Astro 101 Slide Set: Multiple Views of an Extremely Distant Galaxy

A Discovery from the
Hubble Frontier Fields Program

Topic:
Distant galaxies

Concepts:
Galaxy development, Gravitational lensing

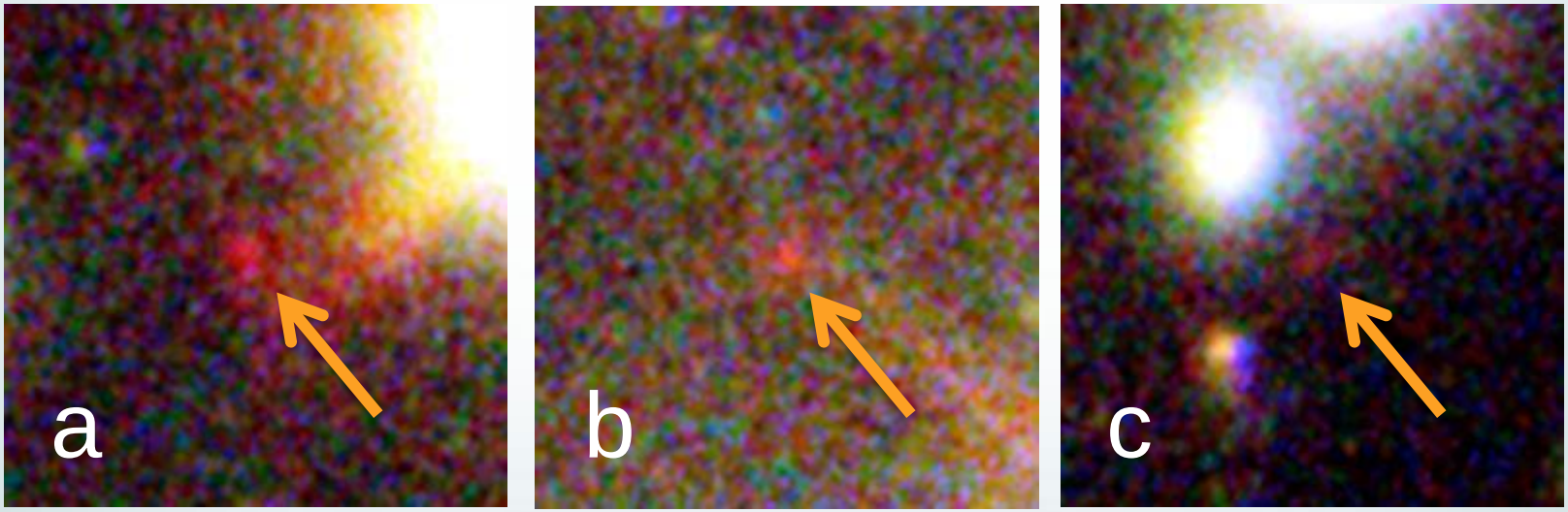
Missions:
Hubble, Spitzer, Chandra

Coordinated by
the NASA Astrophysics Forum

An Instructor's Guide for using the slide sets is available at the ASP website
https://www.astrosociety.org/education/resources-for-the-higher-education-audience/

Three Images of a Diminutive Galaxy

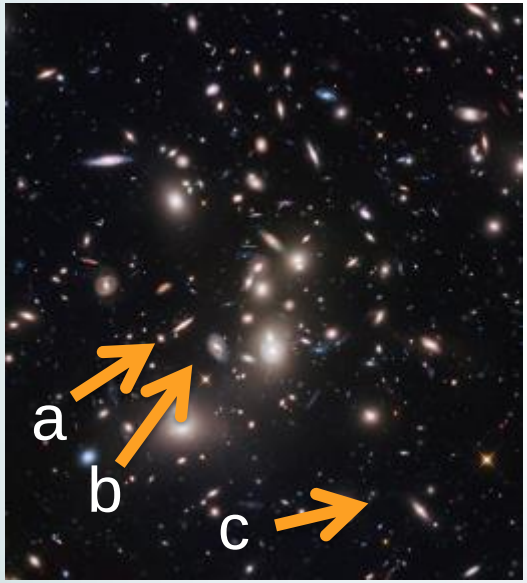
- In October 2014, NASA's Hubble Space Telescope announced the discovery of a small, faint, and extremely distant galaxy.
- Observations were only possible because the galaxy's light was magnified by gravitational lensing of a large, foreground cluster of galaxies.
- The galaxy is tiny, measuring 850 light-years across and containing the mass of about 40 million suns.
- The galaxy is estimated to be over 13 billion light-years away. It is seen at a time when the universe was only about 500 million years old.

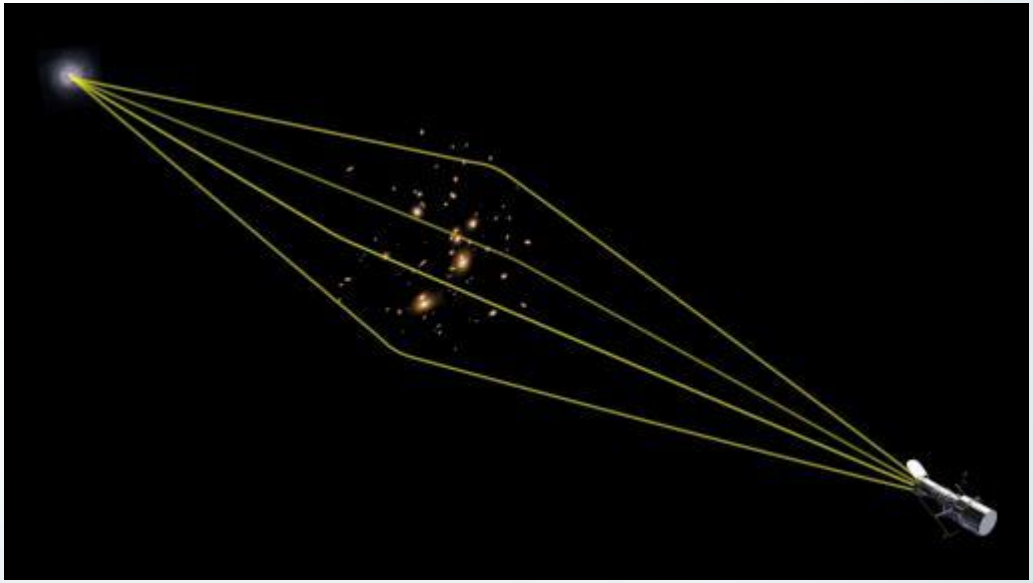


Gravitational lensing by the mammoth galaxy cluster Abell 2744 produced three separate images of the extremely distant galaxy. In each of these images, labeled "a", "b", and "c", the galaxy appears as just a tiny red blob. Credit: NASA, ESA, A. Zitrin (California Institute of Technology), and J. Lotz, M. Mountain, A. Koekemoer, and the HFF Team (STScI)

Seeing Farther with Cosmic Lenses

- Einstein's general relativity describes how mass warps space.
- A massive cluster of galaxies can warp space enough to bend light that passes through it, thus acting like a giant lens in space.
- The light from a distant galaxy can be distorted, magnified, and split into multiple images by the galaxy cluster.
- Without the help of "gravitational lensing", this newly discovered extremely distant galaxy is too faint for Hubble to observe.

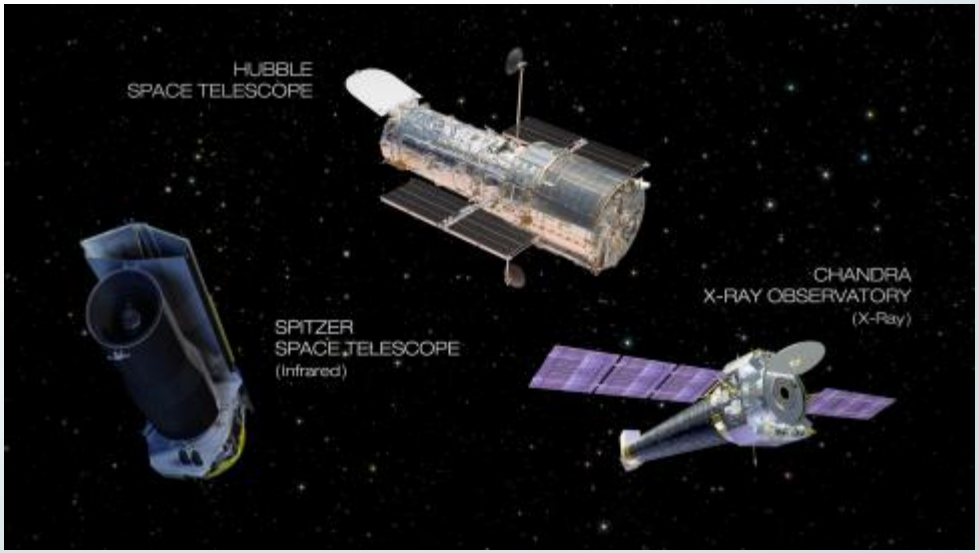




On the left is the Hubble image of galaxy cluster Abell 2744. The three arrows point out where the images of the extremely distant galaxy were observed. On the right is an illustration of gravitational lensing by a galaxy cluster. The light from a distant galaxy is re-directed by the warped space around the cluster. Credit (left): NASA, ESA, and J. Lotz, M. Mountain, A. Koekemoer, and the HFF Team (STScI.) Credit (right): G. Bacon & F. Summers (STScI).

The Frontier Fields

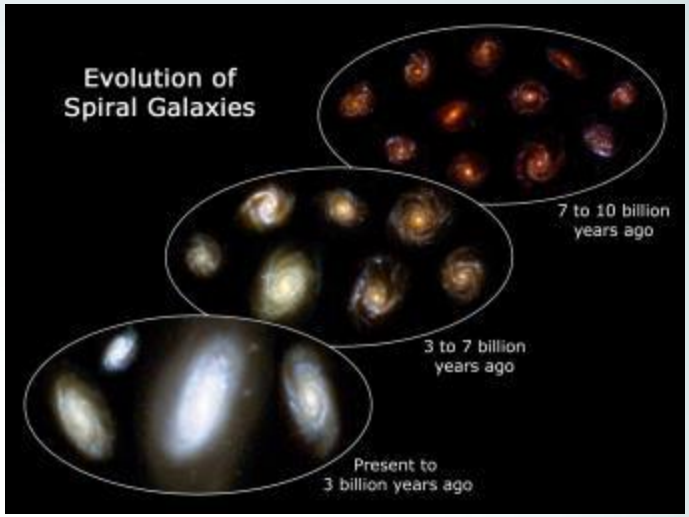
- NASA's three Great Observatories – the Hubble Space Telescope, the Spitzer Space Telescope, and the Chandra X-ray Observatory – have teamed up on an ambitious project to study the distant universe.
- The Frontier Fields project is deeply observing six massive galaxy clusters, looking for extremely distant galaxies that have been gravitationally lensed.
- The project is also observing six new (non-cluster) deep fields to improve our statistical sample of the distant and early universe.
- Other science from the Frontier Fields project include detailed mapping of the mass distributions in the galaxy clusters and searches for supernova explosions in distant galaxies.



The three NASA Great Observatories participating in the Frontier Fields project. Credit: NASA, ESA, and F. Summers, B. Lawton, M. Lussier, G. Bacon, and D. Coe (STScI).

Probing the Development of Galaxies

- Because looking out into space is also looking back into time, distant galaxies tell us about the history of the universe.
- Astronomers have observed how galaxies develop over billions of years.
- This extremely distant galaxy helps examine the first billion years of the universe and the initial formative stages of galaxies.
- This galaxy provides evidence of an abundant population of extremely small and faint galaxies at around 500 million years after the Big Bang.
- Cosmological redshift stretches the light of these most distant and earliest galaxies well into infrared wavelengths.



Previous deep observations have revealed the changes in galaxy size, shape, color, and structure over time. This diagram presents groups of selected spiral galaxies at different distances from a Hubble survey. Credit: NASA, ESA, F. Summers, and Z. Levay (STScI).

- NASA's next Great Observatory, the James Webb Space Telescope, will be able to do the high-resolution, infrared light observations required to more completely study the epoch of galaxy formation.

Resources

Hubble Press Release
Hubble Finds Extremely Distant Galaxy through Cosmic Magnifying Glass
http://hubblesite.org/newscenter/archive/releases/2014/39/

Frontier Fields Blog Post
Gravitational Forensics: Astronomers Discover a Distant Galaxy in the Frontier Fields
http://frontierfields.org/2014/11/12/grav_forensics/

Hubble Hangout (A webcast discussion with researchers)
Hubble Finds Extremely Distant Galaxy in Gravitational Lens
https://www.youtube.com/watch?v=xpNswEjFh_A

Journal Article
A Geometrically Supported z ~ 10 Candidate Multiply Imaged by the Hubble Frontier Fields Cluster A2744
Zitrin, A., et al. 2014, ApJL, 793, L12
http://hubblesite.org/pubinfo/pdf/2014/39/pdf.pdf

Multiple Views of an Extremely Distant Galaxy

BONUS CONTENT

Galaxy Cluster Abell 2744

Credit: NASA, ESA, and J. Lotz, M. Mountain, A. Koekemoer, and the HFF Team (STScI)

Explore the Frontier Fields Project

Frontier Fields Overview Video

Frontier Fields: Exploring the Depths of the Universe

http://hubblesite.org/newscenter/archive/releases/2014/01/video/a/

Hubble Frontier Fields Public Blog

Frontier Fields: Pushing the Limits of the Hubble Space Telescope

http://frontierfields.org/

Hubble Frontier Fields Science Blog

Frontier Fields: A Sneak Peek at the First Billion Years of the Universe

https://blogs.stsci.edu/hstff/

Hubble Frontier Fields Science Page

Hubble Space Telescope Frontier Fields

http://www.stsci.edu/hst/campaigns/frontier-fields/