ASTR 4020 / 8020: Diffuse Matter and Star Formation

Semester 1, 2023
Lecturer / convenor: Mark Krumholz
Class meeting times: Tuesdays and Thursdays 2 - 4 pm
Class location: Woolley Seminar Room
Course web page: http://www.mso.anu.edu.au/~krumholz/teaching/astr8020_s1_2023/

Topics

This course covers the physics and phenomenology of diffuse matter in interstellar and intergalactic space, and of how that matter undergoes gravitational collapse to form new stars. The course can roughly be divided into three parts. The first covers the basic physics of matter at low densities, including processes such as collisional excitation and thermalisation, and matter-radiation interaction. The second covers the phenomenology of diffuse, non-self-gravitating gas, and introduces the various phases of interstellar matter and their properties. The third and final part covers the behaviour of self-gravitating interstellar gas and the phenomenology of how it forms stars.

Texts

This course will use two main textbooks:

- *Physics of the Interstellar and Intergalactic Medium*, by Bruce Draine.
- *Star Formation*, by Mark Krumholz.

Both can be ordered online at the links provided. The campus bookstore also has some copies of the Draine book. The Krumholz book is also available free online.

Assessments

This course has three forms of assessment:

- There will be 5 problem sets, due on the dates indicated in the schedule below. These should be submitted via the course wattle page. The problem sets together form 40% of the total assessment, and are all weighted equally. Late submissions will be accepted, at a penalty of 5% of the credit per working day, up to one week past the original due date, at which time I will distribute solution sets.
- Each student will give an in-class presentation of approximately 20-30 minutes summarising a topic from the recent research literature. Topics will be by mutual agreement between the student and the professor, and will be fixed by the midterm break. Presentations will take place during the last few meetings of the term. All students are expected to attend, and to ask questions and participate in the discussion – such participation will be factored into the presentation grade. This item is 30% of the total course grade.
- There will be an oral final exam during the exam period, which will be scheduled individually. This exam will last approximately 45 minutes, and will consist of making rough estimates, order of magnitude calculations, scaling arguments, and similar quick calculations of the type that one is likely to encounter during a discussion at a scientific conference or similar venue. The exam is worth 30% of the total course grade.

Policy on collaboration

Group work is encouraged in this course. In particular, if your understanding is lacking in places, I strongly encourage you to discuss and debate with other students to reach a better

understanding. However, this should not lead to a number of students producing identical assignments. In the end, you must work through, understand, and answer the assignment questions yourself, not simply reproduce verbatim other students' work. See links for further information on ANU policies on plagiarism and collusion.

Schedule

Date	**Topic**	**Reading**	**Assignments due**
21 Feb	Collisional processes	D1-3, K4-5	
23 Feb	Fluid dynamics		
28 Feb	Radiation-matter interactions	D4-6	
2 Mar	Atomic and molecular structure		
7 Mar	The hydrogen 21 cm line	D8-9	
9 Mar	Absorption lines		Problem set 1
14 Mar	Ionisation and recombination I	D10-11	
16 Mar	Ionisation and recombination II		
21 Mar	Collisionally-excited lines	D13-15, D21-22	
23 Mar	Interstellar dust		Problem set 2
28 Mar	Photoionised regions I	D27-28, K7	
30 Mar	Photoionised regions II		Presentation topic
	Semester break, 3 - 14 Apr		
18 Apr	Atomic gas	D29-30, D34	
20 Apr	Hot gas		Problem set 3
25 Apr	No class – ANZAC Day	K1, K3	
27 Apr	Molecular gas: microphysics		
2 May	Molecular gas: dynamics	K6-8	
4 May	Galaxy-scale star formation I		
9 May	Galaxy-scale star formation II	K9-11	Problem set 4
11 May	Stellar clustering		
16 May	The initial mass function	K12-13, K16-17	
18 May	Protostellar evolution		
23 May	Final presentations		
25 May	Final presentations		Problem set 5
	Exam period, 1 - 17 Jun		

Note on reading: DX indicates chapter(s) X from *Draine*, KX indicates chapter(s) X from *Krumholz*.