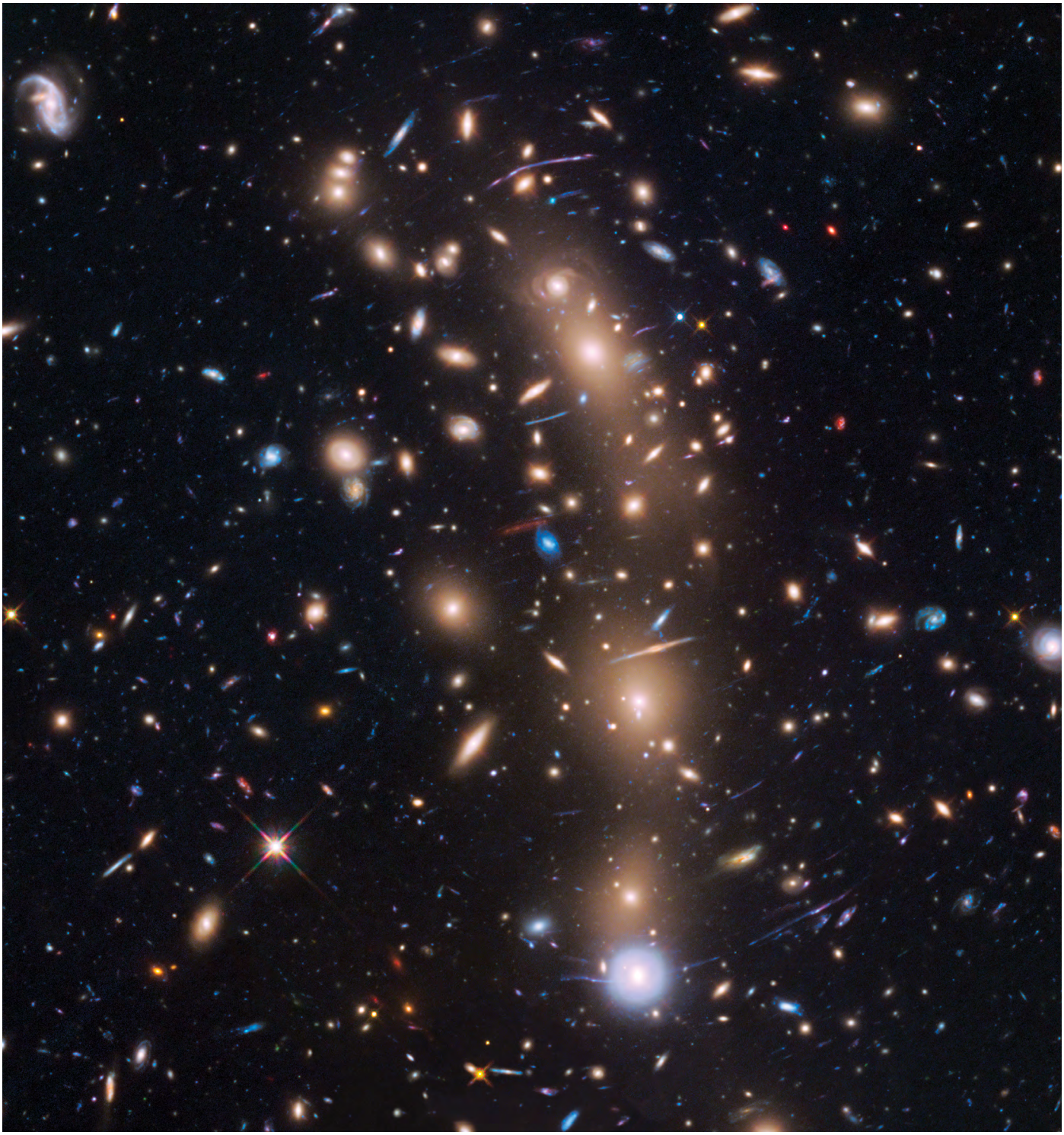
Galaxy Cluster MACS J0416.1-2403

National Aeronautics and Space Administration



Hubble Sees the Distant Universe with Nature's Cosmic Lens

The Hubble Space Telescope is often called a cosmic time machine because when it looks to the far horizon of space, it reveals distant galaxies in the early universe. The light from these galaxies has taken many billions of years to cross space and is just arriving at Earth now, allowing us to see them as they appeared in their formative years.

However, some galaxies are so distant that even Hubble needs a boost from nature to see them. That help comes in the form of massive clusters of galaxies, which act like giant cosmic lenses in space. One such cluster is MACS J0416.1-2403, shown on the front of this lithograph. Its gravity is so powerful that it bends, magnifies, and brightens the light from objects far behind it. This phenomenon is called gravitational lensing.

Gravitational lensing acts like a funhouse mirror, causing the light from background objects to appear as arcs and streaks within the image. Many of these features appear along the line of the yellow cluster galaxies in MACS J0416.

One of the faintest objects ever seen in the early universe was found in MACS J0416, using the combined power of Hubble and NASA's Spitzer Space Telescope. The galaxy is seen as it was 13.4 billion years ago, just 400 million years after the big bang. Without the light-amplifying power of lensing, such distant background objects could not be detected by present-day space observatories.

Most of MACS J0416's lensing power comes from what we cannot see – a substance called dark matter. This invisible form of matter makes up most of the universe's mass. Dark matter is the glue that holds galaxies and clusters of galaxies together.

MACS J0416 is 4 billion light-years away and is one of six massive lensing clusters analyzed in the Hubble Frontier Fields survey.

Image Credits: NASA, ESA, and L. Infante (Pontificia Universidad Católica de Chile);

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Because dark matter cannot be seen, astronomers must use indirect ways to detect it. The red circles in the image of MACS J0416 at left showcase some of the stretched images of background galaxies whose light is magnified by the cluster's gravity. The number, size, and distribution of these lensed arcs help astronomers measure the gravity of the cluster, including the dark matter. Scientists used computer modeling to create a dark matter map of MACS J0416, as shown on the image at right. The ghostly blue glow represents the amount of dark matter spread throughout the cluster, based on the observed gravitational lensing. Dark matter maps give astronomers insight into whether the distribution of this invisible substance is smooth or clumpy, and how this texture correlates with galaxy distribution.

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VOCABULARY

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

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.

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