Galaxy Cluster Abell 2744

National Aeronautics and
Space Administration

Observing the Cosmic Frontier

Our Milky Way Galaxy resides within a small group of galaxies containing three large members and a few dozen smaller ones. In contrast, large clusters of galaxies can encompass hundreds to thousands of galaxies. The massive galaxy cluster Abell 2744 provides a diverse collection of galaxies to study within a single image. Plus, Abell 2744 has a special feature called gravitational lensing.

This feature arises from Einstein's theory of general relativity, which explains how the presence of mass warps the space around it. Light passing through that warped space is bent, in a manner similar to light passing through a glass lens. The gravity of a massive cluster of galaxies like Abell 2744 can thus act like a lens to redirect light.

The light from background galaxies passes through the warped space of Abell 2744 and shows up as stretched and distorted images. (See inset for diagram and examples.) In some cases, multiple images of the same background galaxy can appear. These lensed galaxy images are used to measure the amount and distribution of the mass in the cluster.

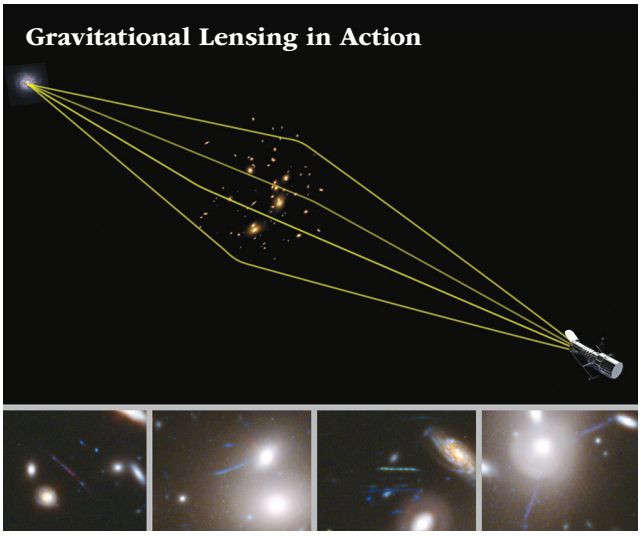
In addition to being distorted, the background galaxy images are also magnified. Very faint, very distant galaxies, which Hubble could not see directly, may be brightened enough to be observable. The gravitational lens of Abell 2744 can augment the telescope's optics, allowing astronomers to examine the farthest reaches of the universe.

Abell 2744 is the first galaxy cluster in an ambitious program searching for such remote galaxies. The Frontier Fields is a multi-year effort to observe a collection of massive clusters of galaxies in unprecedented detail. Each of these clusters provides a gravitational lens with which to search for the most distant objects observable by Hubble.

Clusters of galaxies are complex collections that are fascinating to study in their own right. When a cluster is massive enough to produce gravitational lensing, astronomers get a detailed probe into not only the structure of the cluster, but also the distant galaxies behind it. This natural lens in space and Hubble's technology combine to extend our view toward the cosmic frontier.

VOCABULARY

Gravitational lens: A massive object that magnifies or distorts the light of objects behind it. For example, the powerful gravitational field of a massive cluster of galaxies can bend the light rays from more distant galaxies, just as a camera lens bends light to form a picture.



Top: This diagram illustrates how light from a distant galaxy is deflected when passing through the warped space around a cluster of galaxies. Sometimes, Hubble can observe multiple views of the same galaxy.

Bottom row: Each of these four images features a distant galaxy whose image has been distorted by the gravitational lensing of Abell 2744. The normal shape of each galaxy has been stretched out into a thin line or arc. The fourth image at far right shows multiple views of a background galaxy, appearing as blue streaks at two and seven o'clock relative to the bright cluster galaxy.

Credits: TOP: G. Bacon, F. Summers, D.Coe (STScI); BOTTOM ROW: NASA, ESA, and J. Lotz, M. Mountain, A. Koekemoer, and the HFF Team (STScI)

FAST FACTS

Distance from Earth: About 3.5 billion light-years

Constellation: Sculptor

Credit for front image, Abell 2744: NASA, ESA, and J. Lotz, M. Mountain, A. Koekemoer, and the HFF Team (STScI)

You can get images and other information about the Hubble Space Telescope on the World Wide Web. Visit our website, **http://hubblesite.org/**, and follow the links.

You can find the corresponding classroom activity for this lithograph at **http://amazing-space.stsci.edu/eds/tools/type/pictures.php** or by contacting the Office of Public Outreach at the Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218.

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In Search of … Galaxy Clusters

Description

The "Galaxy Cluster Abell 2744" lithograph serves as the initial source of information to engage students in a Level One Inquiry Activity. In this activity, educators will use lithograph images to help students formulate questions about clusters of galaxies. Educators will suggest selected resources about galaxy clusters to help students answer their questions. Students will then conduct research and provide supporting evidence for their conclusions. This curriculum support tool is designed to be used as an introductory activity in a unit that incorporates scientific inquiry or that has a galaxy cluster or gravitational lensing theme.

About Inquiry-based Learning

The inquiry process is driven by a student's own curiosity, wonder, interest, or passion to understand an observation or to solve a problem. It involves a process of exploring the natural or material world. This exploration prompts students to ask questions and to make discoveries in the search for new insights. A Level One Inquiry Activity uses questions and problem-solving methods directed by an educator. The process of inquiry-based learning can help prepare students to become more independent thinkers.

Grade Level

High school, grades 11-12

Prerequisites

Students should know that galaxies are large collections of stars, gas, and dust held together by gravity. Students should be familiar with the Newtonian view of gravity.

Misconceptions

Educators should be aware of the following common misconceptions and determine whether their students harbor any of them. Students may think that all galaxies are the same and that galaxies never change.

Vocabulary

Terms students may encounter while doing further research on galaxy clusters include:

Light-year: The distance light travels in a year (about 6 trillion miles or 10 trillion kilometers).

Galaxy Cluster: A collection of dozens to thousands of galaxies bound together by gravity.

Gravity (Gravitational Force): The attractive force between all masses in the universe. All objects that have mass possess a gravitational force that attracts all other masses. The more massive the object, the stronger the gravitational force. The closer objects are to each other, the stronger the gravitational attraction.

See the lithograph for additional vocabulary terms.

Purpose:

The purpose of this activity is to engage students in a Level One Inquiry Activity with astronomical images and information. Students will gain experience using the Internet to search for information. They will practice the process skills of observing and analyzing. Students also will organize their material, present their findings, and reflect on what they have learned.

Materials:

- The "Galaxy Cluster Abell 2744" lithograph
- Computer with Internet connection for conducting research

Instructions for Educators

Preparation

- Obtain copies of the lithograph for each student. The "Galaxy Cluster Abell 2744" lithograph can be found at: **http://amazing-space.stsci.edu/capture/galaxy/preview-abell2744.php**.
- Preview the Overview page at: **http://amazing-space.stsci.edu/eds/overviews/print/lithos/abell2744.php**. Use the "Related Materials" section to become familiar with galaxy clusters and the Frontier Fields.
- Bookmark or identify as favorites the following suggested websites:
  - STScI: "Star Witness News: Frontier Fields: Hubble Goes Deep": **http://amazing-space.stsci.edu/news/archive/2014/01/**
  - STScI: "Hubble's First Frontier Field Finds Thousands of Unseen, Faraway Galaxies": **http://hubblesite.org/newscenter/archive/releases/2014/01/**
  - STScI: "NASA's Great Observatories Begin Deepest Ever Probe of the Universe": **http://hubblesite.org/newscenter/archive/releases/2013/44/**

- STScI: "Frontier Fields Blog": **http://frontierfields.org/**
- STScI: "Tales of … Finding one of the brightest and youngest galaxies in the early universe": **http://amazing-space.stsci.edu/resources/tales/young_bright.php**
- Search the HubbleSite NewsCenter archive for "clusters" under the topic of "galaxy"; "gravitational lens" under "exotic"; or "distant galaxies" under "cosmology." **http://hubblesite.org/newscenter/archive/releases/**

Procedure

Identify your students' misconceptions about galaxy clusters by having them write down anything they know and understand about this topic. Use those statements to evaluate your students' misconceptions. Have students volunteer their ideas about galaxy clusters. From those ideas, identify their misconceptions and discuss them with the class. An alternative method is to collect your students' written ideas about galaxy clusters. From those ideas, compile a list of their misconceptions and discuss them with the class.

Ask students to study the images on both the front and back of the lithograph. Then have students write as many questions as they can about the features visible in the images. Collect the questions and group them by common themes. Ask students to read the information on the back of the lithograph. Then ask them if they found the answers to any of their questions. Have students use the Internet to research their questions. The Internet sites listed in the "Preparation" section provide a starting point for their research. Tell students how to access other websites.

Have students prepare presentations or written reports that include the answers to their questions. Their presentations or reports also should address the role galaxy clusters play in imaging distant galaxies. The presentation can be in the form of a skit, a story, a graphic organizer, or a PowerPoint show – any method that conveys a student's understanding of the topic to another student, to a group of students, or to the entire class. Students may work individually or in groups. Ask students to check whether their original questions were answered during their research or from talking with other students. Then ask if they have any additional questions.

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Instructions for the Student

Your teacher will ask you to write down what you know and understand about galaxy clusters. You may be asked to share this information with the rest of the class. Study the image on the front of the lithograph, and then look at the images on the back. Write down as many questions as you can about what you see in the images. When instructed by your teacher, read the back of the lithograph to find answers to your questions.

Using your questions as a guide, conduct research on the Internet to find the answers to your questions. Your teacher will provide websites to use for your research. Your teacher also will ask you to create a presentation or a written report to demonstrate your understanding of the material you collected through your research. The presentation could be a skit, a story, a graphic organizer, a PowerPoint show, or whatever format that will communicate the information you learned about the role galaxy clusters play in imaging distant galaxies. Your teacher will direct you to work individually or in small groups. You may be instructed to make your presentation to another student, to a group of students, or to the entire class.

Education Standards:

AAAS Benchmarks: Project 2061
http://www.project2061.org/publications/bsl/online/bolintro.htm

1. The Nature of Science

B. Scientific Inquiry

By the end of the 12th grade, students should know that:

- Investigations are conducted for different reasons, including to explore new phenomena, to check on previous results, to test how well a theory predicts, and to compare different theories.

10. Historical Perspectives

C. Relating Matter & Energy and Time & Space

By the end of the 12th grade, students should know that:

- A decade after Einstein developed the special theory of relativity, he proposed the general theory of relativity, which pictures Newton's gravitational force as a distortion of space and time.

Educational Product

Educators & Students | Grades 11–12