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BIG IDEAS in COSMOLOGY

A Digital First Curriculum for College Students

What are the "Big Ideas in Cosmology"?

"We can use numbers to answer deep questions"

-Chicago SU student

- Cosmology is the study of the universe as a whole: its origin, contents, structure, and evolution.
- The cosmos is the backdrop against which we live and act.
- ***And also…. a new web-based two-semester curriculum now available for adoption from Great River Learning***

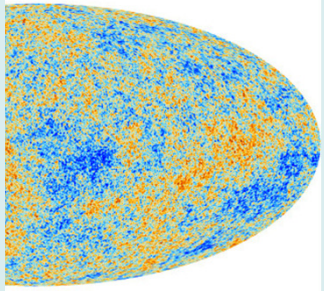
Why Cosmology (and not just Astronomy)?

Only about **20%** of traditional Astro 101 textbooks are dedicated to cosmology

"If students come away with only process, and dull topics whose explanations were known **hundreds** or **thousands** of years ago, we are losing their place in science literacy and losing our chance to help them appreciate how wonderful it is to continue to work to understand the astronomical Universe"

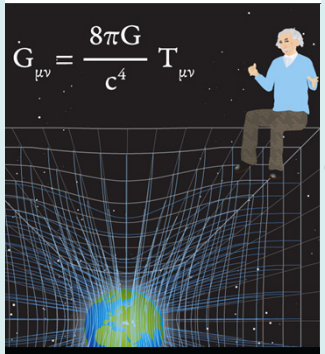
– Jay Pasachoff

Early Universe



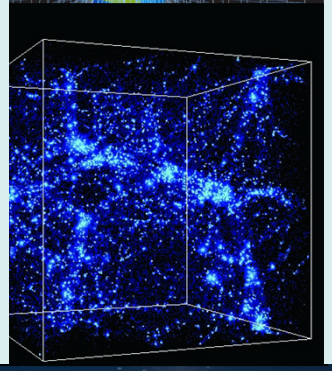
Dark Matter

Relativity

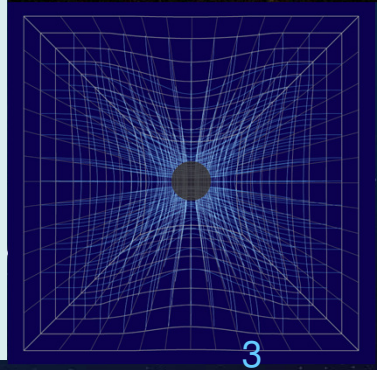


Gravitational Lensing

Structure Growth



Black Holes



Why Online?

- Interactive and engaging
- Scalable
- Flexible and easy to update as scientific thinking evolves
- Use online, hybrid or traditional pedagogies

Key features

- Informed by peer-reviewed education research into preconceptions
- Interactive format which uses real data
- Engages students in higher levels of understanding, analysis and synthesis
- Has been tested in flipped or online learning environments

Chapters

Review of Mathematics
Chapter 1: Size and Scope
Chapter 2: Light
Chapter 3: Telescopes
Chapter 4: Moving through Space
Chapter 5: Moving through Time
Chapter 6: Measuring Cosmic Distances
Chapter 7: Classical Physics: Gravity and Energy
Chapter 8: Dark Matter
Chapter 9: Special Relativity
Chapter 10: General Relativity
Chapter 11: Black Holes
Chapter 12: Gravitational Lensing
*Chapter 13: The Expansion of the Universe
Chapter 14: The Growth of Structure
Chapter 15: The Cosmic Microwave Background
Chapter 16: The Early Universe
Chapter 17: Dark Energy and the Fate of the Universe

- Adopting authors can select any combination of chapters
- Assessment results from both online and hybrid classes available

Chapter Structure

- Introductory Video
- For each subsection:
  - Learning Objectives
  - Student dialogue
  - Conceptual, numerical and interactive activities
- Extensions
  - Going Further (astrophysics)
  - Math Explorations
- Wrapping it Up Activity – synthesizes LOs
- Mission Report (submitted for grade)

Example Student Dialogue

Center of the Universe

Some students are discussing where the center of the Universe might be located.

Alfonso: "I think the Sun is the center of the Universe, because all of the planets orbit around it."

Bess: "I think you're mixing up Universe and Solar System. Also, doesn't the Sun orbit around the Galaxy?"

Caleb: "So where's the center of the Universe? Maybe there's a giant black hole that everything orbits around."

Deanna: "What if there is no center of the Universe?"

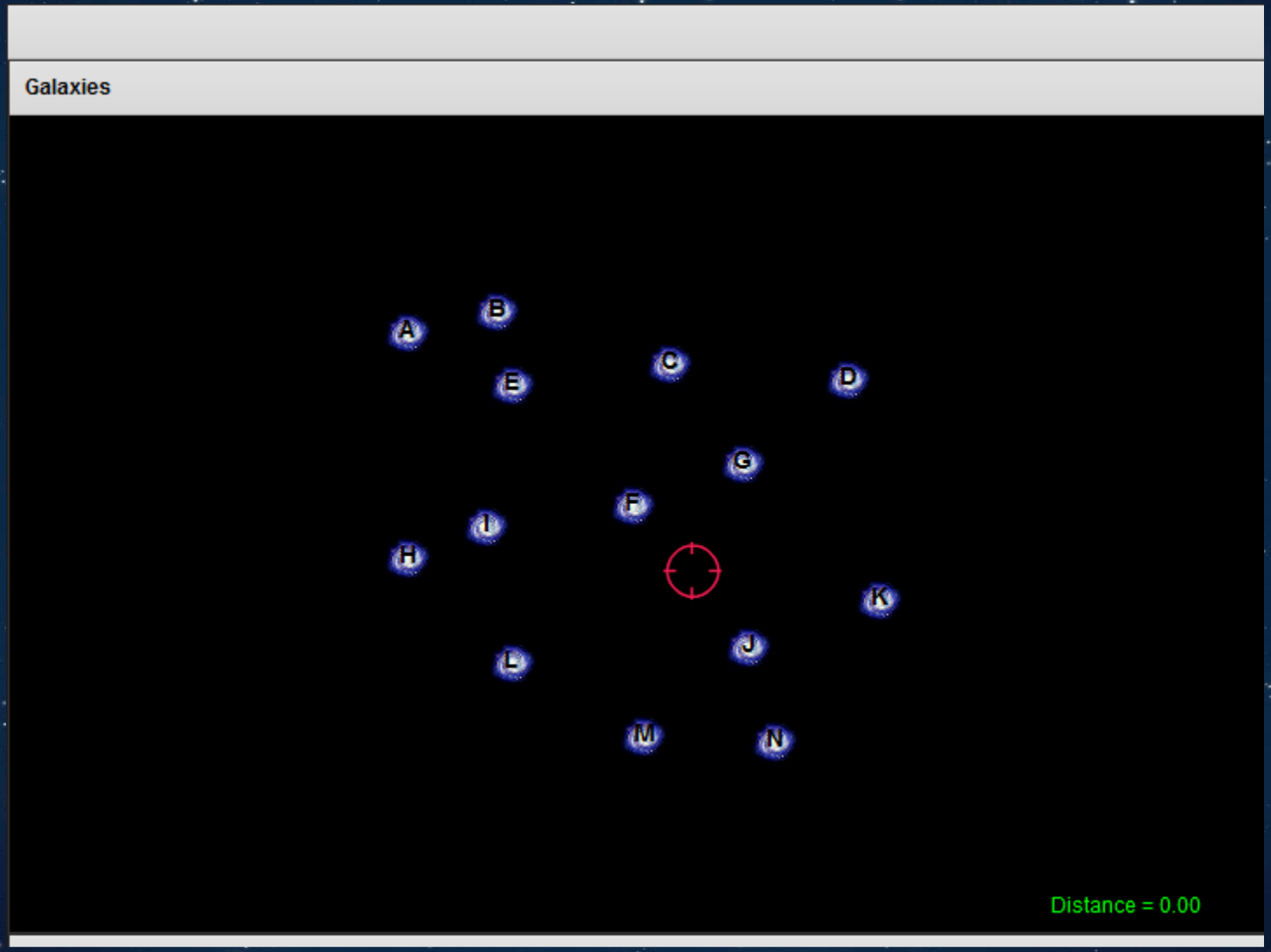
Everett: "I am the center of the Universe!"

Which student(s) do you agree with, if any?

- ☐ Alfonso
- ☐ Bess
- ☐ Caleb
- ☐ Deanna
- ☐ Everett
- ☐ None

SAVE

Example Interactive Activity



Example Conceptual Problems

4. Rank the following galaxies (B, F, J), from the one that moved the smallest distance from A to the one that moved greatest distance from A.

- a. F < B < J
- b. B < F < J
- c. J < F < B
- d. B = F = J

SAVE & CHECK VIEW ANSWER

C. Center of the Universe

1. An inhabitant of galaxy F claims that he is the center of the Universe because all of the other galaxies are moving away from him. Why is he wrong?

- a. If you move the red circle on F and stretch the space, you do not see the other galaxies moving away from F.
- b. The center of the Universe is galaxy A, because we saw that all of the other galaxies are moving away from A.
- c. The center of the Universe is galaxy B, because we saw that all of the other galaxies are moving away from B.
- d. The center of the Universe must be somewhere between all of the galaxies.
- e. If we see the same effect everywhere, then no place is special. There is no center of the Universe.

SAVE & CHECK VIEW ANSWER

Example Wrapping it Up

WRAPPING IT UP 13: HOW WELL DO WE KNOW THE EXPANSION RATE AND AGE OF THE UNIVERSE?

You have already determined a best fit value for the expansion rate and age of the Universe based on your measurements of galactic distances and speeds. In this activity, you will use your data to determine how well you know the expansion rate and age.

Make sure you have your data available in the *Graphing Tool*.

Part I: Accuracy of the Hubble Constant.

A. Your Data.

You may have noticed when you calculated your best fit line that it does not go through all of the data points on your graph. This is the nature of data; there is always some spread.

1. Plot the best fit line through (0,0) again. Recall that the slope is the Hubble constant, H_0. What is your best fit value for H_0?

km/s/Mpc SAVE & CHECK VIEW ANSWER

One simple way to estimate the accuracy of the value of H_0 is to draw the steepest reasonable line and the shallowest reasonable line on the graph, and measure their slopes. To do this using the *Graphing Tool*, adjust the slider bar for the slope.

2. What is the maximum value you get for the value of H_0?

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Thanks to:

Sonoma State University:

Kevin John, Aurore Simonnet and the SSU E/PO group

Chicago State University:

Donna Larrieu, Virginia Hayes, Melissa Nickerson, Carmen Camarillo, K'Maja Bell

Florida International University:

Geraldine Cochran

UNLV:

Roxanne Sanchez

And to support from NASA, ISGC, NSF and CSU

To Learn More:

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Or check out:

http://www.greatriverlearning.com/cosmology