5.1 What IS the Universe?

January 6, 2019 6:04 PM

SCIENCE 10

unit 5: astronomy

book 1: universe 101

NAME: ____________________ BLOCK: ____________

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5.1 what is the universe?

How Large is the Universe? https://www.youtube.com/watch?v=yaX4iGw-b_Y

How Large is the Universe?

What is the Universe?

Chat with the person beside you and come up with an explanation of what the word universe refers to:

your definition.....

https://www.youtube.com/watch?v=6QZZnpSn8-I

After watching the short clip, answer the presenter's question *which of these three theories is your favorite?*

What Is The Universe?

Does uncertainty is science (and other fields) make you feel uncomfortable or optimistic? Explain your answer.

Universe - everything that exists, everywhere.
- all matter that has ever, and will ever exist.

What is our definition of the universe influenced by?

- our level of understanding / knowledge
- the time that you live in => how far has technology advanced.

Reading: *The sense we make of the universe depends on who we are, when we are and what we know.*

Each photo in Figure 4.2 shows a technology that, at that time, was a major communication device. Would you know how to understand and use the device in Photos A and B if you could step out of Photo C and enter those earlier worlds? What about if the person in Photo A stepped into photo B, or if the people in Photos A and B stepped into Photo C?

The time frame in Figure 4.2 is only 100 years. What if the gulf of time were much broader? How would you feel if you stepped into the world of 16th century England, the world of 14th century North America, the world of 2nd century China, or any time and place of your choosing? What if someone your age from those periods and places stepped into your classroom right now?

The term culture shock is used to describe the sense of anxiety and disorientation that a person feels when they experience a dramatically new social and cultural situation. What kind of culture shock would you feel? What about your counterparts from those other times? What things would you know that they don't? What things would they know that you don't?

Return to the present, and consider: How does the period of time when you live affect what you think and believe and how you live your life? How does where you live affect these same things? How do all these things affect your understanding of who you are? (And what do you interpret the phrase "who you are" to mean?)

These are big questions, deep questions, essential questions. Ask yourself these questions every so often as you explore this unit.

Figure 4.2 Communications technologies at three moments in time over a period of about 100 years

Reflection:
Re-read the last two paragraphs. Do you think your answers to questions like those in the paragraph could change over the course of the unit in science class? Do they apply only to your study of this unit?

The Scale of the Universe - *Scientific Notation*

The study of science involves very big and very small numbers. To represent these very big or very small numbers we often use **scientific notation**.

For example if we want to write the number 280,000,000 in scientific notation it would look like 2.8×10^8

$$2.8 \times 10^8$$

± Exponent

A number between 1 – 10

Base 10 (always power of 10, tells how many places the decimal has moved)

How could we represent 1,255,000,000 in scientific notation?

← 9 places left ⊕ exp. 1.255×10^9

What about very small numbers like 0.000000067?

→ 8 places right ⊖ exp. 6.7×10^{-8}

Practice: Complete the following table by changing the number from regular notation to scientific notation or vice versa.

Regular Notation	Scientific Notation
45,000	4.5×10^5
9,000,000	9.0×10^6
7450	7.45×10^3
0.000000089	8.9×10^{-8}
0.000455	4.55×10^{-4}
0.00053	5.3×10^{-4} ⊖ exp move decimal ←
170 000	1.7×10^5 ⊕ exp move decimal →
0.006356	6.356×10^{-3}

How the Universe is Way Bigger Than You Think:
https://www.youtube.com/watch?v=Iy7NzjCmUf0

How the Universe is Way Bigger Than You Think

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Homework

Assignment #5.1 Complete Worksheet Parts 1-3 in the space provided.

Part I: The Scale of The Universe Assignment

Go to the site: http://scaleofuniverse.com/

The simulation starts at the scale of things we are familiar with like ourselves.
Using the bar at the bottom of the screen, scroll to find the scale of each of the following:

Object	**Scale**
Example: Human	10^0
Ant	4×10^{-3}
X chromosome	4×10^{-6}
HIV	9×10^{-8}
DNA	3×10^{-9}
Water molecule	2.8×10^{-10}
Hydrogen atom	3.1×10^{-11}
Proton	1.0×10^{-15}
Neutrino	1.0×10^{-12}
Blue whale	3.0×10^1
Mount Everest	
Earth	
The Sun	
Milky Way Galaxy	
Observable Universe	

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Part II: Understanding Extreme Numbers

Tues.

Watch the following video from SciShow Space: "Understanding the most extreme numbers in the universe": https://www.youtube.com/watch?v=PqFA-I7i3Kg

1. What is our understanding of the distance between two points affected by?

   The amount/size of the "clutter" (or stuff) between them. => This makes measuring in space hard because often there is empty space, not clutter.

2. What can be done to make really big (or really small) numbers or distances more understandable?

   Put huge numbers in terms of smaller, more understandable units. eg. 4.2 Light years instead of talking about billions and billions of kms = Ahh! Big number!

Reading Assignment:

For distances on Earth, the kilometre serves us well. Within our solar system, it is more convenient to use the astronomical unit (AU). One AU is the distance between the Sun and Earth: 150 000 000 km. Thus, the

Reading Assignment:

kms = Ahh! Big number!

For distances on Earth, the kilometre serves us well. Within our solar system, it is more convenient to use the astronomical unit (AU). One AU is the distance between the Sun and Earth: 150 000 000 km. Thus, the Earth-Sun distance is 1 AU (Figure 4.26.) The distance from the Sun to the last planet of the solar system, Neptune, is about 30 AU. However, distances beyond the solar system are too great for AUs, since the distance to the closest star is more than 268 000 AU. This would be like measuring the distance from Victoria to Hope in metres.

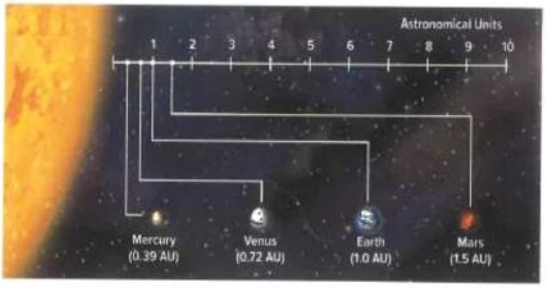

Figure 4.26 Using the AU to measure distances in the solar system is simpler and more convenient than using kilometres.

The Light-Year

light-years a unit of distance equal to the distance light travels in one year

Stellar and interstellar distances are typically measured in **light-years**. A light-year is the distance that light travels in a vacuum (empty space) in one year. In space, light travels at a constant speed of about 300 000 km/s. So 1 light-year (ly) is approximately equal to 10 trillion (9.46×10^{12}) km. Table 4.1 shows the distances of several stars and galaxies.

Table 4.1 **Distance of Some Celestial Objects**

Star or Galaxy	Approximate Distance from Earth (ly)
Proxima Centauri (star closest to ours)	4.24
Vega (part of the constellation Lyra)	25
Polaris (part of the constellation Ursa Minor)	400
Betelgeuse (part of the constellation Orion)	643 (plus or minus 46)
Deneb (part of the constellation Cygnus)	1400
Andromeda Galaxy (galaxy nearest to ours)	2 600 000

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Implications of the Light-Year

The farther a star is from Earth, the longer it takes for its light to reach us. For example, Vega is about 25 ly from Earth. The light from Vega travels at the speed limit of the universe—the speed of light. This means that it takes the light from Vega about 25 years to reach us here on Earth. When you observe Vega in the night sky, you see the light that has taken 25 years to reach your eyes. In other words, you see Vega as it was 25 years ago, not as it is today. It is, in fact, impossible to see Vega in "real time." You can't even see the Sun in real time. The light that travels from the Sun to Earth takes 8 minutes to reach us. The Sun is always 8 minutes old to our eyes. Whenever we look at celestial objects, with or without technology, we see what was, not what is. We are looking back in time.

Stellar Distances

Early astronomers discovered that over a period of weeks and months, the planets appeared to move against a background of stars. This led them to believe that stars are much farther away than the planets. However, we did not have a useful way to measure the distance between celestial objects or the distance between these objects and Earth.

Scientists have since developed various methods to measure interstellar distances—the distances between stars in our galaxy. One method, called *parallax*, relies on geometry. Parallax is the apparent change in position of an object against a fixed background when it is viewed from two different lines of sight. You can observe parallax using the method described in **Figure 4.27**.

A B

Figure 4.27 In A, a student looks through only his right eye as he lines up his thumb with an island in the distance. In B, the student views the same island through only the left eye, and the island seems to change its position. **Conducting: Try this out for yourself!**

Explaining Parallax

Figure 4.28 presents a different view of the phenomenon described in Figure 4.27. In Figure 4.28, each eye views your thumb (the object) from a slightly different position. This results in an apparent change in the position of your thumb when you close one eye. When you have both eyes open, your brain uses parallax to get a sense of the distance between your eyes and your thumb. If you move your thumb halfway to your nose, you can see that parallax increases as distance decreases.

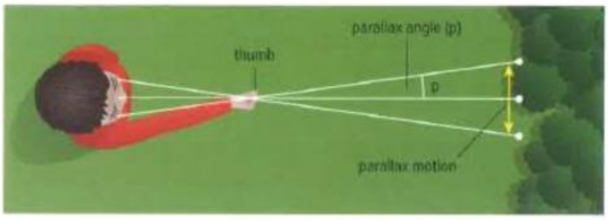


Figure 4.28 Parallax angle is the angle measured between two lines of sight, divided by two.

Parallax can be used to calculate the distance to stars using a method known as *triangulation*. With this method, if you know the length of one side of a triangle and the angles of two of the corners (vertices), you can calculate all the dimensions of the triangle.

Figure 4.29 shows how astronomers use triangulation to calculate the distance from Earth to a star. The diameter of Earth's orbit is the "known" side of the triangle. The star is then observed from two different positions in Earth's orbit around the Sun. To do this, astronomers observe the star and then wait six months to observe it again when Earth is at the opposite end of its orbit. The "triangle" formed by these observations can be used to calculate the distance to the star.

With the aid of extremely large telescopes, astronomers are able to use parallax to estimate the distances to stars as far as 100 ly away. For distances beyond this, using parallax becomes too imprecise. In the early 1990s, a unique satellite called HIPPARCOS (High Precision PARallax COllecting Satellite) was placed in orbit on a star-mapping mission. It was able to accurately measure star positions, parallaxes, and motions of stars up to 500 ly away. The ESA's Gaia telescope is measuring the parallax to about 1 billion stars in the Milky Way and other nearby galaxies.

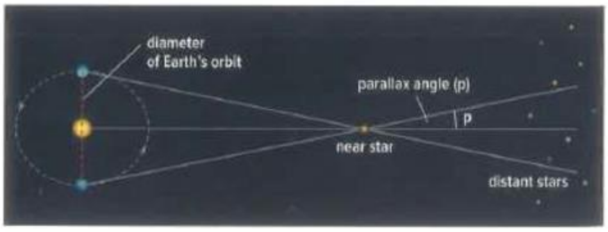


Figure 4.29 Because stars are distant, parallax must be determined from positions that are very far apart. **Innovating: Why is it ingenious to use Earth's orbit to determine the parallax of distant stars?**

Questions: From the reading above answer the questions below.

1. a) What is an AU? AU = astronomical unit
   equal to the distance from sun → Earth
   150,000,000 km

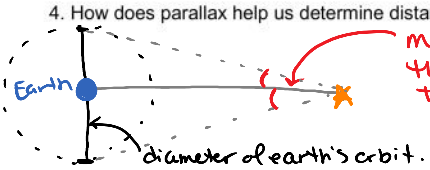
   b) What is a light year?
   The distance Light travels in a vacuum (empty space)
   in one year. 1 ly = 9.46×10^{12} km ≅ 10 trillion kms

   c) Describe a case where it might be convenient for astronomers to use AUs and where it might be convenient to use light years?
   AU's are useful for measuring planetary distances
   Ly's are useful for measuring distances to celestial objects
   Like distant galaxies and stars.

2. Explain why kilometers are not adequate for measuring most distances in the universe.
   1 AU = 150,000,000 km
   Km's are must too small of a unit to be appropriate

3. The light year is a unit of distance. Why does it seem like a unit of time?
   seams like time because of "year". BUT... really means how far Light travels/goes in 1 year.

4. How does parallax help us determine distance?



measure the Parallax angle and use the Earth's diameter (which we know) to "triangulate" or calculate the distance from Earth, to the star.

Part III: Is there more?

The fact that no one knows the answer to this question is what makes it exciting. The story of physics has been one of an ever-expanding understanding of the sheer scale of reality, to the point where physicists are now postulating that there may be far more universes than just our own. Chris Anderson explores the thrilling implications of this idea.

Watch the following video: How Many Universes are There?
https://ed.ted.com/lessons/how-many-universes-are-there and then answer the questions below:

1. Approximately how many planet earths could you fit inside the sun?
   - A Nine
   - B Nine hundred
   - C A million
   - D Nine million

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A fundamental change in the basic concepts + thinking

2. Anderson says we may be experiencing a giant paradigm shift in knowledge. What other paradigm shifts in our knowledge can you think of?

eg. Ptolemy's astronomy (earth centered solar system) was replaced by Copernicus astronomy (sun centered solar system)

3. If a star was the size of a single grain of sand, the number of stars in the Milky Way would

A fill an entire glass (like a glass of milk)

B would look like the Crab Nebulae

C create a beach about 30 ft by 30 ft in size

D be more than all the sand on all the beaches on earth

4. Some string theorists believe there could be as many as 10^500 universes out there. If it's to be believed, we will have moved from the idea of an earth-centered universe prior to the 16th century, to the notion of a single, sun-centered universe up until the 1920s, now to the multiverse. What's the psychological impact of this progression? What does it suggest to us about ourselves?

Another MAJOR paradigm shift.
Traditionally new concepts are difficult for people to understand and "get on board with"

5. Approximately how many galaxies are there in our own universe

A there's only one, the Milky Way.

B 30 billion, give or take 20%

C 100 billion

D Perhaps vastly more than 100 billion, but light from many of them may never reach us.

6. Why should we care how many universes are out there?

• could be up to 10^{500} universes.

• could be parallel universes.

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7. If every atom in our observable universe (which is estimated to have 10 to the 80 atoms) had its own universe (like ours), and all the atoms in all those universes each had ITS own universe, and all the atoms in all THOSE universes had its own universe, how many universes would that be altogether?

- (A) an infinite number
- (B) far more than is predicted by any theory
- (C) a tiny fraction of what some versions of string theory predict
- (D) it's a meaningless question
- (E) my brain just melted

8. When scientists refer to a reality made up of many universes, what do they call it?

- (A) Holy Stephen Hawking
- (B) the super-brain
- (C) the multiverse
- (D) the algorithm
- (E) the quantum field