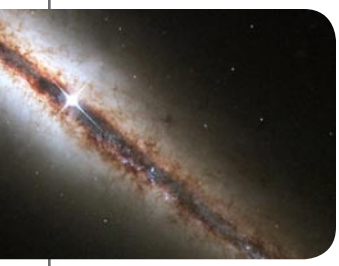
# Expanding Universe

## Lesson Development

GRADES 6-8



Galaxy NGC 4013 (Image: NASA)

Orion Nebula (Image: NASA)

## INSTRUCTIONAL OBJECTIVES

Students will

- complete a KWL chart to assess their understanding of the universe;
- create and work with several models of the expanding universe;
- verify observations through Internet resources to learn more about the expanding universe;
- create a PowerPoint presentation to organize and share their knowledge about the changes in our understanding of the universe; and
- use online telescopes and spectroscopy to extend their understanding of the universe.

## BACKGROUND

From the beginning of time, people have wondered about our place in space. Early thoughts placed Earth at the center of the universe. Scientific observations and theories proved that idea wrong, replacing it with the idea of a Sun-centered universe. That, too, turned out not to be supported by scientific observations. A smaller and simpler universe was imagined until the 1900s. It was believed that a single galaxy, the Milky Way, swirled around the Sun. Stars, planets in our solar system, comets and a few hundred nebulae filled this galaxy. There were no thoughts of other galaxies or a much larger universe. Scientists believed that the universe was static and unchanging.

By 1915, Albert Einstein proposed his revolutionary *General Theory of Relativity* to describe gravity. Two years later, he applied his theory to the universe predicting that gravity would make the universe collapse. Because of prevailing opinion that the universe was unchanging, Einstein modified his model to result in a static universe - an action he later regretted.

In 1922 Alexander Friedmann, a Russian astronomer, developed a model of the universe based on *Einstein's General Theory of Relativity*. This model suggested that the universe was expanding under certain conditions. Later, Einstein and several others improved upon Friedmann's work as they developed models of an expanding universe.

Edwin Hubble was the first to realize that distant galaxies existed outside our Milky Way. In 1927, observations led him to believe that distant galaxies were moving farther and farther away from us. It appeared that the farthest galaxies were moving away the fastest. These observations supported the theory that the universe was expanding and led to *Hubble's Expansion Law*. The earlier models that foretold this expansion were an important tool to help understand the universe.

Now, almost a century later, images from observatories in space continue to support Hubble's observations. Measurements in 1999 showed that the expansion of the universe is very possibly accelerating. This new evidence has, once again, modified our understanding of the universe and the models that describe it. Science progresses through new discoveries and improved models.

If the universe is continuing to expand, it is logical to wonder what would happen if we ran this expansion backwards. *The Standard Model* is today's most accepted explanation for the origin of the universe. This theory suggests that the creation of the universe was accompanied by a very rapid expansion around 13.7 billion years go. This expansion was unimaginably more rapid than the current expansion and is often referred to as the Big Bang.

# Expanding Universe

## *Lesson Development (continued)*

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*Galaxy NGC 4013 (Image: NASA)*

*Orion Nebula (Image: NASA)*

## ENGAGE

Discuss the image of the Milky Way Galaxy with your students to assess their understanding of the universe (TEACHER RESOURCE). Use a KWL (KNOW/WANT TO KNOW/LEARNED) chart to help organize what your students KNOW and WANT TO LEARN about the universe. These questions may help guide your discussion:

- What do you KNOW about the universe?
- How big is the universe?
- How has our knowledge of the universe changed over time?
- What is the Big Bang Theory?
- What would you like to LEARN about the universe?
- What tools of technology help us learn more about the universe?

White dwarf stars in the Milky Way Galaxy

## EXPLORE

Our understanding of the universe has changed over the years. Important observations from Edwin Hubble, announced in 1929, indicated that our universe was expanding. He observed that galaxies outside our own Milky Way were moving away from us. Galaxies farther away appeared to be moving faster. These observations supported the idea of the Big Bang and led to *Hubble's Expansion Law*. Your students will explore the idea of an expanding universe by creating a model.

The following activity is a modification of an activity found in the educator guide for the NASA CONNECT program, *Mirror, Mirror on the Universe*. The original guide can be found at ***http://connect.larc.nasa.gov/connect_bak/pdf/mirror.guides.pdf***

A. Expanding Universe Balloon Model

1. Organize your students into teams of three or four. Gather these materials for each team:
   - One round balloon
   - A metric tape or string and a meter stick
   - Binder clip
   - Permanent marker
   - Data chart (STUDENT HANDOUT)
2. Ask your students to inflate the balloon to about 400 mm circumference (grapefruit size). Show them how to roll the neck of the balloon several times and clamp it with a binder clip so that no air escapes.
3. Ask students to use a permanent marker to label a small, distinct point near the balloon's equator. Label this point "H" for "HOME", our home galaxy, the Milky Way.
4. Starting from "H", ask students to measure 10 mm intervals along the balloon's equator, marking five distinct points. Be sure they're careful not to compress or dent the balloon while making the marks. Students should label these points one through five with one closest to the "H" point.
5. Ask students to check the distance from "H" to each point. This data should be recorded in the data chart found as a STUDENT HANDOUT at the end of this lesson.
6. Students should continue to inflate the balloon to about 600 mm circumference and clamp the neck of the balloon so that no air escapes.
7. Encourage students to make a drawing and describe what they've observed about the points. Ask students to measure and record the new distance from "H" to each point.

# Expanding Universe

## *Lesson Development (continued)*

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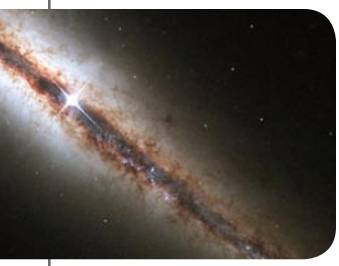

*Galaxy NGC 4013 (Image: NASA)*

*Orion Nebula (Image: NASA)*

8. Ask students to calculate the distance the point moved by subtracting the first recorded distance from "H", from the second recorded distance from "H". They should record the results in the "Distance Traveled Column" on the datasheet.
9. Lead your students in a discussion about the changes they've observed as the balloon expanded.

B. Expanding Universe Raisin Bread Animation

For another model to help understand the concept of an expanding universe, visit the Wilkinson Microwave Anisotropy Probe (WMAP) Cosmology 101 Website: ***http://map.gsfc.nasa.gov/m_uni/uni_101bbtest1.html***

At this site you'll see an animation of an expanding loaf of raisin bread. As you watch, the bread expands and the raisins, inside the bread, move away from each other. Help your students compare what they see in this animation to what they've observed while completing the balloon experience.

## EXPLAIN

A. Use this demonstration to continue the discussion with your students about their observation from the EXPLORE experience. The balloon model focused on expansion of a curved space. This demonstration looks at expansion on a flat space.

1. Make four overhead transparencies from the "Dots-Galaxies" drawing (TEACHER RESOURCE). One transparency should be the original size. One should be created at 75 percent the original size. The third should be created at 50 percent the original size. And the last transparency should be at 150 percent the original size. Highlight the dots on each transparency with a different color marker.
2. Place the 50 percent reproduction transparency on an overhead projector. The points represent a collection of distant galaxies.
3. Mark any point (1-6) as "H" and place the 75 percent reproduction transparency on top of the 50 percent transparency, lining the "H" dot of one transparency to the "H" dot of the second transparency. Only the "H" dots on both transparencies will be aligned.
4. Ask how this demonstration compares to the balloon expansion experience.
5. Place the original transparency on top of the other two transparencies, aligning the "H" dots of all three transparencies. Discuss the patterns that can be observed.
6. Finally, place the 150 percent reproduction transparency on top of the others, aligning all "H" dots.
7. Use these questions to help guide the discussion.
   - What is the relationship between the points on the balloon, dots on the transparencies and galaxies in space?
   - If the points represent galaxies, do the points get larger in this demonstration and the balloon activity? What is expanding, the galaxies or the space between the galaxies?
   - What patterns do you see?
   - How do these models represent the idea of an expanding universe?
   - What happens when you deflate the balloon or shrink the pattern of dots on the transparency? How might reversing expansion give us clues to the origin of the universe?
   - What are some limitations to these models?

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## Lesson Development *(continued)*

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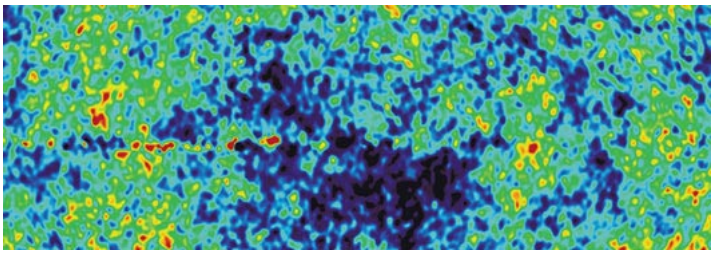
*Galaxy NGC 4013 (Image: NASA)*

*Orion Nebula (Image: NASA)*

B. Guide students to these Internet resources for more information about the expanding universe and the Big Bang Theory.
   1. Brent Tully, an astronomer at the University of Hawaii, describes how big the universe is at NOVA ONLINE: ***http://www.pbs.org/wgbh/nova/universe/howbig.html***
   2. Images from NASA's Great Observatories help us peer into deep space. Find out more about these space-borne observatories by visiting: ***http://www.nasa.gov/audience/forstudents/postsecondary/features/F_NASA_Great_Observatories_PS.html***
   3. Students will find paper models of NASA's Hubble Space Telescope, Compton Gamma Ray Observatory, and Chandra X-ray Observatory at ***http://www1.jsc.nasa.gov/er/seh/NASA_Great_Observatories.pdf***
   4. WMAP is a NASA Explorer mission that measures temperatures of cosmic background radiation. By doing this, scientists begin to answer basic questions about the Big Bang Theory and the origin and fate of our universe.



WMAP image of the universe.

Discuss the WMAP image of the universe with your students (TEACHER RESOURCE). This is believed to be the oldest and youngest picture ever taken of the universe. It's the oldest picture because the light that's been captured took nearly 14 billion years to reach us. It's the youngest picture because it is a snapshot of our universe as a newborn, long before the first stars and galaxies formed. Clumps of simple matter are seen as bright patterns. These will eventually form stars and galaxies.

Read more about "The Oldest Light in the Universe" at Science@NASA:
***http://science.nasa.gov/headlines/y2003/11feb_map.htm***
More can be learned about WMAP by visiting the WMAP Website:
***http://map.gsfc.nasa.gov/m_mm.html***

   5. How Big is Our Universe? This Harvard education Website takes students on an exploration of time and space. ***http://cfa-www.harvard.edu/seuforum/howfar/howfar.html***
   6. Here is another model to help your students understand the vast nature of the universe. This NASA Smithsonian Universe Forum Publication, "The Incredible Two-Inch Universe," can be found at ***http://cfa-www.harvard.edu/seuforum/download/2inchUniverse.pdf***

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*Galaxy NGC 4013 (Image: NASA)*

*Orion Nebula (Image: NASA)*

## ELABORATE

Challenge your students to create a short PowerPoint presentation that demonstrates what they've learned about our expanding universe. Some may want to create a presentation that depicts how our understanding of the universe has changed over time. In this presentation, students may focus on innovations in technology that allow us to see farther and farther into space.

Before you begin, you may want your students to use a storyboard to help them plan and organize their slides. One example of a storyboard can be found at ***http://nortellearnit.org/resources/Handouts/***

It may also be helpful for your students to review these Nortel LearniT video tutorials for help in creating their PowerPoint presentation. They can be found at ***http://nortellearnit.org/technology/PowerPoint_Presentations/***

Your students may want to use images found during their review of Websites in the EXPLAIN section of this lesson. They can either download those pictures to the hard drive, or save the URL as a "Favorite" in the Web browser.

Encourage your students to put a descriptive title screen, credits and references at the end of the PowerPoint presentation.

Please remind students to use only images that they have permission to include. Review copyright and copywrongs by watching the Nortel LearniT video tutorial at ***http://nortellearnit.org/technology/Digital_Ethics/***

## EVALUATE

Through discussion and the results of the EXPLORE experience, determine if your students have an accurate understanding of the expanding universe.

Complete the K/W/L chart started during the ENGAGE experience.

Use this "Cosmic Survey" to assess your students' understanding about objects in space and the structure and evolution of the universe:
***http://www.cfa.harvard.edu/seuforum/download/CosmicSurvey2003.pdf***

To evaluate the PowerPoint slides, use a rubric found at the Nortel LearniT site:
***http://nortellearnit.org/resources/Handouts/***

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## EXTEND

These activities may be used to extend or continue your students' exploration.

A. EXPERT INTERVIEWS - WHAT DO YOU WONDER NOW?
What are your students wondering now that they've learned more about the universe? Generate a list of questions that your students might ask "the experts" from NASA, the National Institute of Aerospace and research universities. Submit this list following the link on this Website. Several questions from all submitted will be used in video interviews with "experts" and posted to this site.

B. Find out more about how astronomers know that things in space are moving and how fast they're moving at this interactive NOVA Website: ***http://www.pbs.org/wgbh/nova/universe/moving.html***

C. You can be an astronomer tonight! Take your students to the MicroObservatory Guest Observer Portal to use an online working telescope. Pictures of your choosing will be taken and e-mailed to you. You'll be using a telescope that can detect objects in our solar system, galaxy and beyond.
***http://mo-www.cfa.harvard.edu/microobs/guestobserverportal/***

D. Take your students to a virtual spectroscopy lab to investigate for themselves how fast several galaxies are moving:
***http://www.cfa.harvard.edu/seuforum/galSpeed/***

E. Peer into space and view some amazing images taken by the Hubble Space Telescope at the Hubble Website: ***http://hubblesite.org/***

F. Find out more about the Hubble Space Telescope, Hubble Deep Field and how NASA engineers are developing the Next Generation Space Telescope (NGST) by viewing this 30-minute segment of NASA CONNECT, *Mirror, Mirror on the Universe.* You can view and download the video at ***http://nasa.ibiblio.org/details.php?videoid=6095&start=0&query=mirror, %20mirror&action=search***

G. Take your class on a virtual field trip to the edge of the observable universe. Visit Amazing Space: Hubble Deep Field Academy at ***http://edu.larc.nasa.gov/connect/mirror/norbert/lab.html***

This online activity allows students to join Professor Wifpic and the cadets of the Hubble Academy as they count, classify and analyze objects from the Hubble Deep Field, almost 12 billion light-years away.

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Teacher Resource

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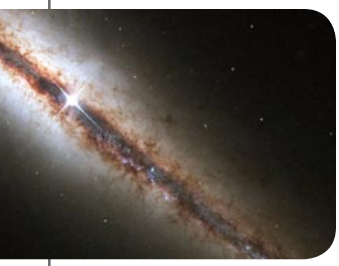

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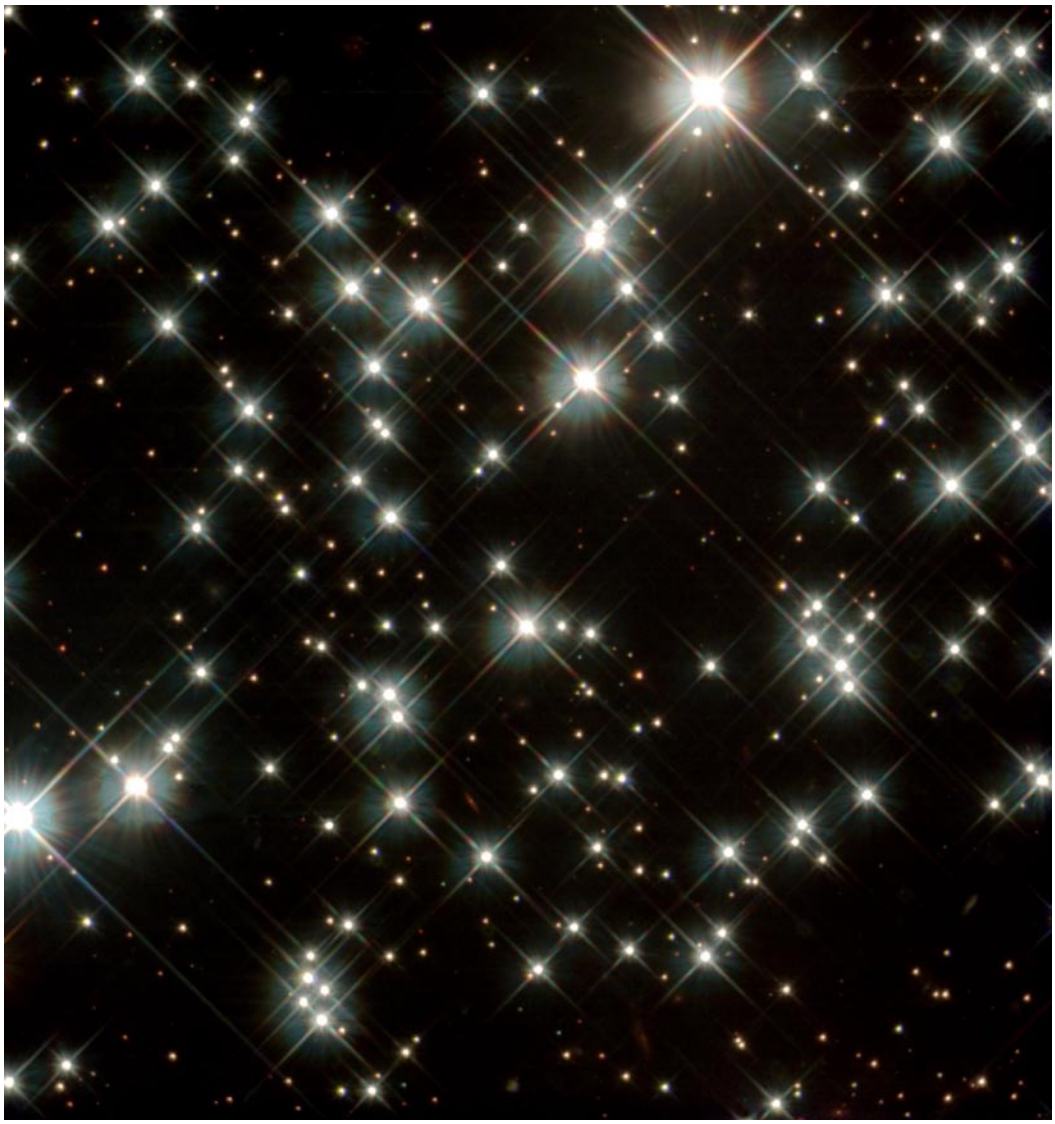
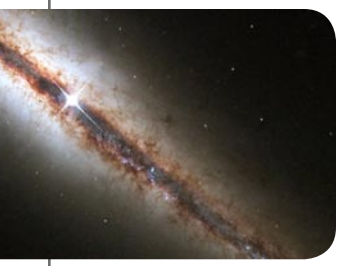


Image: NASA and H. Richer (University of British Columbia)
White dwarf stars in the Milky Way Galaxy

# Expanding Universe

Student Handout

GRADES 6-8



Galaxy NGC 4013 (Image: NASA)

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## DATA CHART
## BALLOON EXPANDING UNIVERSE

| POINTS | Starting Distance from "H" (millimeters) | Second Distance from "H" (millimeters) | Distance traveled (millimeters) |
|---|---|---|---|
| 1. | | | |
| 2. | | | |
| 3. | | | |
| 4. | | | |
| 5. | | | |

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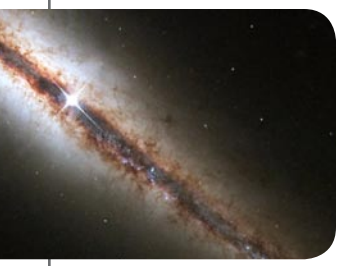

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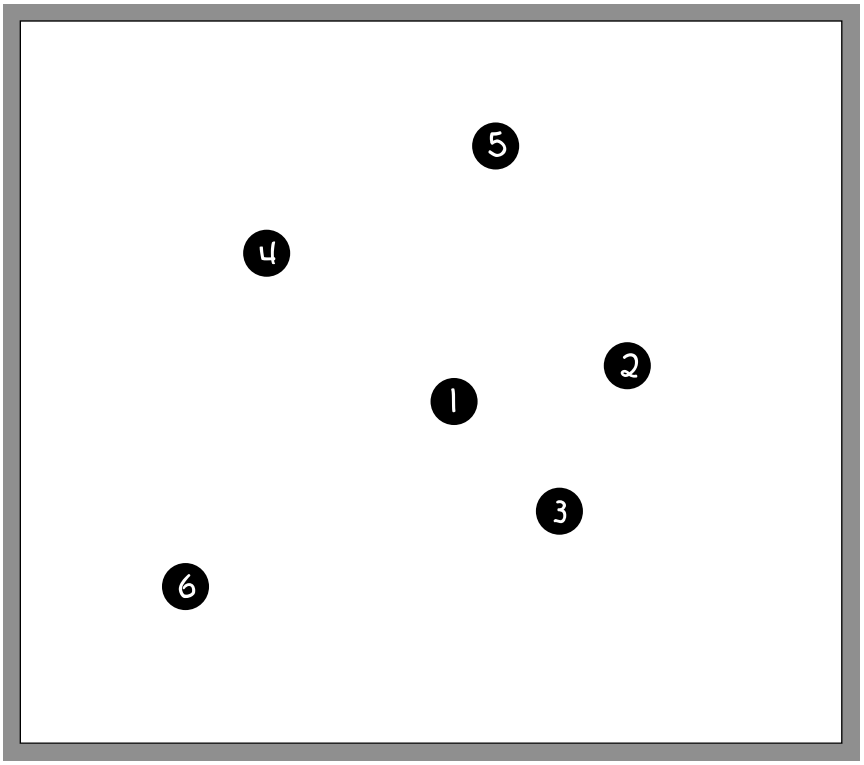


**DOTS – GALAXIES DRAWING**

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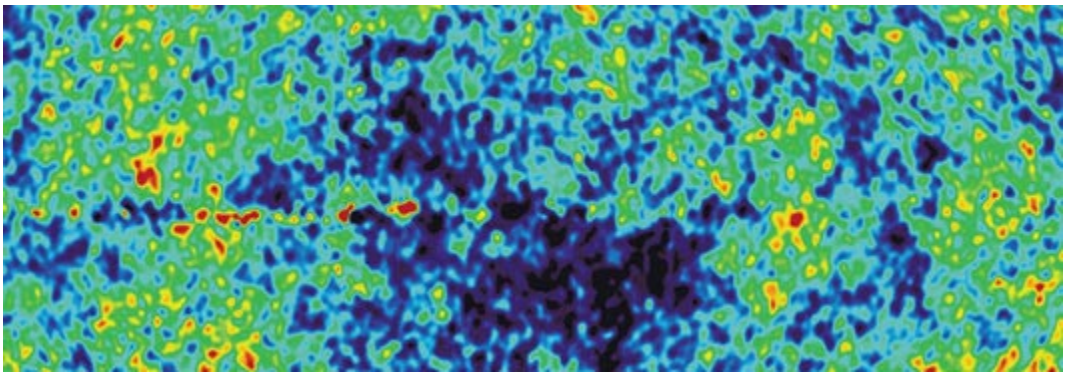

Image: NASA/WMAP Science Team
**WMAP IMAGE OF THE UNIVERSE**