

AST 393F – SURVEY OF THE INTERSTELLAR MEDIUM

Unique No. 46665, Fall 2020

Instructor: Prof. Harriet Dinerstein, PMA 16.324

Teaching Mode: Online synchronous

Meetings: Tu Th 9:30 – 10:45 AM, via Zoom

Office Hours: Wed early afternoons (flexible) or at other times by appointment



ISM adjacent to R136 in 30 Dor
(Hubblesite.org, April 2012)

Description and Goals:

AST 393F is a core or “required” course in the Astronomy Ph.D. program. In this course we will address the physics, phases, and paradigms of low-density astrophysical matter as manifested in the wide range of environments found in the interstellar medium. We will survey findings from multi-wavelength studies of H I regions, H II regions, molecular clouds, dust, hot phases, and interfaces. We will also review atomic and molecular structure and spectra, radiative transfer in dilute radiation fields, emission mechanisms, and thermal balance, to develop an intuition for how to study the different phases of the ISM and understand their global impacts in galaxies.

After taking this course, you should: (1) Be aware of/able to predict which spectral features are good tracers of ISM of all phases. This requires knowing the observables for each phase, element, etc., and how to use or interpret them; and understanding their limitations and ease of detection. (2) Be prepared to apply new knowledge to your own research, whether the ISM is part of the science or interference you must correct for (dust extinction, absorption due to intervening gas). (3) Gain familiarity with and facility in explaining fundamental principles, approximations, and equations that arise in many astrophysical contexts, to prepare you to answer questions in seminars and Qualifying Exams. Towards this end we will have a low-stakes, practice oral exam.

Coursework and Fractional Credit towards the Course Grade:

- We will read historical *papers that established key ideas* before discussing them in class, plus a few papers providing updates. Students will briefly summarize the latter in class: credit **10%**.
- *Daily reflections*: Fill out a short survey on what seemed most important, relevant, confusing, etc. in each class meeting, due 24 hours after that class: credit **10%**.
- *Hack day*: Locate an ISM-relevant online tool you think is generally useful, ideally web-based and simple, not requiring extensive downloads or installation: **5%**.
- *Challenge Questions*: You’ll discuss two broad, “what if”-style questions in small groups, each of which will prepare a “white paper” summarizing the group’s ideas: **10%**.
- Major assignments: (1) *Spectroscopy project*: Evaluate and predict the most observable spectroscopic tracers of a particular element in multiple ISM phases: **15%** (2) *Term project*: An in-depth investigation into a topic of interest to you (selected with the instructor’s approval). Presentations of these will take place at the end of the semester: **25%**.
- *Homework*: We will have a few homework sets of modest length, probably peer-graded, during the first 2/3rd of the course while we cover basic material: **10%**
- *Oral Exam*: There will be a short oral exam towards but not at the very end of the semester, focusing on the basic material. The main purpose is to practice taking oral exams: **15%**.

Resources and References:

I will post a set of notes in pdf form that I have developed over the years. The 2018 version was nearly 200 pages including equations, and figures from a variety of sources. After a long hiatus following publication of Lyman Spitzer's "Physical Processes in the Interstellar Medium" (1978), a spate of new books on the ISM emerged between 2002 and 2011. Probably the most widely used is Draine. I told the UT Co-op that it was a recommended textbook for our class, but you can also get it as an eBook. There are several other books out there, each with its own emphasis and strengths. I will occasionally post on Canvas scanned copies of selected pages from the sources below.

Draine, Bruce. "Physics of the Interstellar and Intergalactic Medium." (2011). This is more a reference book than a traditionally structured text, comprised of 42 short chapters on a mix of topics ranging from physical processes to astrophysical applications.

Tielens, A.G.G.M. "The Physics and Chemistry of the Interstellar Medium." (2005). Especially good for molecules, dust spectroscopy, and interfaces (H II/H I/molecular gas).

Spitzer, Lyman, Jr. "Physical Processes in the Interstellar Medium." (1978). Still interesting for basic derivations. You can download some or all of it from the UT library website.

Dopita, Michael & **Sutherland**, Ralph. "Astrophysics of the Diffuse Universe." (2003). Especially good for spectroscopy, atomic processes, and shocks.

Osterbrock, Donald & **Ferland**, Gary. "Astrophysics of Gaseous Nebulae and Active Galactic Nuclei." (2006, 2nd edition of AGN²). The definitive book on H II regions.

Dyson, J.E. & **Williams**, D.A. "The Physics of the Interstellar Medium," 2nd ed. (1997). On a more basic level (i.e. undergraduate) than the above books but good as a starting point.

Kwok, Sun. "Physics and Chemistry of the Interstellar Medium." (2007). Intermediate in level between Dyson and the other books. Useful for molecules, chemistry, and dust.

Rules of Class Engagement:

Running a class like this entirely online will be a new experience for us all. I have had a grand total of 6 weeks of experience teaching remotely, and that was an asynchronous lower-division course for non-science majors. There are guaranteed to be glitches and bumps in the road, so let's all be patient. I will sometimes look to you for technical info and help! A few points:

- It's best to use a computer/laptop rather than an iPad (tablet) for joining class sessions, as certain features won't work with the latter (e.g. Zoom annotate on shared screens).
- Discussions will feel more interactive if you keep your video on, although it's okay to disable it if you wish. You can mute your audio to cut down on background noise.
- Check that your Canvas Notifications are set to enable receipt of Announcements, etc.
- I will record some portions of class meetings for instructional purposes. These will not be posted and may be shared only by special arrangement, with members of the class.
- Course materials are for your personal academic use only. There are very strict UT policies about posting or distributing proprietary materials on academic "sharing" sites.
- Let's figure out protocols for asking questions, etc. (raised hand, chat, unmuting) together.
- Let's take a short break in the middle of each class session to avoid Zoom zombie syndrome!

Preliminary Schedule:

The table below represents my currently projected schedule for the semester. We may make adjustments once the semester begins and we have a better understanding of how things will work under this new instructional mode.

T = Tielens, DS = Dopita & Sutherland, FO = Ferland/Osterbrock, K = Kwok

Items in blue involve in-class work or presentations by students.

Dates	Topics	Draine chs.	Other Readings (chs.)
8/27, 9/1	Overview, Phases	1, 12, 30	T[1,8] DS[1,14] K[1]
9/3, 8	Atoms & Lines	4, 17	T[2] DS[2,3] K[5]
9/10,15	H I regions	6-9,16,29-30	T[3] DS[4]
9/17,22,24	H II regions	10,13-15,18,27	T[7] DS[6,9-10] K[4,6]
9/29, 10/1	Spectroscopy Reports		
10/6,8,13	IS Molecules*	5,19-20,31-33	T[4,10] DS[2,13] K[7-9]
10/15,20,27	IS Dust	21-26	T[5,6] DS[12] K[10-13]
10/22	Hack day: web tools		
10/29	Coronal gas	34,40	DS [5,7]
11/3	Challenge Question 1		
11/5,10	Interfaces (shocks,PDRs)	36-39	T[9,11] DS[8,11]
11/12	Challenge Question 2		
11/17,19	Oral exams		
11/24, 12/1,3	Term Reports		
12/10	Reports (<i>only if needed</i>)	Final exam slot	2 – 5 pm

*Special Guest Lecturer, Neal Evans (10/6, 8)

Possible HW due dates: Sep. 17; Oct. 8; Oct. 29; Nov. 10

RESOURCES FOR STUDENT SUPPORT:

- **Inclusivity Policies** – The university is committed to maintaining an accessible and inclusive learning environment for every member of our community. Bias, discrimination, and harassment have no place here. If you have concerns, contact the Campus Climate Response Team at diversity.utexas.edu/ccrt. Other places to turn to with your concerns about safety and behavior are the Behavior Concerns Advice Line, BCAL (512) 232-5050, and BeVocal, wellnessnetwork.utexas.edu/BeVocal.
- You also can access the **Counseling and Mental Health Center (CMHC)**, which offers programs and services that enhance and support students' mental health and well-being. For information on their programs, call (512) 471-3515. If you are experiencing a mental health crisis, call **the CMHC Crisis Line** at (512) 471-2255, 24/7.
- In difficult or emergency situations, you can obtain assistance (not counseling) from **Student Emergency Services**: email studentemergency@austin.utexas.edu or call (512) 471-5017 (Mon.-Fri., business hours), who will notify your instructors. More information is given at deanofstudents.utexas.edu/emergency. For immediate threats or emergencies, call 911.

GENERAL UNIVERSITY POLICIES: (The following content is recommended by the College of Natural Sciences or required in course syllabi by the University)

- **Academic Integrity:** Each student is expected to abide by the University of Texas Honor Code: “As a student of The University of Texas at Austin, I shall abide by the core values of the University and uphold academic integrity.” Copying or presenting someone else’s work as your own is academic dishonesty and entirely unacceptable, and is subject to academic disciplinary action, including failure in the course. (This information may be most relevant to you when you are a Teaching Assistant reviewing student work.) You are responsible for understanding UT’s Honor Code, found at: <https://deanofstudents.utexas.edu/conduct/standardsconduct.php>.
- **Sharing of Course Materials is Prohibited:** No materials used in this class may be shared online or with anyone outside the class unless you have explicit, written permission of the instructor. Unauthorized sharing of materials is a violation of the University’s Honor Code. If any of this course’s materials are found on any of the sites where unauthorized academic materials are shared and are associated with you, it may be reported to the Office of the Dean of Students, which can result in sanctions or other serious consequences.
- **Religious Holidays:** If you will miss a class meeting or be unable to meet a course requirement due to a schedule conflict with observance of a religious holiday, please let the instructor know at least two weeks in advance. You will not be penalized for this although you will still be responsible for material covered in class.
- **Class Recordings:** Class recordings are curated by the Instructor and reserved for private, approved use only by students in the class. They are used strictly for educational purposes and are protected under FERPA. Therefore, recordings will not be shared outside the class in any form. Violation of this restriction could lead to Student Misconduct proceedings.
- **Title IX:** Title IX is a federal law that protects against sex and gender-based discrimination, sexual harassment, assault, and unprofessional or inappropriate conduct, dating/domestic violence and stalking at federally funded educational institutions. UT can intervene to prevent continuation or escalation, provide support, and investigate and discipline violators. Recent changes on the federal and state level have created an expanded definition of “mandatory reporters,” personnel who are required to report any potential violation (also called “responsible employees”). For example, as a T.A. or UT employee, you are a mandatory reporter for information you hear or receive. When speaking to a person with a complaint, communicate this fact before hearing their story, and explain that if they wish to speak with someone who can provide support without automatically triggering an official report they can email advocate@austin.utexas.edu. For more information: titleix@austin.utexas.edu, (512) 471-0419, or <http://www/titleix.utexas.edu>. The Title IX office can provide support and resources for survivors.
- **Services for Students with Disabilities:** Some students are eligible for certain accommodations on course requirements through authorization by Services for Students with Disabilities (SSD). If you have a disability or think you may, and need accommodations, please contact SSD as soon as possible. See SSD’s website at diversity.utexas.edu/disability/ for information. Once an Accommodation Letter is provided, you will need to meet with the Instructor individually to discuss your needs and accommodations and arrange for these to be implemented. (If you are a T.A., your instructor may ask you to help provide special arrangements for students with SSD accommodations.)