

ASTR 340: Origin of the Universe

Prof. Benedikt Diemer

Lecture 1 • Our place in the Universe: Creation myths

08/31/2021

Masks & COVID protocols



Please take masking seriously!

Today

- Logistics
 - Resources
 - Assignments, exams, grading
 - Policies
 - Classroom (n)etiquette
 - COVID protocols
- Semester plan
 - What is cosmology?
- The scientific method
 - Cosmology vs. mythology

ASTRO 340 • ORIGIN OF THE UNIVERSE • FALL 2021

Basic information

Title	Origin of the Universe	Instructor	Benedikt Diemer (he/him)
Number	ASTR 340 (Fall 2021)	Email	diemer@umd.edu
Website	ELMS/Canvas	Office	PSC 1107
Location	ATL 2400		
Lecture times	Tue/Thu 12:30 – 1:45pm	TA/Grader	Ernesto Benitez (he/him)
Office hours	Wed 3-4pm	TA's email	ebenite1@terpmail.umd.edu
	Thu 11am -12pm	TA's office hours	Mon 11am-12pm (on zoom)

Description

Welcome to *Origin of the Universe*! The goal of this course is to give you an overview of cosmology, the study of the cosmos. We'll start right at home in our own solar system but quickly branch out to our galaxy and to the Universe as a whole - how it started, how it's evolving, and how it'll end. Along the way, we'll encounter all kinds of bizarre physical and astronomical phenomena such as relativity, the Big Bang, dark matter, dark energy, and gravitational waves.

By the end of the course, you will...

- be able to paint an accurate picture of how the Universe formed and evolved
- use observations and the scientific method to support this picture
- have reached the boundaries of our current knowledge, such as multiverse theories and the nature of dark energy
- ...and, most importantly: crush it in debates with anyone bragging about their half-baked knowledge of gravity waves, wormholes, aliens, and other sci-fi topics!

Pre-requisites

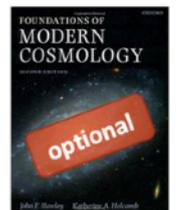
This course is intended for non-astronomy majors and assumes high-school-level algebra and general problem-solving skills. Either ASTR 100 or 101 are a prerequisite. We will try to keep the math as simple as possible, but cosmology is a fundamentally mathematical discipline, so some equations are inevitable.

Resources

Turning Point App: You will need a phone with the TurningPoint quiz app, which you can download for free in the AppStore or GooglePlay. Please create a TurningPoint account using your UMD email (the same as used in Canvas)!

Textbook (optional): John Hawley & Katherine Holcomb
Foundations of Modern Cosmology (2nd ed.)
Oxford University Press, ISBN 0-19-853096-X

Device for zoom: If lectures switch to an online format, you will need a device to access the zoom lectures and slides



Part 1a: Resources

Introduction

- **Instructor**
 - Prof. Benedikt Diemer (he/him)
 - diemer@umd.edu
- **TA / Grader**
 - Ernesto Benitez (he/him)
 - ebenite1@terpmail.umd.edu



Weekly schedule

Time	Monday	Tuesday	Wednesday	Thursday	Friday
11:00-12:00	TA office hours			Office hours	
12:00-12:30					
12:30-1:45		Lecture		Lecture	
1:45-3:00					
3:00-4:00			Office hours		
4:00-11:59					
11:59			Tue quiz due		Thu quiz due

ELMS/Canvas page

☰ ASTR340

Fall 2021

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Clickers

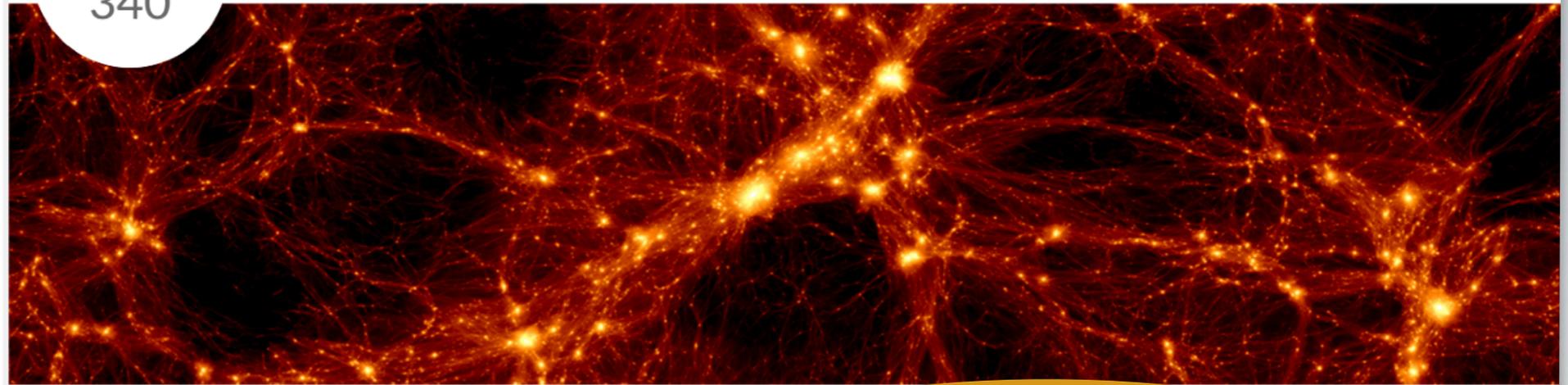
Grades

Zoom

Panopto Recordings

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ORIGIN OF THE UNIVERSE



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Welcome to *Origin of the Universe*! The goal of this course is to give you an overview of cosmology, the study of the cosmos. We'll start right at home in our own solar system but quickly branch out to our galaxy and to the Universe as a whole - how it started, how it's evolving, and how it'll end. Along the way, we'll encounter all kinds of bizarre physical and astronomical phenomena such as relativity, the Big Bang, dark matter, dark energy, and gravitational waves.

As first step, please carefully read the [syllabus](#) ↓.

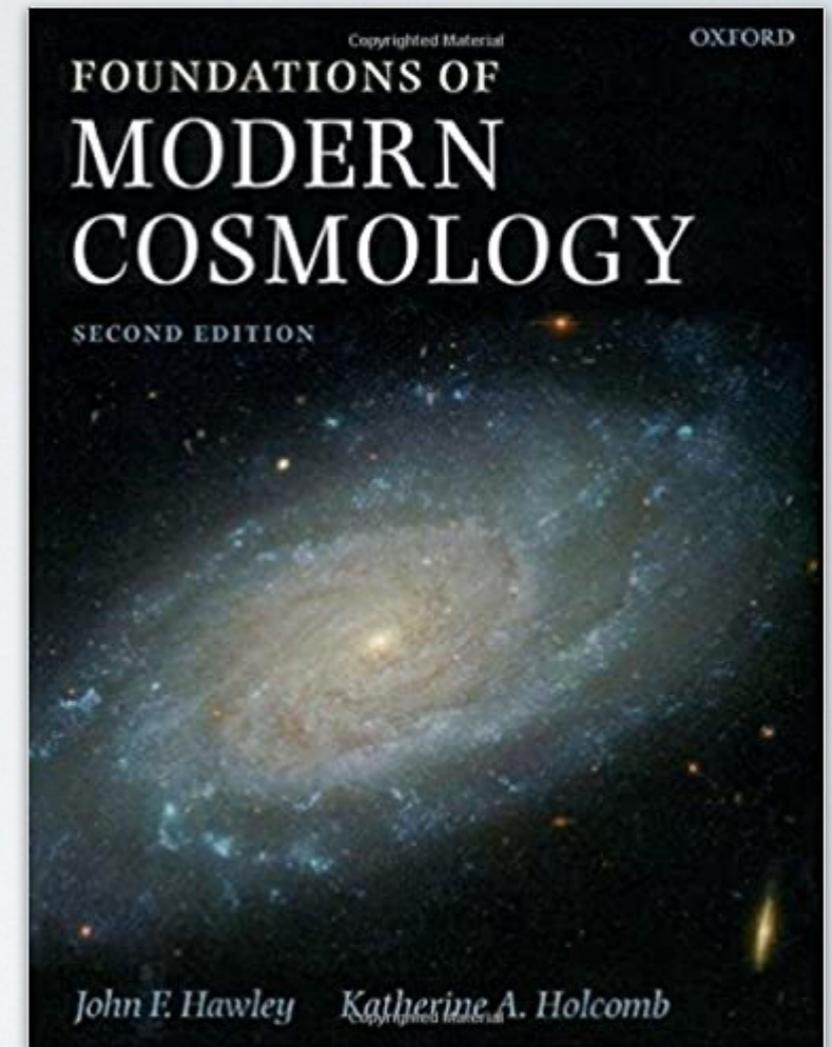
Textbook (optional)

- **Textbook**

Hawley & Holcomb

Foundations of modern cosmology

(2nd edition)



Part 1b: Assignments, exams, grading

Assignments & Grading

Type of grade	Weight
Participation	20%
Quizzes	20%
Homework	30%
Midterm exam	10%
Final exam	20%
Total	100%

Letter grades

A	100 – 90%
B	<90 – 80%
C	<80 – 70%
D	<70 – 55%
F	<55%

You'll need to be here to understand this slide.

Participation

- Will mostly consist of in-class **quizzes and group discussions**
- **If you miss a few classes, that's fine! But you WILL miss out on the participation credit.**
- **Dropping (at least) 5** bottom participation grades (but not bottom 5 classes!)



Test live quiz



Please respond to the live quiz via Turning Point.

Comprehension quizzes

- Graded quizzes **after each lecture**
- Will be due midnight the day after the lecture so that you have time to catch up

Syllabus quiz & survey



If you haven't done so yet, **submit the syllabus quiz** and pre-semester survey by tomorrow night

Syllabus quiz & survey

☰ [ASTR340](#) > [Assignments](#)

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▼ Upcoming Assignments



Post-lecture quiz #1 (syllabus quiz)

Available until Sep 1 at 11:59pm | Due Sep 1 at 11:59pm | -/10 pts

Homeworks

- Homework will be assigned **7 times** (about every 2 weeks)
- Submitted electronically in Canvas **a week later**
(I'll specify the exact date/time)
- **Reduced/no credit for late homework!**
- If you miss it because of an emergency, please document it!

Exams

- **Mid-term on Thursday 10/21** (same time as lectures)
- **Final on Monday 12/20 at 1:30pm**
- Exams will (probably) be in-person and closed-book/notes
- Missing an exam
 - If you need **special arrangements**, contact me now
 - If there is an **emergency** forcing you to miss the exam, contact me prior to the exam if at all possible!
 - Document the emergency

Part 1c: Policies

(N)Etiquette

- **DO**

- **Express yourself** freely — there are no “dumb” questions!
- **Respect** everyone’s contributions and point of view
- **Support** each other throughout academically and personally

- **DON'T**

- Talk over others and/or interrupt them
- Use hateful or derogatory language
- Harass or intimidate fellow students
- **Let me know** if you feel threatened, dismissed or harassed



Academic integrity

	 Use notes	 Use book	 Use internet	 Collaborate	 Work in group
Participation (group discussions)	✓	✓	✗	✓	✓
Comprehension quizzes	✓	✓	✓	✗	✗
Homework Assignments	✓	✓	✓	✗	✗
Midterm and final exams	✗	✗	✗	✗	✗

Academic integrity

- **DO**

- Present your own thoughts in your own words
- Cite any references that you use

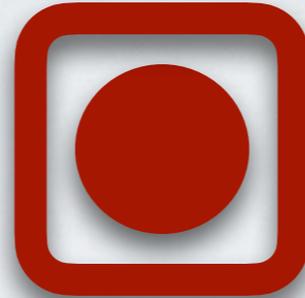
- **DON'T**

- Copy from another student
- Allow other students to copy from you
- Directly quote a source without giving credit

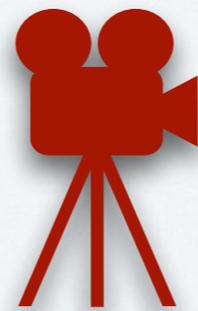


IF we have to go online...

Lectures & Recordings



- Please **mute your mic** unless you are speaking
- Zoom lectures are **recorded**
- Zoom office hours are **not recorded**
- **Recordings posted in ELMS/Canvas** so you can catch up / revisit
- **Do not repost / share** the lecture recordings!
- You do not have to turn your **camera** on, although your peers will appreciate it if you do so



Lecture recordings

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Your current Time Zone is (GMT-04:00) Eastern Time (US and Canada). [🔗](#)

Upcoming Meetings

Previous Meetings

Cloud Recordings

Get Training [🔗](#)

Start Time	Topic	Meeting ID		
Tue, Sep 1 (Recurring) 12:30 PM	Lecture (Tuesday)	937 7349 3353	Join	Invitation
Thu, Sep 3 (Recurring) 12:30 AM	Lecture (Thursday)	931 2723 3018	Join	Invitation

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📁 ASTR340-0101: Origin of the Universe-Fall 2020 diemer



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This folder contains no videos.

Zoom chat & Questions during lectures

- Experiment: **please feel free to type** into the chat at any time as long as it is **related to the lecture!**
 - Questions
 - Didn't get this last point, could you explain again?
 - Got it, move on already
- I'll **try to monitor** the chat box, but can't promise I'll always succeed
 - If you have a burning, unanswered question, feel free to unmute
- Chat will **not be in the recording** or preserved in any way



Technology-related policies

- **Internet is out**
 - NOT an excused absence in general (e.g., for homeworks)
- **Continuing issues** accessing lectures or ELMS/Canvas page
 - Let me know



Part 2: What is cosmology?



Night sky in Maryland

Participation: Discussion #1



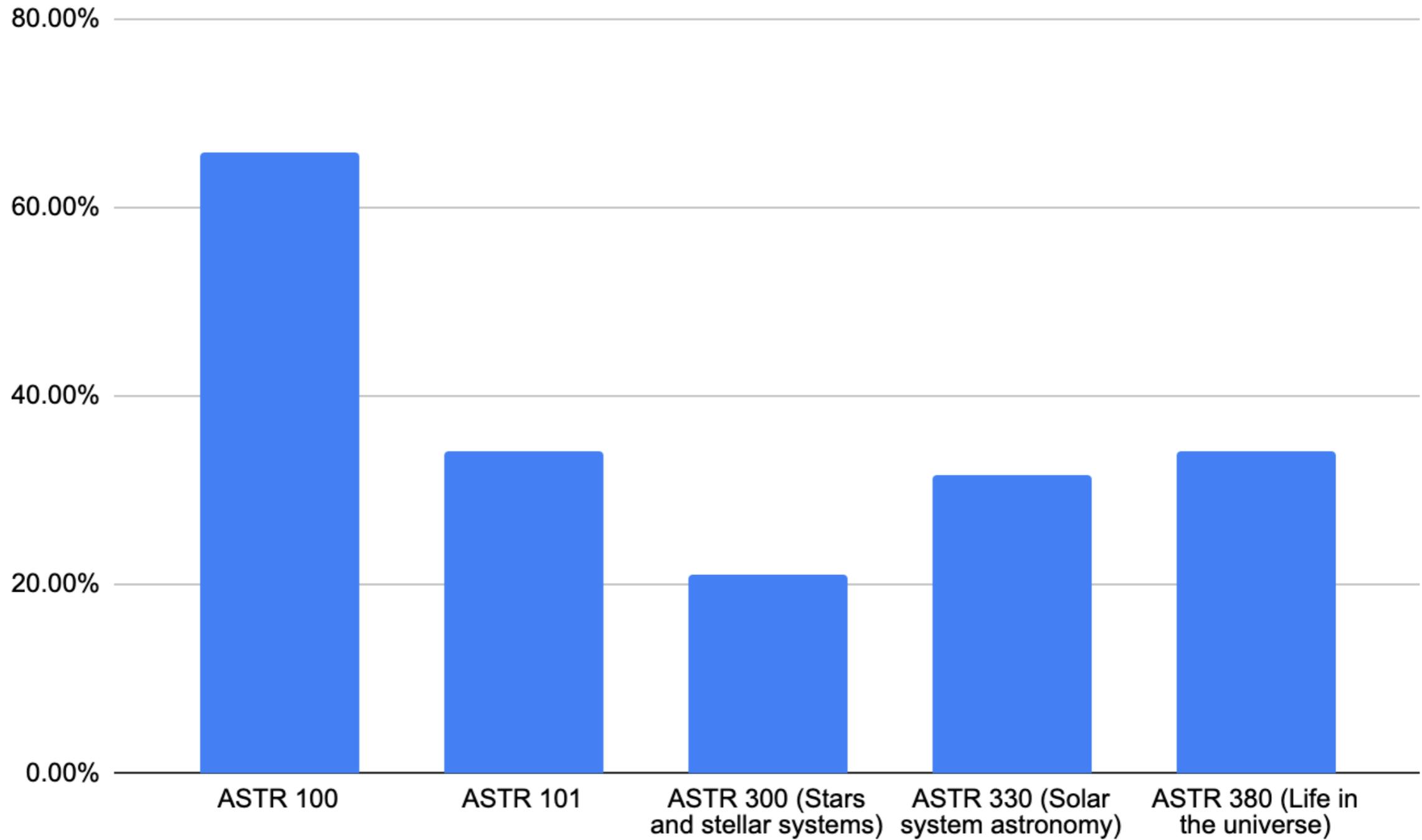
Wrong answers only!*

Based solely on what we can see with our eyes, what is the **simplest physical model** of the Universe you can think of?



10 minutes

Common ASTR courses (from 2020)

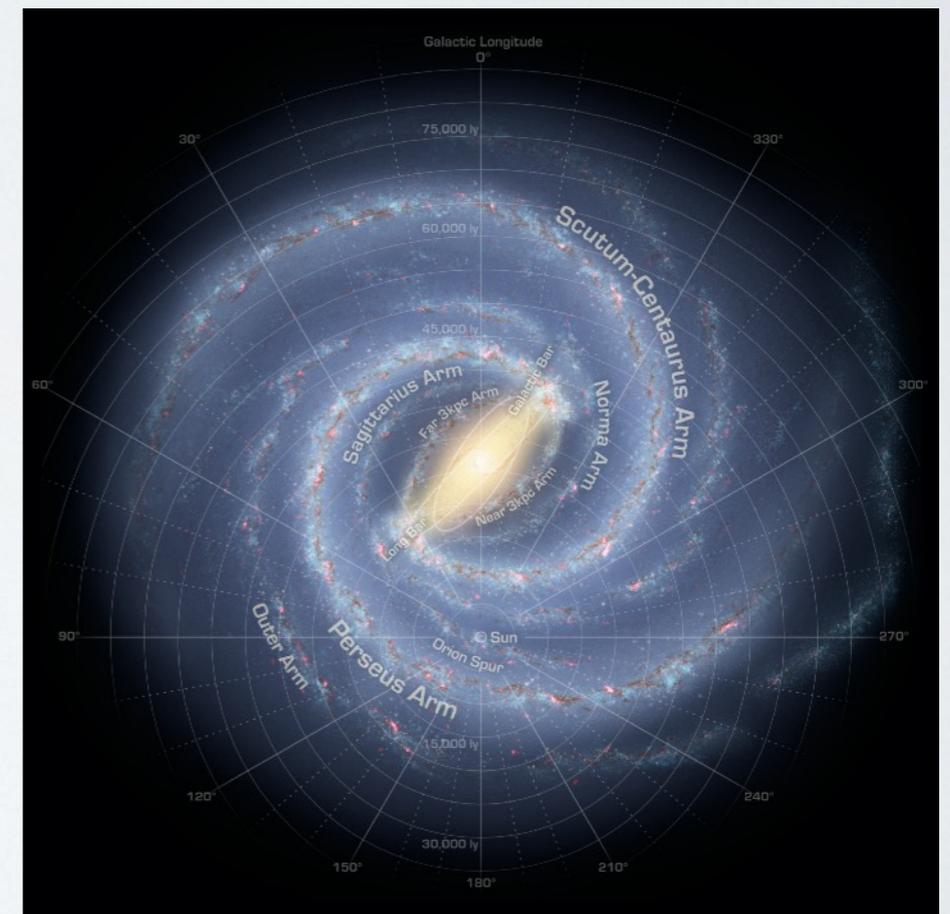
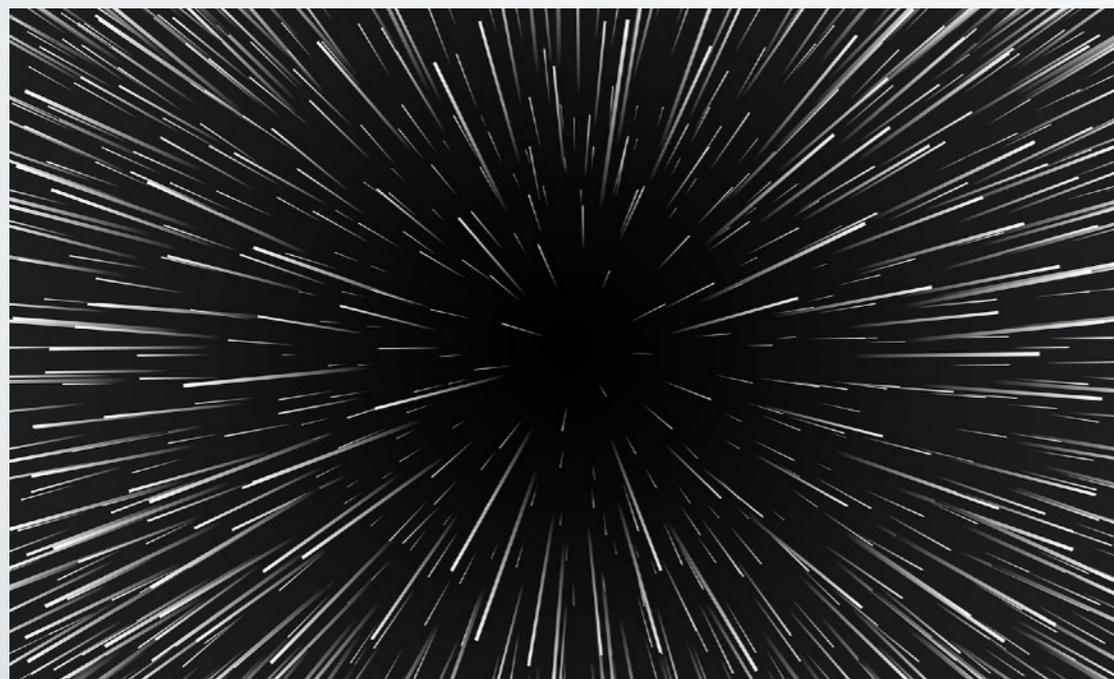
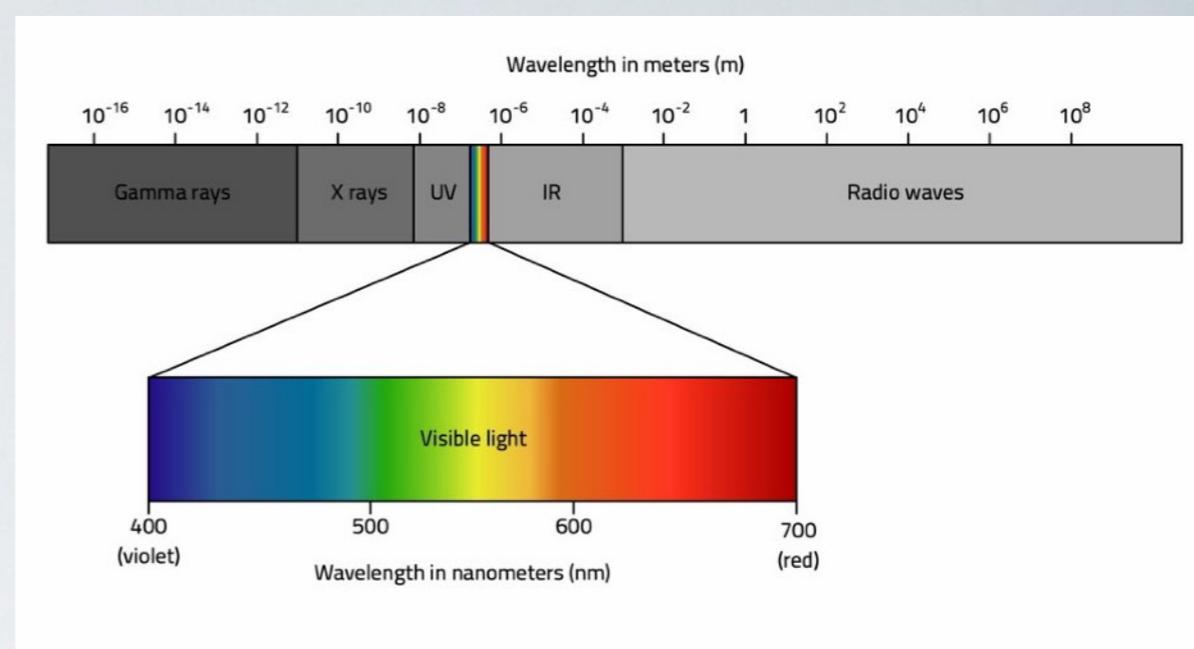


Pre-requisites

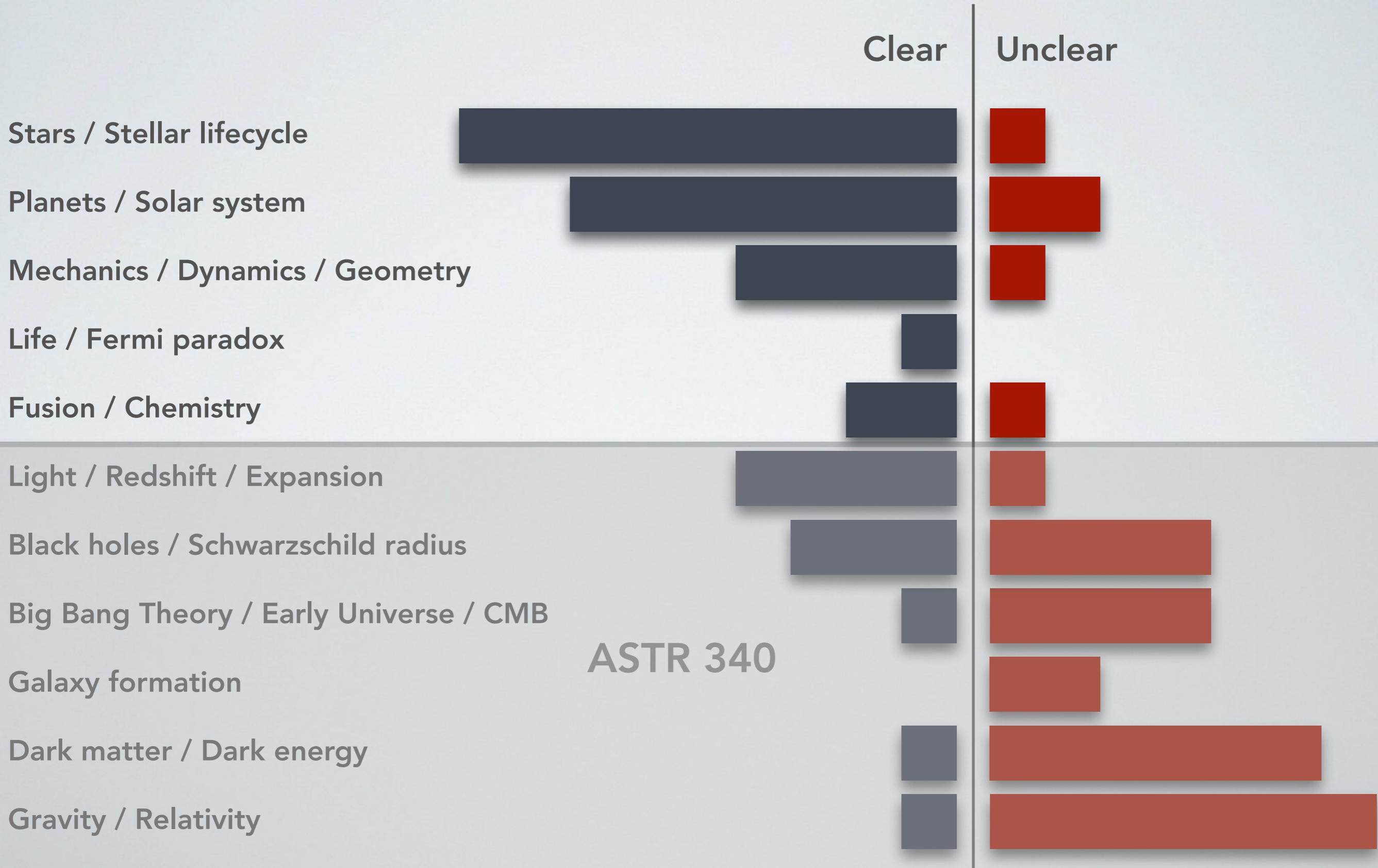
- **Mathematics**
 - High-school algebra and geometry/trigonometry
- **Physics & Astronomy**
 - Familiarity with astronomy at ASTR 100/101 level
 - Course is self-contained but will use basic astronomy terms:
 - planet, star, galaxy
 - light, photon, spectrum, Doppler effect
 - Consult **chapters 4 and 5** of the textbook for review/ refresher, as needed
- Please **ask about terms** when you are unsure!

Familiar concepts?

- Scientific method
- Competing geo/heliocentric pictures
- Kepler's law, gravity
- Light & the electromagnetic spectrum
- Solar system formation
- Stellar evolution
- The Milky Way galaxy
- Expansion of the Universe



Concepts from previous classes (from 2020)



What is cosmology?

- The study of the **Universe as a whole**
 - What does the present-day Universe look like?
 - What was the history of the Universe?
 - What is the future of the Universe?
 - What is driving this evolution?
 - How did we come to be (galaxy, star, planet, life)?
- These are clearly **big questions!**
- Goal: use the **scientific method** to derive a **simple description** of the underlying laws of the Universe
- How does it compare to **astronomy?**

Rough timeline

Key topics:

- History of cosmology
- The fundamental laws that govern the Universe
 - Newton's laws of motion and gravitation
 - Einstein's Theory of Relativity
- Geometry and expansion of the Universe
- The Big Bang theory and the very early Universe
- Open questions in contemporary cosmology

Key themes:

- Scientific method: inferring theory from observations
- Computer simulations as a third pillar

Part 3: The scientific method & mythical cosmogony

Cosmology vs. cosmogony

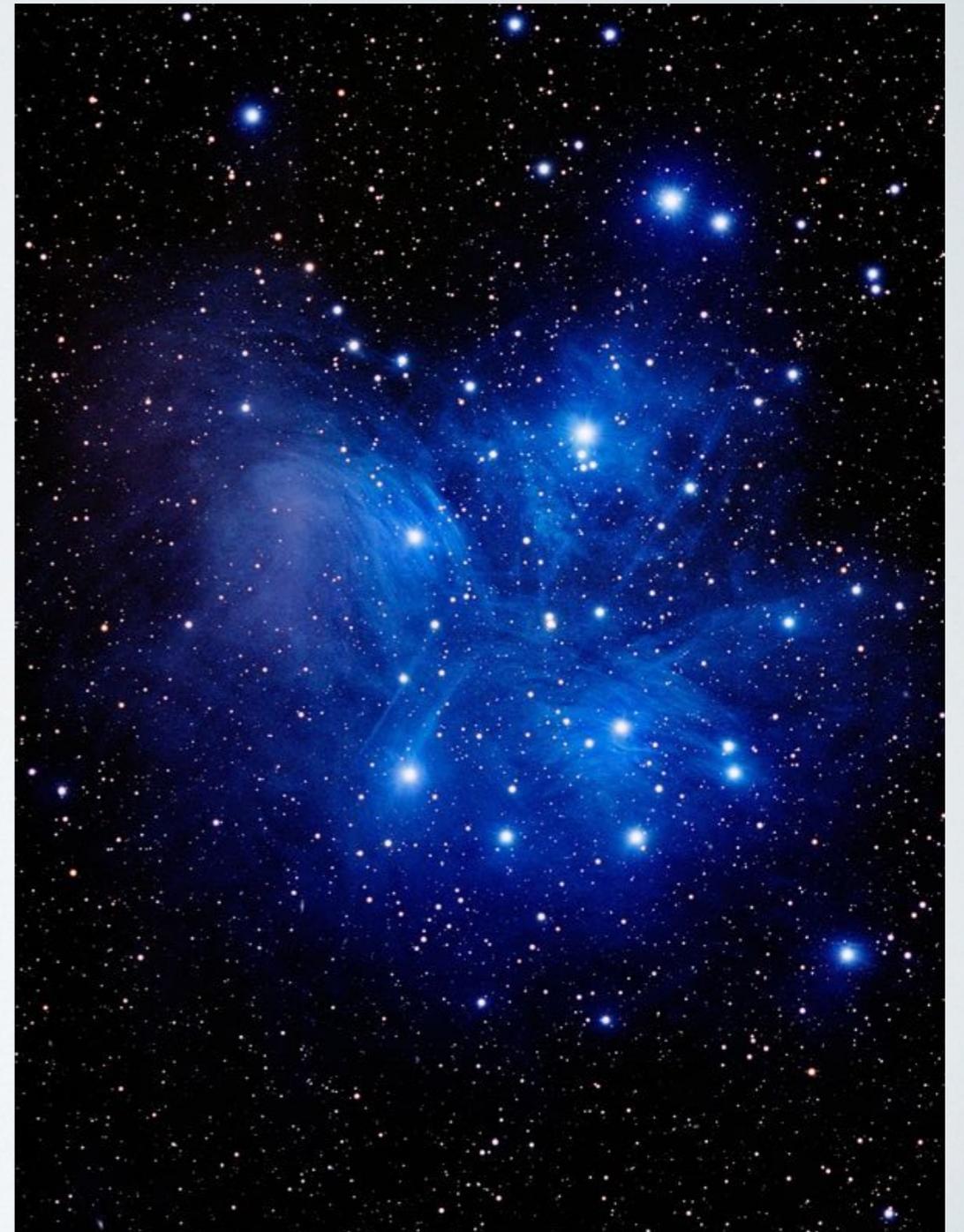
- **Cosmogony:** an explanation of the origin and evolution of the Universe
- **Cosmology:** the scientific study of the formation, structure, and evolution of the Universe

Creation myths

- Myths may be meant **literally or figuratively**
- Mythology reflects what is important to a **culture**, e.g.
 - revolve around seasons, planting & harvesting for agricultural societies
 - involve animals with human characteristics for hunter-gathering peoples
- Creation myths tend to share **common themes**
 - Use similar imagery to describe origins of the Universe, e.g. creation from a seed or egg, a supreme craftsman, or order from chaos
 - Use past events to explain aspects of the human condition
 - Involve catastrophes and supernatural occurrences
 - Establish relationships among animals, humans, and gods
 - Assert the **centrality of humans** to the Cosmos or explain it in human terms ("anthropomorphism")

Early observations & thoughts

- Nebra sky disk
- About 1600 BCE (bronze age)
- Shows the sun, moon, and Pleiades



Early observations & thoughts

- Concept of time in Hindu cosmology: “kala”
- Time is eternal
- Different entities experience time differently

Unit ^[a]	Definition	Human	Pitri	Deva	Manu	Brahma
Mahā-kalpa	36,000 <i>Kalpa</i> & <i>Pralaya</i>	311,040,000,000,000 yr	10,368,000,000,000 yr	864,000,000,000 yr	~101,408,450.70 yr	100 yr
Mahā-pralaya	<i>Mahā-kalpa</i> length					
Parārdha	$\frac{1}{2}$ <i>Mahā-kalpa</i>	155,520,000,000,000 yr	5,184,000,000,000 yr	432,000,000,000 yr	~50,704,225.35 yr	50 yr
Kalpa	1,000 CY; 14 M + 15 MS	4,320,000,000 yr	144,000,000 yr	12,000,000 yr	~1,408.45 yr	12 hr
Pralaya	<i>Kalpa</i> length					
Manvantara [M]	71 <i>Catur-yuga</i>	306				51.12 min
Manvantara-sandhyā [MS]	<i>Kṛta-yuga</i> length	1				2.88 min
Catur-yuga [CY]	<i>Kṛta</i> , <i>Tretā</i> , <i>Dvāpara</i> & <i>Kali yugas</i>	4				43.20 sec

4.3 bn years ~ age of the earth



Scientific cosmology

- **Not centered on humans** (“non-anthropocentric”)
- Based on concept of **causality** (but not purpose!)
- Derives from **data**: objective (= reproducible), quantitative observations of the physical world

The scientific method

- A systematic, **empirical process** for deriving knowledge
- Conditions for a scientific **hypothesis/theory**:
 - **Relevant** (explanatory power)
 - **Consistent** (within and without)
 - **Predictive** (qualitative and quantitative)
 - **Testable** (falsifiable)
 - **Simple** (Occam's razor)
- If a hypothesis survives significant tests of many of its predictions, it **becomes** a theory (or a law)

The scientific method

- **Hypothesis 1:** COVID is caused by a virus transmitted by respiratory droplets
- **Hypothesis 2:** COVID is a hoax devised by the Deep State
- **Are they...**
 - Relevant?
 - Consistent?
 - Predictive?
 - Testable?
 - Simple?

Take-aways

- **Participation** is a big part of this course
- Cosmology is the study of the **Universe as a whole**, by way of the scientific method
- The scientific method is an **empirical process** to derive scientific knowledge

Next time...

We'll talk about:

- The scientific method
- The beginnings of scientific cosmology

Reading:

- H&H Chapter 2