential.

- Cathie **Clarke &** Bob **Carswell**
  Principles of astrophysical fluid dynamics
  Cambridge University Press, ISBN 978-0511813450
- Bruce **Draine**
  Physics of the interstellar and intergalactic medium
  Oxford University Press, ISBN 0-19-853096-X
- Donald **Osterbrock** & Gary **Ferland**
  Astrophysics of Gaseous Nebulae and AGN (2nd ed.)
  University Science Books, ISBN 978-1891389344
- James **Lequeux**
  The interstellar medium
  Springer, ISBN 3540213260









Semester schedule

This schedule is preliminary and likely to evolve during the semester. The abbreviations are "CC" for Clarke & Carswell, "D" for Draine, "OF" for Osterbrock & Ferland, and "L" for Lequeux.

Date		#	Topic	Suggested Reading
Part I: Hydrodynamics				
Mo	08/29/2022	1	What is hydrodynamics?	CC §1.1-1.2
We	08/31/2022	2	The equations of hydrodynamics	CC §1.3-2.3, 4.3
We	09/07/2022	3	Equilibrium and steady flows	CC §5.1-5.3, 9.1
Mo	09/12/2022	4	Waves	CC §6.1
We	09/14/2022	5	Numerical hydrodynamics I	---
Mo	09/19/2022	6	Numerical hydrodynamics II	---
We	09/21/2022	7	Shocks	CC §7.1
Mo	09/26/2022	8	Blast waves	CC §7.2, 8.1-8.3
We	09/28/2022	9	Numerical hydrodynamics III	---
Mo	10/03/2022	10	Higher-order schemes & Fluid instabilities	CC §10.1-10.2
We	10/05/2022	11	Magneto-hydrodynamics I	CC §13.1-13.2
Mo	10/10/2022	12	Magneto-hydrodynamics II	CC §13.4-13.7
We	10/12/2022	---	Midterm exam	---
Part II: The interstellar medium				
Mo	10/17/2022	13	Introduction to the ISM	D §1.1
We	10/19/2022	14	The phases of the ISM	D §1.2-3
Mo	10/24/2022	15	Collisional ionization and cooling	D §10.1, §34.1-2
We	10/26/2022	16	Supernovae and stellar winds	D §38.1, §39.1-2
Mo	10/31/2022	---	Project presentations I	---
We	11/02/2022	---	Project presentations II	---
Mo	11/07/2022	17	Atomic physics I: Photoionization	D §3.1-6, §4.1-5, §13.1, §14.1-2
We	11/09/2022	18	H II regions	D §15.1-3, §27.4, OF §2.1-3,
Mo	11/14/2022	19	Atomic physics II: Levels and excitation	D §6.1-2, §6.7, §17.1-2, §18.1-2
We	11/16/2022	20	Atomic gas	D §8.1-2, §17.3, §29.1-2
Mo	11/21/2022	21	Atomic physics III: Molecules	D §5.1, §31.1-4, §31.7, §32.1
Mo	11/28/2022	22	Molecular clouds and dust	D §19.1-3, §21.1, §23.1, §32.9
We	11/30/2022	23	Star formation	D §41.1, §42.3-5
Mo	12/05/2022	24	Turbulence	L §13.2-3
We	12/07/2022	25	Multiphase models of the ISM	D §30.4, §39.4
Mo	12/12/2022	---	Course summary	---
Sat	12/17/2022	---	Final exam (1:30 – 3:30)	---