Activity Guide
The Expanded Universe: Playing with Time

Overview

In this activity, participants use balloons to model the expansion of the universe and observe how expansion affects wavelengths of light and distance between galaxies.

Main Takeaways

- The universe is expanding and has done so since the big bang.
- As the universe expands, the distance between the galaxies increases.
- Light from galaxies stretches—the wavelength of light increases—as the universe expands and the galaxies move apart.

Type of Activity

- ☑ Independent activity
- ☑ Facilitated Activity

Audience

- Families or other mixed-age groups
- Youth ages 12+

Prep. Time

~ 5 - 20 min.

Activity Time

~ 10 - 45 min.

Supply Cost

~ $20 - $30 *(initial supply cost)*

Example Materials List

Stickers to represent the galaxies (3300 count)–		Round color coding circle dot labels, 10 bright neon colors	Sample vendor: Amazon
To represent the universe 1 pack (20 count) –		9 “ Latex Snow White Balloons	Sample vendor: Amazon NOTE: label latex on all documents in work station for allergy concerns.
To draw on the balloon 1 set (about 6) –		Sharpie Ultra Fine Point Permanent Marker	Sample vendor: Amazon
Optional: Monster Stationery- 6 inch translucent colored rulers- shatter resistant- pk of 5 mixed. Most sizes will work			Sample Vendor: Amazon
Optional: Kids Balloon Pump- 1 Portable Balloon Inflator- Sports & Outdoors, Party Accessories and Favors			Sample Vendor: Amazon

The Activity: Playing with Time

The universe as we know it began with an event known as the big bang. Ever since, the universe has been expanding. Let's go back in time to the start of the universe and recreate the expansion!

1. With a partner, pick a balloon. The balloon will represent the universe. The surface of the balloon will represent space.

2. Now choose 6-12 circle stickers. Place these at different spots on the balloon. Each sticker represents a galaxy. Optional: measure with your ruler how far apart your galaxies are from one another.

3. With the galaxies stickered on, draw a small wave ripple pattern with one of the sharpies available on the table. Make sure to use the ultrafine point tip! These will represent light travelled through time. Should look like this:

4. Now the fun part! You or a partner will blow up the balloon. This will represent the first several million years after the big bang explosion. Hold the tab to keep the air in. With your partner, observe what you see. Optional: with your ruler, see how far apart some of the stickers are from one another. Has the space around them spread out far? Measure the length of the wave ripples you drew; have they expanded? Now, pump the balloon to twice the size (without bursting the balloon!).

5. Let's say, we are closer to the present day with the full-blown balloon filled with air. The expansion of the balloon (the universe) has occurred over billions of years. Holding the tab to keep the air in, observe where the stickers are. Did they move or did the space around them get bigger? Do the wave ripples look longer or shorter? Optional: measure with your ruler and compare to your first measurements.

6. Take turns holding the balloon and observing what you see. Imagine the Universe. Where you see the stickers you placed, imagine galaxies. Why do you think the stickers were chosen to represent galaxies and not drawn on circles like how it is directed to draw on the wavelength with wave ripples? Did the stickers get larger as the balloon expanded? Discuss any and all ideas! Hint: Gravity.

7. Now let’s go back in time! Try releasing the air slowly to see the balloon revert back to its original size. What do you notice about the stickers and wave ripples? Are they getting smaller or bigger? Closer together or farther apart? Why do you think so? Discuss with your partner.

8. The theory of the big bang together with astronomical observations suggest that the universe is expanding the same way you and your partner just blew up the balloon. If we keep pumping air into the balloon it will eventually pop; lucky for us the universe is a lot stronger than balloons. Let’s make a prediction: will the universe keep expanding?

9. If we know how fast the galaxies are moving away from one another and how far apart they are, then we can work backwards to estimate the length of time they have been moving and estimate the age of the universe. How old do you think the universe is? Hint: It takes light from the closest galaxies millions of years to reach Earth.

Facilitator Guidelines

For this independent activity, you need to have all the materials out on a flat table or multiple tables if the work space promotes it. For every two participants you should have one balloon, one air pump, two sharpies, two rulers, and a pack of 12 stickers.

Questions that may arise from visitors when doing this activity:

1. Why is a balloon being used as a model for the Universe?
    a. Explain first that no model is perfect. It is good to mention that the model is showing how the universe is expanding over time, NOT to show how big it is or its shape.
2. What is a galaxy?
    a. A galaxy is an enormous collection of gas, dust and billions of stars held together by gravity. One galaxy can have hundreds of billions of stars and be as large as 200,000 light-years across.
3. Why do we use a marker to draw light waves straight on the balloon, but stickers to represent galaxies? Why not just draw the galaxies on the balloon too?
    a. The reason the galaxies are represented by stickers is because galaxies do not expand the same way with the universe like wavelength does. This is due to gravitational pulls that keep the galaxies together.
4. When did the big bang happen?
    a. About 13.8 billion years ago.
5. In what sense is the universe expanding?
    a. Although we see galaxies moving away from us in all directions, this does not mean that our galaxy is in the center of some sort of explosion; observers in other galaxies would see the same thing. It only means that the space between all galaxies is growing larger. Unlike the balloon, the universe is not expanding into anything.
6. How big is the universe?
    a. We can observe only a portion of the entire universe. Because the universe is only about 13.8 billion years old, light has only had about 13.8 billion years to travel through it. Although the observable universe is finite, the entire universe is probably much larger. It could even extend infinitely in all directions.

Resources

STEM Resources

NASA Wavelength – An online collection of NASA Earth and space science activities and resources for educators and learners. https://science.nasa.gov/learners/wavelength

STAR_Net STEM Activity Clearinghouse – An online collection of STEM activities for libraries. http://clearinghouse.starnetlibraries.org/

Activities

Observing with NASA

Control your own telescope and process your very own space images. https://mo-www.cfa.harvard.edu/OWN/

Chandra: Size and Color
http://chandra.si.edu/micro/

National Informal Education STEM Network

Exploring the Universe: Filtered Light – this toolkit demonstrates how scientists can use telescopes and other tools to capture and filter different energies of light to study the universe. http://nisenet.org/catalog/exploring-universe-filtered-light-2018

Multimedia

The ViewSpace Video Library: History and Origins of the Universe
https://viewspace.org/video_library?tags=460

Family Connections

Families can explore the expanded universe at home too. This activity can be done at home with the materials listed above on page 2.

Science Background Resources

Tour of the Electromagnetic Spectrum
https://science.nasa.gov/ems

Chandra: Scale and Distance
https://chandra.si.edu/scale/

Deep Field: The Impossible Magnitude of our Universe
https://deepfieldfilm.com

Chandra: Angular Measurement
http://chandra.si.edu/photo/scale_distance.html

FAQs

The Hubble Constant

The Hubble Constant is the unit of measurement used to describe the expansion of the universe. The cosmos has been getting bigger since the Big Bang kick-started the growth about 13.82 billion years ago. The expansion of the universe, in fact, is accelerating as it gets bigger.

The implications of the expansion

If the expansion begins to slow down, that implies that there is something in the universe that is making the growth slow down — perhaps dark matter, which can't be sensed with conventional instruments. As the growth gets faster, it's possible that dark energy is pushing the expansion faster.

The discovery by Edwin Hubble

The constant was first proposed by Edwin Hubble (the namesake for the Hubble Space Telescope). Hubble was an American astronomer who studied galaxies, particularly those that are far away from us.

In 1929 -based on a realization from astronomer Harlow Shapley that galaxies appear to be moving away from the Milky Way- Hubble found that the farther these galaxies are from Earth, the faster they appear to be moving, according to NASA.

While scientists then understood the phenomenon to be galaxies moving away from each other, today astronomers know that what is actually being observed is the expansion of the universe. No matter where you are located in the cosmos, you would see the same phenomenon happening at the same speed.

Hubble's initial calculations have been refined over the years, as more and more sensitive telescopes have been used to make the measurements, including the Hubble Space Telescope.

Who was Edwin Hubble?

The Hubble Space Telescope was named after astronomer Edwin Powell Hubble (1889–1953), who made some of the most important discoveries in modern astronomy. In the 1920s, making use of relationships established by Henrietta Swan Leavitt, Dr. Hubble showed that some of the numerous distant, faint clouds of light in the universe were actually entire galaxies — much like our own Milky Way. The realization that the Milky Way is only one of many galaxies forever changed the way humanity views our place in the universe. But perhaps his greatest discovery came in 1929, when Hubble determined that the farther a galaxy is from Earth, the faster it

appears to move away. This notion of an expanding universe formed the basis of the big bang theory, which states that the universe began with an intense burst of energy at a single moment in time and has been expanding ever since.