ASTRONOMY 340: Origin of the Universe

The course is an introduction to modern Cosmology intended primarily for non-science majors. We will study the progression of our knowledge about the origin and evolution of the universe through history, with particular emphasis on modern cosmological results. Topics include: early cosmological models, geocentric vs. heliocentric theory, curvature of space, Hubble's Law, Big Bang Theory, microwave background radiation, evolution of stars and galaxies, dark matter, active galaxies, and the future of the universe. Modern Cosmology uses the laws of Physics to construct models of the universe that describe how it evolved from simple initial conditions. The current cosmological paradigm has been quite successful at explaining many of the amazing aspects of the Universe around us. In order to do so, however, cosmologists introduced new concepts such as ``dark matter'' and ``dark energy''. We will discuss the need for such concepts, and the physics behind them. Whether these hypotheses will stand the test of time is the subject of much current research.

Course Prerequisite

The course is intended for non-science majors and assumes high-school-level algebra, and either ASTR 100 or 101 as a prerequisite. See also the official UMD info on this course.

Mathematics, not English, is the language of the natural world; that is why it is used in science. Because this is a general course, I will endeavor to introduce concepts using the simplest possible math, explaining them in words and graphs before resorting to equations. Some math, however, is unavoidable and, I would argue, desirable.

Contact Information

Instructor: Prof. Alberto Bolatto

- Office: PSC 1158
- E-mail: bolatto "at" umd "dot" edu
- Phone: (301) 405 1521
- Office hours: Monday 11 am to noon. Always confirm first by email, frequently I have telecons or meetings to attend.

Teaching assistant/Grader: Ms. Rachel Weller

- Office: ATL 1243
- E-mail: rweller1 "at" umd "dot" edu
- Phone: NA
- Office hours: Wed 10 am to 11 am

Textbook (support, not required)

Optional Textbook:

Foundations of Modern Cosmology 2/e, by John F. Hawley and Katherine A. Holcomb. Oxford University Press, ISBN 0-19-853096-X

Lecture Plan

#		Date	Topic	Book ch.	HW
Part I: History of cosmology					
1	Thu	1/26/2023	Our place in the universe: creation myths	1	
2	Tue	1/31/2023	Towards a scientific cosmology	2	
3	Thu	2/02/2023	Geocentric and Heliocentric pictures	2	
4	Tue	2/07/2023	The Universe of physical law	3	
Part II: Space, time, and relativity					
5	Thu	2/09/2023	Principles of space and time I	6	
6	Tue	2/14/2023	Principles of space and time II	6	1
7	Thu	2/16/2023	Special relativity I	7	
8	Tue	2/21/2023	Special relativity II	7	
9	Thu	2/23/2023	General relativity I	8	
10	Tue	2/28/2023	General relativity II	8	2
Part III: Modern cosmology					
11	Thu	3/02/2023	The universe beyond our galaxy	10	
12	Tue	3/07/2023	The expanding universe	11	
13	Thu	3/09/2023	Density is destiny	11	3
--	Tue	3/14/2023	Review	1-11	
--	Thu	3/16/2023	Midterm exam	1-11	
	Tue	3/21/2023	SPRING BREAK		
	Thu	3/23/2023	SPRING BREAK		
14	Tue	3/28/2023	Dark energy and the accelerated expansion	11	
15	Thu	3/30/2023	The very, very, very early universe	12	
16	Tue	4/04/2023	We are all made of star stuff	12	
17	Thu	4/06/2023	The Cosmic Microwave Background	14	4
Part IV: The limits of our knowledge: contemporary cosmology					
18	Tue	4/11/2023	Measuring the invisible	13	
19	Thu	4/13/2023	Concordance cosmology	15	
20	Tue	4/18/2023	The cosmic web of dark matter	--	
21	Thu	4/20/2023	From dark halos to galaxies to stars	--	5
22	Tue	4/25/2023	The Milky Way in context	--	
23	Thu	4/27/2023	Black holes	9	
24	Tue*	5/02/2023	Listening to gravitational waves	--	
25	Thu*	5/04/2023	Inflation and multiverses	16	
26	Tue	5/09/2023	Our place in the universe and the anthropic principle	--	6
--	Thu	5/11/2023	Review	1-16	

--	Thu	5/18/2023	Final exam (1:30pm-3:30pm)	1-16	

* Travel (lecture covered by another faculty)

Course Grading

Final grades for this course will be computed based on cumulative points (out of 100 total) in the areas below, according to the weights listed:

- Homework 30%
- Midterm exam 15%
- Final exam 20%
- Class participation (clicker quizzes) 15%
- ELMS quizzes 20%

Final letter grades will be curved, based on the total points received. The minimum letter grade that you can obtain is

- A: more than 90 points (over a total of 100 points)
- B: between 80 and 89 points
- C: between 70 and 79 points
- D: between 55 and 69 points
- F: less than 55 points

You can (and usually will) get a better grade depending on the average performance of the class.

Homework: will be assigned 6 times during the semester, due the following week, and must be turned in at the beginning of class. This is 30% of your grade (5% per homework), so do not forget to turn it in. The only late homework accepted will be for excused, documented absences (see below). Points will not be given for any ``extra credit projects.'' It is important to timely complete all the regular assignments to get the most you can out of the class! I will drop your lowest grade from the final grade calculation, so if you could not complete one homework it will not affect your final grade.

Participation: will be measured through clicker quizzes during the lectures, where I will make use of a clicker/clicker software. **Please register for the use of a clicker with your university email!** (there is a link in the ELMS page). Students who answer randomly because they are not present in class or not paying attention to the lecture distort the results of the quizzes and will not get credit. **Not being present in class while answering quizzes will be considered cheating and treated accordingly.** Students who answer 50% or more of the questions will get full credit for the day, no matter if their answers are right or wrong: the point is to make you think and participate, and to let me evaluate whether you are understanding the concepts. I will drop the lowest 5 scores from the final grade calculation, so if you miss participating in 5 lectures it will not affect your final grade.

ELMS quizzes: after each lecture a quiz will open in ELMS with some simple questions about the lecture. You will have until midnight of the next day to complete it, after that it will close. As with the class participation, I will drop the lowest 5 scores from the final grade calculation.

Midterm exam: There will be one in-class examination during normal class hours. The exam will be closed book, and consist of a section of short answer questions, followed by longer essay and problem solving and/or multiple choice questions.

Final exam: As per the University rules, the final exam for this course will be held on the date and place specified in the schedule. The final exam **will cover all material discussed** in this course. The format of the final exam will be the similar to the midterm exam.

Office hours: I will have office hours once a week. My office is on the first floor of the Physical Sciences Complex, 1158. Sometimes I may have telecons or other appointments, so please email me/contact me to make sure I will be able to meet. I can also meet at other times during the week: email me to arrange a time. The TA will also have weekly office hours.

Travel: As an active researcher I have to travel with some frequency: advisory committees, invited talks, evaluation panels, etc. Those dates are marked in the calendar with an asterik (*) in as much as I can anticipate them at the beginning of the semester. The class will be taught in my absence by another professor from the Department of Astronomy, and due homeworks will still be due.

Uniform course policies: The University of Maryland has a uniform set of course policies that are respected by all courses on campus. They are found in Course Policies. Please read them for your own information. What is below is just a summary of some of them.

Masks in classroom: We will follow university policy at all times. Masks are required if you are COVID positive, or have symptoms (cough, sneezing), or have been exposed. The official web page is here.

Excused absence policy for exams or prolonged absences: See below.

Religious observances: It is the student responsibility to inform the instructor of any intended absences for religious observances in advance. That prior notification is especially important in connection with final examinations, since failure to reschedule a final examination before the conclusion of the final examination period may result in loss of credits during the semester.

Class engagement: Although slides will be made available for each lecture, it is important to attend the lectures. There is a strong correlation between class attendance and performance in the exams. Moreover, sitting in the back while reading the newspaper, surfing the Internet, or texting during a lecture is not particularly useful. Paying attention, and asking/answering questions to ensure that information is effectively and accurately transferred between teacher

and student is ideal. I will not verify attendance to each lecture, but I will have in-class clicker questions that will be part of your grade.

Course materials are copyrighted: It is illegal to upload or otherwise distribute any of the lecture materials posted in the site, including slides, notes, homework, homework solutions, quizzes, etc. These are all copyrighted materials, and their distribution or upload to other websites will be prosecuted by the university.

Open laptops: Partially to discourage distracting behavior such as Internet surfing or email checking I do not want open laptops during lectures. If you need your laptop to take notes, come talk to me and be prepared to sit in the first two rows.

Students with Special Needs: Students with a documented disability who wish to discuss academic accommodations should contact the professor as soon as possible.

Academic Integrity and Excused Absence

University regulations will apply regarding academic honesty and excused absences.

If you are ill and miss lectures, please get notes from a student who attended class: you do not need to inform me unless there is an exam or a homework is due. Students who are ill or have another valid excuse must explain the circumstances to the instructor before the due date of an assignment or exam if at all possible, and then complete the work within the following week, in order to get full credit. Any illnesses or emergencies need to be properly documented. In addition to the University of Maryland course policies, please read this uniform policy document for the Astronomy Department. Absences from individual lectures need not be justified and are not excusable, see above that I will automatically drop the 5 lowest participation scores from the calculation (so really you should not worry unless you are missing more than 5 lectures during the semester).

The University of Maryland, College Park has a nationally recognized Code of Academic Integrity, administered by the Student Honor Council. University standards regarding academic integrity apply to all work performed for credit in this course, and as a student you are responsible for upholding these standards. Particulars of the University's Code are printed in the Undergraduate Catalog, and a description of what constitutes academic dishonesty is also given in the on-line Schedule of Classes. In brief, the Code requires that you must never engage in acts of academic dishonesty at any time. Acts of academic dishonesty include cheating, fabrication, plagiarism, or helping another person to do any of these things. Violation of the Code carries very serious consequences; for more information, please visit the Student Honor Council web site.

The rules regarding academic integrity apply to homework as well as to exams. As a part of these rules, you must give credit to any book, published article, or web page that you have used to help you with a particular assignment. These rules also apply to unpublished sources of

information. In particular, students are encouraged to discuss assignments and other class material with each other, but every student must personally think through and write up his or her own answers to the homework/exam questions. **Copying or cheating will not be tolerated**. To further exhibit your commitment to academic integrity, remember to sign the Honor Pledge on all examinations and assignments:

"I pledge on my honor that I have not given or received any unauthorized assistance on this assignment/examination."

Homework

Homework will typically be assigned once every two weeks, due the following week, and must be turned in by the date and time specified in ELMS. Homeworks should be worked out by each person individually, in a piece of paper or an electronic document, and handed back to me by uploading a .pdf or .jpg in ELMS. You should expect about 6 assignments during the semester. I have marked in the calendar the **tentative** dates when homeworks will be handed out using ELMS.

Course Evaluations

Your participation in the evaluation of courses through CourseEvalUM is a responsibility you hold as a student member of our academic community. Your feedback is confidential and important to the improvement of teaching and learning at the University as well as to the tenure and promotion process. CourseEvalUM will be open for you to complete your evaluations sometime in November. Please go directly to the CourseEvalUM website to complete your evaluations around that time. The process should take less than 20 minutes, and the sooner it is done the less will it get in the way of studying for the finals. By completing all of your evaluations each semester, you will have the privilege of accessing online, at Testudo, the evaluation reports for the thousands of courses for which 70% or more students submitted their evaluations.

Useful Links

- Astronomy Picture of the Day (APOD)
- Ned Wright's cosmology web page at UCLA
- Level 5 cosmology articles

Simulations

- Millenium cosmological simulations
- Millenium II cosmological simulations
- Aquarius simulations: forming the Milky Way
- Nick Gnedin's cosmology simulations
- Center for Cosmological Physics simulations

- Simple galaxy simulator for a PC
- Relativistic distortion velocity raptor dinosaur game

Astronomy Nobel Prize Lectures

- Roger Penrose's 2020 Nobel Prize lecture (black holes)
- Reinhard Genzel's 2020 Nobel Prize lecture (black holes)
- Andrea Ghez's 2020 Nobel Prize lecture (black holes)
- James Peebles' 2019 Nobel Prize lecture (physical cosmology)
- Saul Perlmutter's 2011 Nobel Prize lecture (acceleration of the cosmic expansion using supernovae)
- Brian Schmidt's 2011 Nobel Prize lecture (acceleration of the cosmic expansion using supernovae)
- Adam Riess' 2011 Nobel Prize lecture (acceleration of the cosmic expansion using supernovae)
- John Mather's 2006 Nobel Prize lecture (precision measurements of the CMB)
- George Smoot's 2006 Nobel Prize lecture (precision measurements of the CMB)
- Arno Penzias' 1978 Nobel Prize lecture (discovery of the CMB)
- Robert W. Wilson's 1978 Nobel Prize lecture (discovery of the CMB)