Basic information

Title	ASTR 620 • Galaxies
Website	ELMS/Canvas
Location	ATL 0201
Lecture times	Tue/Thu 12:30 – 1:45pm
Instructor	Benedikt Diemer (he/him)
Email	diemer@umd.edu
Office	PSC 1107
Office hours	By appointment

Description

Most of the exciting physics in the Universe happens inside galaxies: vast collections of dark matter, stars, gas, and black holes. We will begin with a survey of the observational properties of galaxies before investigating the critical ingredients for their formation, namely the collapse of dark matter halos, the cooling of gas, the formation of stars, and feedback from supernovae and AGN. Throughout the course, we will analyze data and implement theoretical models, from simple statistical methods such as abundance matching to more sophisticated semi-analytical models.

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

- Analyze data from the Sloan Digital Sky Survey
- Implement and run simple models of galaxy formation
- Read, summarize, and present papers on galaxy-related topics
- Connect physics on large (Universe) and small (stellar) scales

Expectations

Your most important contribution to this course will be to actively participate, that is, to attend class in person (zoom will generally *NOT* be an option), ask questions, and stay engaged throughout. Please bring your initiative and curiosity! The main goal is not to satisfy some grading rubric but to develop a deep understanding, as well as skills that will hopefully serve you throughout graduate school and beyond.

Most material will be covered in lectures, but be prepared for some independent study as well. The latter will include working through lecture notes and interactive python notebooks, book readings, homework assignments, digesting a journal paper, and a substantial term project. You will complete the term project over the course of a few months towards the end of the course and present it in class. The projects will consist of a mixture of literature review, coding, simulations, and/or math.

This course contains a significant computational component. It is totally fine to start the course without much foundation in python or coding, but in that case you will need to develop your programming skills rather quickly 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.

One final, important expectation is for you to reach out proactively if you need my help or advice, be it with the course material or with any other issue that may prevent you from staying on top of the course.

Course policies

Type of grade	Weight
Participation	10%
Homework	40%
Term project	15%
Midterm exam	15%
Final exam	20%

Grading: Your grade will be composed of a participation score, about five homework sets, a term project, and two exams. The participation score will be based on in-person attendance, questions and contributions to discussions during lectures, and the presentation of a journal paper. Late homework will only be accepted for excused, documented absences. The final grades will be curved such that an A corresponds to a strong and a B to an acceptable performance.

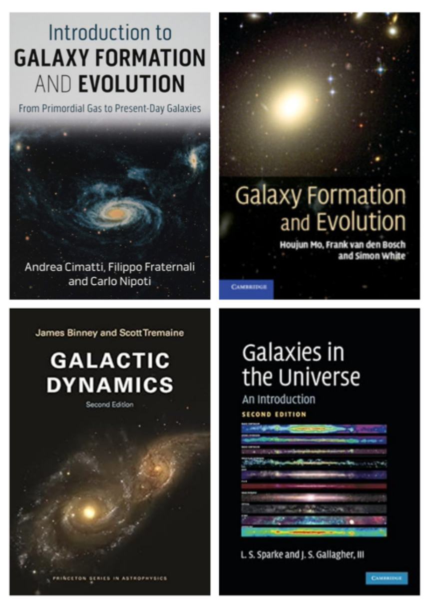
Collaboration on assignments: While you are encouraged to discuss with your peers, your homework and term project need to be the result of your own work, thinking, and understanding. Please see the UMD sites on academic integrity and general course policies.

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.

Textbooks

There is no one book that covers the full contents of this course. We will mainly refer to two textbooks, for which reading is listed in the following table and on the slides. You do not need to purchase the books.

- Andrea **Cimatti**, Filippo **Fraternali** & Carlo **Nipoti**
  Introduction to Galaxy Formation and Evolution
  Cambridge University Press, 2019, ISBN 1107134765
- Houjun **Mo**, Frank **van den Bosch** & Simon **White**
  Galaxy Formation and Evolution
  Cambridge University Press, 2010, ISBN 0521857937



The following can be good sources of additional information:

- James **Binney** & Scott **Tremaine**
  Galactic Dynamics (2nd edition)
  Princeton University Press, 2008, ISBN 0691130272
- Linda **Sparke** & John **Gallagher**
  Galaxies in the Universe (2nd edition)
  Cambridge University Press, 2007, ISBN 0521671868

Semester schedule

The reading columns refer to the main textbook (Cimatti, Fraternali & Nipoti, CFN) and to additional, sometimes more technical reading in Mo, van den Bosch & White (MvdBW).

Date		#	Chapter	Suggested Reading	
				CFN	MvdBW
Part I: The observed galaxy population					
Thu	01/25/2024	1	Ch. 1: A brief history of galaxies	2.1-2.3	1.4, 3.1-3.2
Tue	01/30/2024	2	Ch. 2.1: SDSS: Distribution in space	6.6	2.7-2.7.1
Thu	02/01/2024	3	Ch. 2.2: SDSS: Photometry	C2-4	2.1
Tue	02/06/2024	4	Ch. 2.3: SDSS: Surface brightness	3.1.2-4	2.4.2
Thu	02/08/2024	5	Ch. 2.4: SDSS: Luminosity	3.5	15.2.1
Tue	02/13/2024	6	Ch. 2.5: SDSS: Morphology	3.1	2.3.1
Part II: Galaxy formation: from quantum noise to stars					
Thu	02/15/2024	7	Ch. 3: Density fluctuations in the early Universe	2.4, 7.1-2, 7.3.1, 7.4.1-2	4.1-4.1.6, 4.4.2, 4.4.4, 4.5
Tue	02/20/2024	8			
Thu	02/22/2024	9	Ch. 4: The formation of dark matter halos	7.3.2, 7.4.3-4, 7.5.2	5.1, 5.4.4, 7.2, 7.5.1
Tue	02/27/2024	10			
Thu	02/29/2024	11	Ch. 5: The galaxy-halo connection	10.10.1	15.3
Tue	03/05/2024	12			
Thu	03/07/2024	13	Ch. 6: Gas accretion and cooling	8.1.1, 8.2, 9.4, 9.9	8.1-5
Tue	03/12/2024	14			
Thu	03/14/2024	15	Midterm	---	---
Tue	03/26/2024	16	Ch. 7.1: Stars: Star formation	4.2.9, 8.3	9
Thu	03/28/2024	17	Ch. 7.2: Stars: Stellar feedback	8.7.1-2	8.6, 10.5
Tue	04/02/2024	18	Ch. 7.3: Stars: Stellar pop.	8.6	10.3
Thu	04/04/2024	19	Ch. 7.4: Stars: Obs. indicators	3.4.0, 11.1.2-3	---
Tue	04/09/2024	20	Ch. 7.5: Stars: Obs. correlations	3.4.1, 4.4.4, 11.3.4-5	---
Part III: Galaxy evolution and dynamics					
Thu	04/11/2024	21	Ch. 8: The co-evolution of halos, gas, stars, and metals	8.4-5, 8.7	10.4, 11.8.1, 15.7.1
Tue	04/16/2024	22			
Thu	04/18/2024	23	Ch. 9: Black holes and AGN feedback	3.6, 8.8	14
Tue	04/23/2024	24			
Thu	04/25/2024	25	Ch. 10: Satellites and mergers	6.1-6.4.1, 8.9-8.9.5…	2.5, 12, 13.2.2-3
Tue	04/30/2024	26	Ch. 11.1: Dynamics: Disks	4.3, 4.4.1, 10.1-2	2.3.3, 11.1-6
Thu	05/02/2024	27	Ch. 11.2: Dynamics: Ellipticals	5.1.2, 5.4, 10.3	2.3.2, 13.4
Presentations and final					
Tue	05/04/2024	28	Project presentations	---	---
Thu	05/09/2024	29			
Thu	05/16/2024	30	Final exam (1:30 - 3:30)	---	---