Spring 2-1-2022

ASTR 142N.80: The Evolving Universe - Honors

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Astronomy 142: The Evolving Universe

University of Montana, Spring 2022
MWF 2:00 – 2:50 pm, CHCB 230
Tu 2:00 – 3:50 pm, CHCB 230
Course Number 30840

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Office Hours: by appointment

Course Description

In Astronomy 142, we'll study our amazing, dynamic and varied Universe. We'll investigate our place in the Universe, and how we got here. We'll examine the night sky and the tools we use to study it. We'll explore the Solar System, probe the interiors of planets and learn the techniques used to detect exoplanets orbiting distant stars. We'll speculate about astrobiology and the prospects of life elsewhere in the Universe. We'll learn about the births, lives and spectacular deaths of stars. We'll consider familiar objects like our local star (the Sun), more fantastic things like quasars, exploding supernovae and the expanding Universe, and things we cannot even see like supermassive black holes, dark matter and dark energy. Our studies will take us from the very small scale of subatomic particles to the largest scale of all: the primordial cosmic microwave background radiation that fills the Universe! Along the way we'll discover how the Universe began, how it is changing, and its final fate, and examine the many ways astronomers piece together this wondrous puzzle.

Course Objectives

My goals in this course are to…

1. Convey the framework and physical basis of our understanding of the Universe.
2. Demonstrate that the Universe is dynamic and ever changing.
3. Establish that the Universe is knowable through the process of science and that physical laws are universal.

Required Materials

Astronomy
by A. Fraknoi, D. Morrison and S. Wolff
This OpenStax textbook is available FREE(!) at https://openstax.org/details/books/astronomy

Expectations of the Professor

This is an honors university science course that offers an intensive learning environment for motivated undergraduates. The sole pre-requisite is a working knowledge of precalculus (algebra and trigonometry). Class meetings are an essential part of this course, and it will be to your benefit to attend class meetings, whether in-person or remotely via Zoom. Group work is an integral part of your learning experience, and you must participate to benefit. Quizzes will be based on material presented in class and the lab activities. This course is a collaborative effort – please ask questions, offer your opinions and ideas, and be prepared to participate in the discussion.

At UM, one "credit" represents three hours of work by the student. This is a four-credit course, so you can expect to put 12 hours of work into the course each week, including time in class. I strongly recommend that you complete the day's reading assignment before attending class.

Classroom Activities

Being actively involved in class activities will help you learn better. That is why I'm going to such effort to provide opportunities for you to engage! Your role in this class is to actively participate and take charge of your own learning. This means reading the relevant sections of the textbook before each class meeting, asking questions, discussing the material and activities with other students in class, and coming to office hours if you are struggling. My role as the instructor is to find ways to help you learn, show illustrative examples, ask you questions to find out what is confusing you, be available for and answer your questions, and provide lots of tools, feedback, and ways for you to assess your own learning.

Astronomy is a varied field, and as such we will approach the course material in a variety of ways. Most days will include a discussion of new material as listed on the course schedule in this syllabus. On Mondays, class will begin with a 10 minute quiz over material from the previous week. Tuesdays are the 2-hour lab class, with small group lab activities on the topic of the week. On Wednesdays, a pair of students will present a topic from an Astrobites article. Fridays will feature a small group order-of-magnitude estimation problem, worked in class with no access to other information sources. At some point during the semester, weather and virus permitting, we will also use the university's 0.4-meter telescope to observe the night sky from campus.

Grading Policy

This course will be graded on the University's traditional letter grade system. Your grade will be based on your performance as weighted below. I have not chosen in advance how many As, Bs, etc to award – you will get the grade you earn regardless of the grades of your classmates. You are most certainly **NOT** competing with each other for grades! Do work together – you will learn a lot from your peers.

Homework	25%
Labs	25%
Quizzes	25% (total)
Participation	15%
Final exam	10%

There will be ten quizzes, each 10 minutes in length, scheduled at the beginning of class on Mondays. Each quiz represents 2.5% of your course grade. There will be ~14 lab activities, typically conducted during the Tuesday afternoon lab sessions. Homework problems are due in class on Fridays. There will be no penalty for late work, but do try to stay current on the homework as it will prepare you for the quizzes. I cannot accept late work beyond May 9, as I will need sufficient time for grading. Your participation grade will consist of an oral report to the class (5%) and your solutions to the 10 in-class order of magnitude estimation problems (1% each) on Fridays. The final exam will summarize the material from the quizzes, and will be cumulative for the full semester. Updates on your performance in the course will be available on the course Moodle page during the semester so that you always know where you stand.

Public Health and COVID-19

We begin Spring semester 2022 while a firestorm of the highly-infectious omicron strain of coronavirus engulfs the country. The contagion is currently spreading rapidly in Montana. The best defense against severe illness remains the widely available vaccines – I highly recommend that you protect yourself via vaccination and the booster. Please direct questions regarding covid vaccination to Curry Health Center. Ventilation is the second line of defense, and windows will remain open each day in our classroom during this semester. Please dress accordingly, as the fresh winter air can be rather bracing. Use of a mask covering the nose and mouth remains mandatory within the classroom at UM this semester, preferably KN95 or N95 if available. **If you feel sick and/or are exhibiting COVID symptoms, do NOT come to class.** Contact the Curry Health Center at 406-243-4330. If you are required to isolate or quarantine, you will receive support in this class to ensure continued academic progress. All class discussions will be available via Zoom, and you need not justify your choice to participate remotely. Let's all be kind, and prioritize our health and well being in this trying time.

Course Schedule

			Readings
M	Jan 17	*Martin Luther King, Jr. Holiday*	
T	Jan 18	*No class meeting – reserved for evening observing*	
W	Jan 19	Introduction	Chapter 1
F	Jan 21	Order of magnitude estimation in science	
M	Jan 24	Energy and light	Section 5.2
T	Jan 25	**Lab:** Light	
W	Jan 26	Inverse squared law of light	Section 5.1
F	Jan 28	Light and Earth's atmosphere	
M	Jan 31	Telescopes and observatories	Chapter 6
T	Feb 1	**Lab:** Observatories Around the World	
W	Feb 2	Kepler's laws of planetary motion	Section 3.1
F	Feb 4	Gravity and orbital motion	Sections 3.2 – 3.3
M	Feb 7	Solar system: terrestrial planets	Sect 7.1, Ch 9, 10
T	Feb 8	**Lab:** Gravity and Orbital Motion	
W	Feb 9	Solar system: rocky bodies	Chapter 13
F	Feb 11	Solar system: gas giants	Chapter 11
M	Feb 14	Planetary composition	Section 7.2
T	Feb 15	**Lab:** Bulk Density and Planet Composition	
W	Feb 16	Exoplanets: Transit detection	Section 21.4
F	Feb 18	Exoplanets: Doppler detection	Section 21.5
M	Feb 21	*Presidents Day Holiday*	
T	Feb 22	**Lab:** RV and Exoplanets: The Doppler Technique	
W	Feb 23	Astrobiology: Habitable Zone	Sections 30.1 – 30.2
F	Feb 25	Astrobiology: the Drake Equation	Sections 30.3 – 30.4
M	Feb 28	Spectroscopy	Sections 5.3 – 5.5
T	Mar 1	**Lab:** Spectroscopy	
W	Mar 2	Energy & matter	Section 5.2 (review)
F	Mar 4	Sun as a star	Section 15.1
M	Mar 7	Nuclear energy in the Sun	Section 16.1
T	Mar 8	**Lab:** Nuclear Fusion and Energy in Stars	
W	Mar 9	Solar interior and structure	Section 16.2
F	Mar 11	Properties of stars	Sections 17.1 – 17.2
M	Mar 14	Hertzsprung-Russell diagram	Ch 18, Sect 19.4
T	Mar 15	**Lab:** Stars and the H-R Diagram	
W	Mar 16	Binary stars and stellar masses	Section 18.2
F	Mar 18	Variable stars and cosmic distances	Section 19.3
		Spring Break	

M	Mar 28	Interstellar medium	Chapter 20
T	Mar 29	**Lab:** Planetarium – night sky motions	
W	Mar 30	Star formation	Sections 21.1 – 21.3
F	Apr 1	Main sequence lifetime, M-L relation	Sections 22.1 – 22.3
M	Apr 4	Post main-sequence evolution and red giants	Section 22.4 – 22.5
T	Apr 5	**Lab:** Planetarium – constellations & planetary motions	
W	Apr 6	Stellar endpoints: white dwarfs & supernovae	Chapter 23
F	Apr 8	Exotic remnants: neutron stars & black holes	Chapter 24
M	Apr 11	Contents of the Milky Way	Chapter 25
T	Apr 12	**Lab:** Star Clusters and the Ages of Stars	
W	Apr 13	Morphology of galaxies	Sect 26.1 – 26.4
F	Apr 15	Hubble law	Section 26.5
M	Apr 18	Active galactic nuclei and quasars	Chapter 27
T	Apr 19	**Lab:** Hubble law and the Expansion of the Universe	
W	Apr 20	Galaxy evolution	Sections 28.1, 28.5
F	Apr 22	Dark matter	Section 28.4
M	Apr 25	Our expanding Universe	Section 29.1
T	Apr 26	**Lab:** Expansion and the Age of the Universe	
W	Apr 27	Cosmic microwave background	Section 29.4
F	Apr 29	Big Bang nucleosynthesis	Section 29.5
M	May 2	Expansion history of the Universe	Section 29.2
T	May 3	**Lab:** Accelerating Expansion of the Universe	
W	May 4	Distant supernovae and dark energy	Section 29.5
F	May 5	Course review, fun with estimations	
W	May 11	Final Exam, 3:20 – 5:20 pm	

Additional Reading Material

The free textbook we will use in this course is encyclopedic, and touches on most topics in astronomy. If you would like to extend your reading at the popular science level, here are some that I recommend.

NightWatch: A Practical Guide to Viewing the Universe, by Dickinson (stargazing in your backyard)
Bright Star Atlas, by Tirion (easy to use maps of the night sky)
The Stars: A New Way to See Them, by Rey (a constellation guide, more aimed at kids but a total classic)
A Student's Guide to the Mathematics of Astronomy, by Fleisch & Kregenow (a tutor in your pocket)
The Backyard Astronomer's Guide, by Dickinson (a guide to buying and using a small telescope)
The Martian, by Weir (fictional, but the science is great – a look at human exploration of Mars)
How I Killed Pluto and Why It Had It Coming, by Brown (a great look at how astronomers work)
How do You Find an Exoplanet?, by Johnson (an insider's guide to the techniques of planet hunting)
Cosmos, by Sagan (a classic book – and TV series – that launched the careers of many astronomers)
Welcome to the Universe, by Tyson, Strauss & Gott (a guided tour of the cosmos as of 2016)
Black Holes & Time Warps, by Thorne (a terrific book about exotic objects, worm holes, time travel)
Cosmic Catastrophes, by Wheeler (modern astronomy relating to gamma ray bursts, supernovae, etc.)
A Brief History of Time, by Hawking (cosmology and the history of the Universe, a classic book)
The Elegant Universe, by Greene (great summary of contemporary astrophysics, plus string theory)