Course Meetings: We will be meeting in person Mondays and Wednesdays 10:00 AM – 11:30 AM in PMA 15.216B.

Course Webpage: Your main source of information will be the course webpage on Canvas. This is where you will find announcements, homework and reading assignments, grades, deadlines, be able to ask questions, and more. It is your responsibility to check the Canvas course page on a regular basis. Please come to class prepared, having done the assigned pre-class readings and assignments, and be ready to participate in discussions and activities.

Course Materials: In this class we will use both textbook and software digital content. To get started, you will need:


2. **Software**: You will need astroconda, pip, python, jupyter notebooks, and the following python packages installed on your computer to do some of the group activities and homeworks:

   - **Extinction**:
     
     ```
     > conda install -c conda-forge extinction
     ```

   - **LMFIT**:
     
     ```
     > pip install lmfit
     ```

   - **Dustmaps**:
     
     ```
     > pip install dustmaps
     > from dustmaps.config import config
     > config[‘data_dir’] = ‘/path/to/store/maps/in’
     > import dustmaps.bayestar
     > dustmaps.bayestar.fetch()
     ```

   - **PyNeb**:
     
     ```
     > pip install PyNeb
     ```

   - **Pyspeckit**:
     
     ```
     > pip install pyspeckit
     ```

   - **Plotly**:
> conda install -c plotly plotly=5.8.0
Chart_studio:
> pip install chart_studio

**Lecture Notes:** All lecture pdfs (and notes) will be available to you after class via the Files tab on the left-hand side of our class Canvas page.

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**COURSE DESCRIPTION**

This course is intended to provide you with a detailed overview of the physical processes and properties of the interstellar medium. We will cover a wide range of materials, from extremely cold molecular gas and dust, to diffuse atomic hydrogen nebulae, to hot ionized gas around luminous stars; some of these are relevant to the intergalactic and intercluster media as well. These topics form the fundamental physical basis of our current understanding of the observed properties of astrophysical plasmas observed throughout the Universe.

**Course Objectives:** By the end of this course, you should successfully be able to ...

1. Describe / discuss the following topics:
   - **Overview of ISM:** Phases, properties of gas and dust, distribution of ISM
   - **Ionized gas:** Strömgren spheres, partially ionized regions, recombination lines, free-free radiation, bound-free radiation, forbidden line emission, determining temperatures, densities and abundances in HII regions, thermal balance in HII regions, diffuse ionized gas, radio propagation effects.
   - **Neutral gas:** The 21-cm line: basic radio astronomy, emission and absorption, rotation curves kinematic distances, temperatures, UV & visible interstellar absorption lines, interstellar abundances, diffuse interstellar bands, heating, cooling, instabilities and phases of ISM.
   - **Molecular gas:** Interstellar chemistry, mm-wave emission, cloud models, typical properties of molecular clouds, interstellar masers.
   - **Interstellar dust:** Extinction, reddening, scattering, polarization, thermal equilibrium of dust grains, VSGs and PAH emission, size and nature of dust grains, origin and destruction mechanisms.
   - **Non-thermal phenomena:** Interstellar magnetism, cosmic rays, synchrotron emission, supernova remnants.
   - **Shock Waves** Sound speed, jump conditions, ionization fronts, radiation from shocks, coronal lines, X-ray emission, hot gas phase.
   - **Heating, cooling and phases of ISM** Cooling processes in molecular, atomic and ionized gas, heating processes, pressure balance, thermal instabilities, shock heated gas, models for interstellar clouds, photo-dissociation regions.
   - **Distribution of interstellar gas** Scale heights, galactic structure, high velocity clouds, galactic center, local bubble, solar vicinity.
   - **Gravity and Stability** Jeans length, fragmentation, Parker instability, stability of molecular clouds, virial mass, spherical collapse, rotation, formation of disks
   - **Star forming regions** Molecular cores, low mass star formation, bipolar flows, clustering, high mass star formation, triggered star formation.
• **Origin and fate of interstellar matter** Mass loss stars, planetary nebulae, Supernovae, evolution and balance of interstellar medium.

**2. Perform the following functional skills:**

- Present basic ISM concepts and answer questions.
- Place basic ISM concepts and their importance into a larger astronomical framework.
- Read and understand current research papers dealing with low-density gases in the form of HII regions, planetary nebulae, HI regions, molecular clouds, photodissociation regions, supernova remnants, etc.
- Learn new python tools and analysis methods.
- Analyze ISM data and write up the results in a publication-level letter.
- Further develop latex skills.
- Have knowledge of our current understanding of various ISM topics and the current challenges to advancing the field.
- Construct new ideas to study the ISM and argue their scientific importance and observability in a competitive observing proposal.
- Apply your knowledge of the ISM to evaluate proposal ideas.

**COURSE STRUCTURE**

Each week during our scheduled course times (M & W 10 AM – 11:30 AM), there will be 2 x 90-min meetings that will include lectures, discussions, and group activities. You are expected to complete assigned readings and homeworks prior to class; they are designed to aid your comprehension and explore some of the course topics in greater depth. **There will be no exams but there will be a midterm project and a final proposal.**

**Course Communication:** As we return back to in-person learning, here are some guidelines to help make sure we keep up good communication and that our interactions are enjoyable:

- **Questions:** I'm always happy to take questions during lecture; please raise your hand so that I can see that you have a question. For questions outside of class, please post to the Canvas discussion board for our class, discuss with classmates, visit the help hours, or email me or Karla.
- **Announcements:** I will make relevant announcements at the beginning of each class. I also reserve the right to email the class or post information using the announcements page on Canvas. **Please check your notifications settings** in Canvas to ensure that you are receiving the email versions of those announcements frequently.
- **Environment & Etiquette:** I am committed to providing you with a friendly, productive, and effective learning environment. There are things that you can do to help with this:
  1. Make the class environment safe and respectful for all: employ language and conduct that is honest, civil, courteous, and responsible.
  2. Participate in class and assignments and work with whomever you are assigned.
  3. Show respect for the dignity and diversity of individuals, and work on building **constructive** relationships with instructors and your fellow peers.
  4. Refrain from behaviors that are sexually harassing, culturally insensitive, or interpersonally inappropriate.
5. Respect the value of other individuals' time – show up to class and group meetings on time, turn in work on time, etc.

6. **No electronics allowed during class.** (Unless told otherwise)

7. Use professional language: use standard English, appropriate grammar, and critical thinking and analysis in your writing and verbal communications in order to demonstrate academic proficiency. Refrain from profanity and improper language by developing higher levels of language usage in order to better represent yourself. Refrain from malicious gossip, slander, or defamation of character against others, including faculty, staff, professionals in the academic and surrounding communities, and their fellow students.

8. Use professional judgment: Learn and utilize decision-making and problem-solving skills that allow for self-monitoring and improved behavioral and emotional control. Refrain from loud, abusive, negative, demeaning, sarcastic, inappropriate, combative language in interpersonal interactions with others. Refrain from emotional outbursts that intimidate or endanger the welfare of others. Be aware of your own physical, mental, or emotional problems and seek assistance for problems that reach the level of impairment.

9. Practice professional behavior: Properly prepare for coursework, meet deadlines consistently, report to class on time, and remain for the entire class period, honor faculty requests for classroom decorum. Accept and use constructive feedback non-defensively and practice giving feedback that is thoughtful and constructive.

**Course Participation:** In-person class participation is required and is part of your grade.

**COURSE GRADING**

Course grade will be evaluated on three components:

1. Homework – constitutes 60%.
2. Midterm project / Collaboration grade – constitutes 10 %.
3. In-class participation – constitutes 20%.
4. Final proposal – constitutes 10%.

**Grading Scale:** The grading scale is below. Note that this course will not be graded on a curve. Your grade is calculated to the nearest 1/100th of a percentage point.

- **A:** 94.00 – 100%
- **A–:** 91.00 – 93.99%
- **B+:** 87.00 – 90.99%
- **B:** 83.00 – 86.99%
- **B–:** 79.00 – 82.99%
- **C+:** 76.00 – 78.99%
- **C:** 73.00 – 75.99%
- **C–:** 70.00 – 72.99%
- **D+:** 67.00 – 70.99%
- **D:** 63.00 – 66.99%
- **D–:** 60.00 – 62.99%
- **F:** 0.00 – 59.99%

**Homework:** There will be regular reading (for each class) and homework assignments (most weeks), which all together will make up 60% of your grade. Homework must be handed in by the start (10:00 AM) of each class that they are due (see schedule below or on CANVAS). Homework solutions will be posted after class, so no late work will be accepted. To reiterate: *Late homework will not be accepted.*

**Exams:** There are no exams for this course.
**Midterm Project:** The midterm project is due **October 12th** and is worth **10%** of your grade.
- Acceptable projects: Selected from the Project Descriptions sheet.
- Group size: Must be completed in groups of 2-3 people.
- Collaborative Evaluation: Each group member will turn in an evaluation of their other group members collaboration efforts.

**In-class Participation:** One of the primary goals of this class is to develop relevant skills for your future career, whether that be in academia, industry, outreach, etc., and this is best done by active practice. Therefore, you will earn your in-class participation grade through (1) your engagement in class discussions / activities and (2) your mini lectures and your engagement during other mini lectures.
- **Mini Lectures:** Each student is assigned 2 lectures to present throughout the course. You will be given relatively short notice on your specific topic – this is intentional; part of the purpose of this assignment is have you practice thinking and answering questions on your feet. This skill is critical for your 2nd year exam, your PhD defense, and for any future presentations you give, no matter the venue.
  - Topic: You will be assigned a relevant subtopic of the lecture material for the day you are assigned. Your specific topic will be assigned 2-3 days in advance.
  - Length: You are responsible for preparing a 10-min lecture + 5-min for questions.
  - Level: Your presentation should be teaching the material to your peers. It is important to practice breaking down ideas and our presentation of them.

**Final Proposal:** The final component of the class will be to write an observing proposal and perform mock proposal panels to evaluate them. It is due by the **5 PM CT on Monday, Nov 28th** and is worth **10%** of your grade.
- Topic: Any ISM-relevant scientific objective.
- Group size: 1. Each student must turn in their own, individual proposal.
- Format: Following the standard HST or JWST templates and their official guidelines (e.g., page limits, anonymity).
- Evaluation: Your grade will be determined based on are three components:
  - 1. My assessment of your proposal – 60%
  - 2. The panel’s assessment of your proposal – 25%
  - 3. Your participation on the panel – your presentation of other proposals, discussion, and write up – 15%
- **Mock panels:** Proposals will be anonymized and distributed to you on the night of Monday, November 28th. The class will be split up into 3 mock panels to avoid any conflicts of proposals being evaluated.
  - Date: The mock panels will be held on the final day of class, **Monday, Dec 5th**.
  - Please plan to be present from 10 AM – 12 PM and let me know as soon as possible if you cannot stay until 12 PM.
  - Reading assignment: You will be responsible for reading 5 or 6 proposals prior to the panels meeting.
  - Presenter assignments: For each proposal, you will be assigned as primary reviewer, secondary reviewer, scribe or panelist.
- **Primary reviewers** are responsible for presenting a summary of the proposal to the panel, including its main strengths and weaknesses.
- **Secondary reviewers** should be prepared to present after the primary, focusing on any important comments not mentioned by the primary.
- **Scribes** are responsible for taking notes of the panel’s discussion of a given proposal and will edit these notes into the final report.
- **Other panel members** are expected to add comments or discuss the proposal after the primary and secondary finish their summaries.

**COURSE POLICIES**

**Communication Policy:** Please email me or visit me in my office at any time for questions or discussions of a personal nature. For questions about class content or logistics you **must** post the question to the canvas discussion board, ask others in your class, or ask me during student help hours. If your question is still unanswered, you may then email me.

**Homework and Exams:** No late or makeup work / projects will be accepted.

**Exceptions:** Late and makeup work will not be accepted. However, I understand that unpredictable life events happen, so exceptions may be made for special circumstances. If you are unable to submit homework on time or attend a class, you must **contact me in advance of the due date for your exception to be considered.** If you experience a personal or family emergency (death in the family, protracted sickness, serious mental health issues) that prevents you from attending class, you should contact me, your other professors, and the graduate advisor. If you need help finding additional resources, please do not hesitate to contact me.

**Accommodations for Religious/Cultural Holidays:** A student who is absent from a class for the observance of a religious/cultural holiday will be permitted to make up the missed work, if notice is given at least fourteen days prior to such an absence.

**Accommodations for disabilities:** If you have any kind of disability, whether apparent or non-apparent, learning, emotional, physical, or cognitive, please feel free to contact me to discuss reasonable accommodations for your access needs. Students with disabilities may also request appropriate accommodations from the university: The University of Austin provides upon request appropriate academic accommodations for qualified students with disabilities. For more information, contact the Office of the Dean of Students (471-6259, 471-6441 TTY) or Division of Diversity and Community Engagement, Services for Students with Disabilities (512-471-6259).
Zero-tolerance of harassment/assault: Harassment of any sort will not be tolerated in this class or related workspaces. Title IX and Title VII makes clear that violence and harassment based on sex, gender, race, or national origin are Civil Rights violations subject to investigation and disciplinary action on behalf of the University. The same kinds of accountability and support will be applied to offenses against other categories such as sexual orientation and gender identity. If you or someone you know has been harassed or assaulted, either in the classroom or outside of the classroom space, you can find the appropriate resources through the University Title IX Coordinator (512-232-3992), UT Austin Campus Police (512-471-4441), the Student Ombuds Services (which can provide confidential advice, resources and help; 512-471-3825), and the UT Counseling and Mental Health Center (512-471-3515).

Mental Health Services: Graduate school is challenging and stressful; Your first priority should be taking care of yourself and your own health, and those around you. If you experience diminished mental health, please seek help. Diminished mental health, including significant stress, mood changes, excessive worry, or problems with eating and/or sleeping can interfere with optimal academic performance. Similarly, problems with relationships, family worries, loss, or a personal struggle or crisis can also contribute to decreased academic performance. UT Austin’s Counseling and Mental Health Center (512-471-3515) provides mental health services to support the academic success of students. This includes counseling services, wellness workshops, free and confidential therapy groups, and general information. I encourage you to browse their website and actively seek support if you’re experiencing any of these difficulties.

Expectations regarding mutual respect: Astronomy belongs to all people, independent of race, religion, gender, gender identity, gender expression, or sexual orientation. Incidents of discrimination, assault, harassment, threats, intimidation, profiling, or coercion based on membership or perceived membership will not be tolerated. Show each other respect no matter perceived knowledge or performance in this class, or any other.

Sharing of Course Materials is Prohibited: No materials used in this class, including, but not limited to, lecture hand-outs, videos, assessments (quizzes, papers, projects, homework assignments), in-class materials, review sheets, and additional problem sets, may be shared online or with anyone outside of the class unless you have my explicit, written permission. Unauthorized sharing of materials diminishes the ability of others to learn. It is a violation of the University’s Student Honor Code and an act of academic dishonesty. I
am well aware of the sites used for sharing materials, and any materials found online that are associated with you, or any suspected unauthorized sharing of materials, will be reported to Student Conduct and Academic Integrity in the Office of the Dean of Students. These reports can result in sanctions, including failure in the course.

**Class Recordings:** Class recordings are available only for those with official UT notice of accommodations needs. Such recordings are reserved only for students in this class for educational purposes and are protected under FERPA. The recordings should not be shared outside the class in any form. Violation of this restriction by a student could lead to Student Misconduct proceeding.
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