AST 393F – SURVEY OF THE INTERSTELLAR MEDIUM (48070) – Jan. 11, 2013
Instructor: Prof. Harriet Dinerstein
Class: MWF 10 – 11 AM, RLM 15.216B, Spring 2013
Office Hours: Tu & Th 1 – 2 PM, or by appointment

Brief Description:

This course will address the physics, phases, and paradigms of low-density astrophysical matter. The ISM (the Interstellar Medium or Interstellar Matter) is very diverse, with temperatures and densities spanning many orders of magnitude and observational tracers from across the entire electromagnetic spectrum. While the ISM contains a few structures that are more or less discrete objects, most of it is essentially a fluid with continuously varying local conditions determined by the *in situ* detailed balance among (usually just a few) atomic-scale radiative and/or collisional processes. (See the Hubble ACS image of the Carina Nebula at right for an illustration of its complexity.) This fluid is ubiquitous within galaxies, and even between them (the Intergalactic Medium, or IGM). The ISM/IGM is critical to the ecosystems of galaxies, as the reservoir of matter from which stars form and into which they expel mass in chemically and nucleosynthetically altered forms. It also has observable effects on the light from distant luminosity sources that passes through it, and thus plays an important role in all aspects of astronomy.

Content:

I will attempt to live up to the word "Survey" in the course title. We will begin with global descriptions of the ISM and the evolution of the concepts of thermal phases and multi-phase models. Next, we will march through the major thermal phases: H I regions (neutral atomic ISM), H II regions, and molecular clouds. After that, we'll look at the dust, which pervades all of these gas phases, and is energetically and observationally influential despite representing only a small fraction of the overall mass. Other topics will be chosen to complement topics chosen by students for oral presentations (which, ideally, will be on a topic somewhat related to your own particular research interests).

Goals:

For all students in the class: Become familiar with, understand the basis of, and be able to critically evaluate other people's work: to ask informed questions at colloquia and seminars and judge the validity and significance of papers in a journal or on astro-ph.

Additional goal for second-year students: Help prepare for the second-year defense! Over the semester, we will identify and collect a set of questions about the ISM likely to be asked during second-year defenses.

Stretch goal: Understand the physical basis for and empirical limitations on the observables well enough to be able to innovate in this field. This is most relevant for those whose research is in or touches on the ISM. We will also try to practice this by incorporating "what if" questions on homework and exams.

Coursework:

- I will assign homework problems as we go along, with 3 or 4 collection dates over the semester. Cumulatively, these will count about 30% of the course grade.
- There will be two individual student projects/reports. The first, due before Spring Break, will involve the domain and observability of particular chemical species in the ISM. This will be submitted in written form and worth 20% of the grade.
- A second report, to be presented in oral format to the class in April (specific dates to be determined, most likely during the period April 8 - 19), will be on a broader topic, agreed-upon by both instructor and student. The presentation and accompanying visual materials are worth 30% of the grade.
- The remaining 20% of the grade will be based on an oral exam given towards the end of the semester, coordinated with the student's second year defense if applicable.

Resources:

I will post my notes for some of the material as pdf files on the class website. In addition, I have placed a set of reference books on reserve in the PMA (4^{th} floor) Library, and second copies of the most useful of these books on the Reserve shelf in Peridier Library. Books with asterisks will (eventually) be in both places.

***Draine,** Bruce. "Physics of the Interstellar and Intergalactic Medium." (2011). The most comprehensive and up-to-date of the recent crop of books, and probably the one to purchase if you want something on your shelf (partly because it's cheaper).

***Spitzer,** Lyman, Jr. "Physical Processes in the Interstellar Medium." (1978). The classic volume. Viewable online, one page at a time, through the UT libraries.

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

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

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

Dyson, J.E. & Williams, D.A. "The Physics of the Interstellar Medium," 2^{nd} ed. (1997). On a more basic level than the above books. Can download the full text through UT.

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

Preliminary Schedule: Subject to change. Chapters in square brackets are mostly on the background physics.

Week	**Approx. Dates**	**Topics**	**Chs. in Draine**	**Readings in**
				Other Books
1	Jan. 14 – 18	Overview; Thermal Phases	1, 3, 12, 16	Tielens; Dopita
2	Jan. 23 – 25	Atoms: Levels & Lines	[4], 17	Dopita
3 - 4	Jan. 28 – Feb. 8	H I regions (A) Abs'n lines (B) 21 cm (low-freq.)	29 [8, 9], 30 [16]	
5 – 6	Feb. 11 – 22	H II regions, planetary nebulae, AGN	15, 18, 27	Osterbrock; Dopita; Kwok
7 8	Feb. 25 – Mar. 1 Mar. 4 – 8	Molecules; guest lectures by John Lacy in week 7	5, 31, 32 [19]	Tielens; Kwok
	Mar. 11 – 15	SPRING BREAK		N/A
9 – 10	Mar. 18 – 29	Interstellar Dust	21, 23, 24	Tielens; Kwok
11	Apr. 1 – 5; some of Apr. 8 – 19	Hot gas, interfaces (PDRs, shocks), stellar ejecta	33 – 34, 36 – 39	Tielens; Dopita; Kwok
12 – 13	rest, Apr. 8 – 19	Student Reports		
14	Apr. 22 – 26	Molecular Clouds & Star Formation; Nealfest 4/26	41 – 42	
15	Apr. 29 – May 3	Selected Topics	Continued from early Apr	