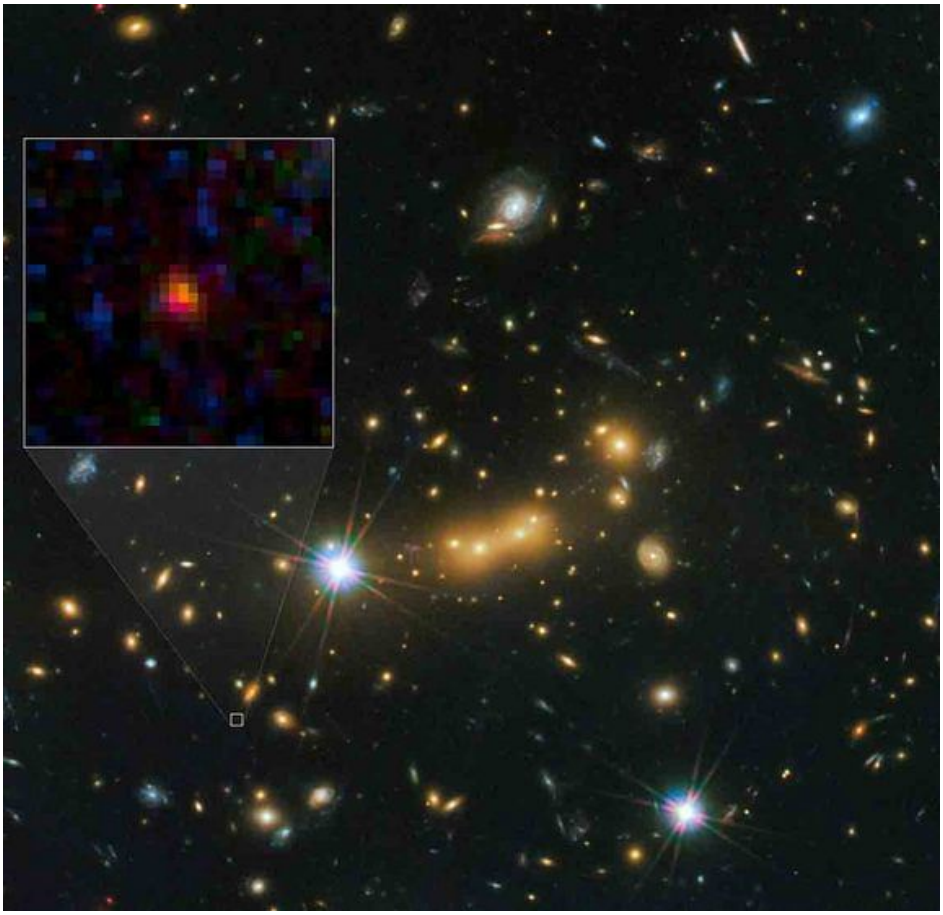
Farthest Known Galaxy in the Universe Discovered

By Clara Moskowitz | SPACE.com



A new celestial wonder has stolen the title of most distant object ever seen in the universe, astronomers report.

The new record holder is the galaxy MACS0647-JD, which is about 13.3 billion light-years away. The universe itself is only 13.7 billion years old, so this galaxy's light has been traveling toward us for almost the whole history of space and time.

Astronomers spotted the object using NASA's Hubble and Spitzer space telescopes, with the aid of a naturally occurring cosmic zoom lens as well. This lens is a huge cluster of galaxies whose collective gravity warps space-time, producing what's called a gravitational lens. As the distant galaxy's light traveled through this lens on its way to Earth, it was magnified.

"This cluster does what no manmade telescope can do," Marc Postman of the Space Telescope Science Institute in Baltimore, Md., said in a statement unveiling the discovery today (Nov. 15). "Without the magnification, it would require a Herculean effort to

observe this galaxy." Postman leads the Cluster Lensing And Supernova Survey with Hubble (CLASH), which performed the study.

The distant galaxy is just a tiny blob, and is much smaller than our own Milky Way, researchers said. The object is very young, and it also dates from an epoch when the universe itself was still a baby, just 420 million years old, or 3 percent of its present age.

The mini galaxy is less than 600 light-years wide; for comparison, the Milky Way is 150,000 light-years across. Astronomers think MACS0647-JD may eventually combine with other small galaxies to create a larger whole.

"This object may be one of many building blocks of a galaxy," said the Space Telescope Science Institute's Dan Coe, who led the study of this particular galaxy. "Over the next 13 billion years, it may have dozens, hundreds, or even thousands of merging events with other galaxies and galaxy fragments."

Astronomers are continually spotting ever farther galaxies as their observation techniques and tools improve. The last object to hold the title of farthest thing ever seen was the galaxy SXDF-NB1006-2, which lies 12.91 billion light-years from Earth. That object was sighted by the Subaru and Keck Telescopes in Hawaii.

The CLASH survey, which discovered the new galaxy, MACS0647-JD, is working on a cosmic census of 25 large galaxy clusters using Hubble's Wide Field Camera 3 and Advanced Camera for Surveys. Those instruments first spotted MACS0647-JD, and then the Spitzer telescope, which observes in infrared light, confirmed the object was as far away as it appeared.

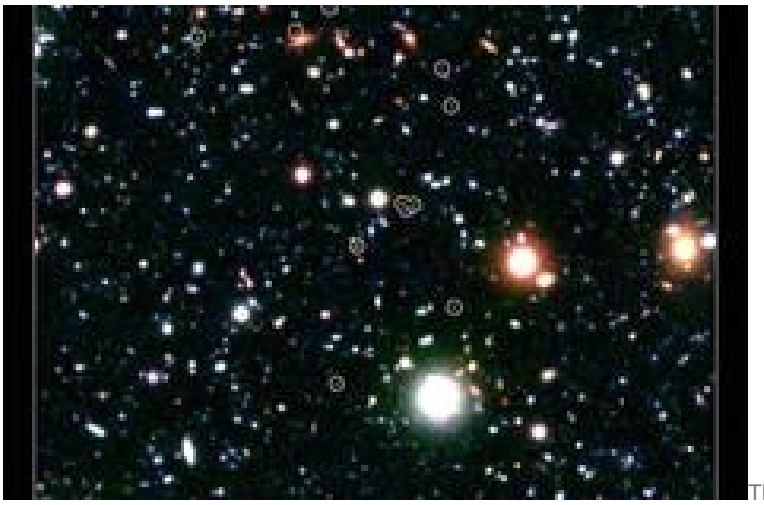
The discovery will be detailed in a paper published in the Dec. 20 issue of The Astrophysical Journal.

Universe – Overview

The universe was born with the Big Bang as an unimaginably hot, dense point. When the universe was just 10^{-34} of a second or so old — that is, a hundredth of a billionth of a trillionth of a trillionth of a second in age — it experienced an incredible burst of expansion known as inflation, in which space itself expanded faster than the speed of light. During this period, the universe doubled in size at least 90 times, going from subatomic-sized to golf-ball-sized almost instantaneously.

After inflation, the growth of the universe continued, but at a slower rate. As space expanded, the universe cooled and matter formed. One second after the Big Bang, the universe was filled with neutrons, protons, electrons, anti-electrons, photons and neutrinos.

How the Universe Came to Be

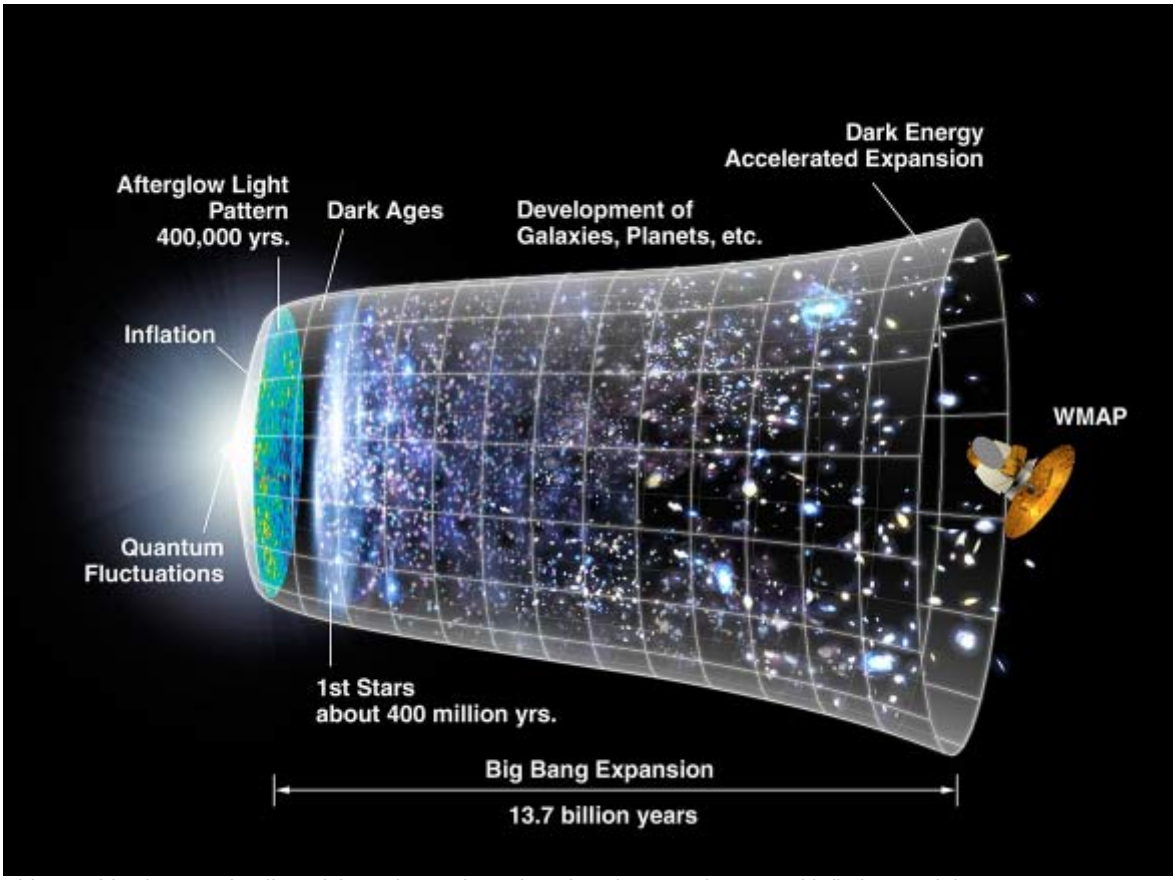


This extremely distant protocluster represents a group of galaxies forming very early in the universe, about only a billion years after the Big Bang. *Credit: Subaru/ P. Capak (SSC/Caltech)*

The broadly accepted theory for the origin and evolution of our universe is the Big Bang model, which states that the universe began as an incredibly hot, dense point roughly 13.7 billion years ago. So, how did the universe go from being fractions of an inch (a few millimeters) across to what it is today?

Here is a breakdown of the Big Bang to now in 10 easy-to-understand steps.

It took quite a bit more than seven days to create the universe as we know it today. SPACE.com looks at the mysteries of the heavens in our eight-part series: The History & Future of the Cosmos. This is Part 3 in that series.



This graphic shows a timeline of the universe based on the Big Bang theory and inflation models.
Credit: NASA/WMAP

How It All Started

The Big Bang was not an explosion in space, as the theory's name might suggest. Instead, it was the appearance of space everywhere in the universe, researchers have said. According to the Big Bang theory, the universe was born as a very hot, very dense, single point in space.

Cosmologists are unsure what happened before this moment, but with sophisticated space missions, ground-based telescopes and complicated calculations, scientists have been working to paint a clearer picture of the early universe and its formation. [Full Story]

A key part of this comes from observations of the cosmic microwave background, which contains the afterglow of light and radiation left over from the Big Bang. This relic of the Big Bang pervades the universe and is visible to microwave detectors, which allows scientists to piece together clues of the early universe.

In 2001, NASA launched the Wilkinson Microwave Anisotropy Probe (WMAP) mission to study the conditions as they existed in the early universe by measuring radiation from the cosmic microwave background. Among other discoveries, WMAP was able to determine the age of the universe — about 13.7 billion years old.

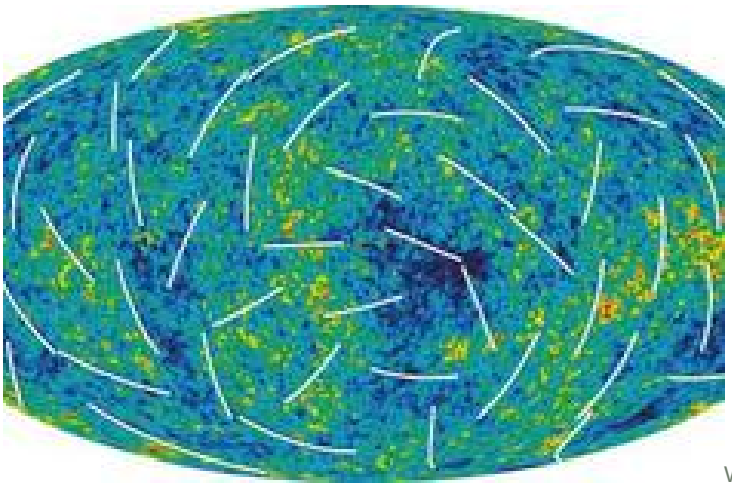
This view of nearly 10,000 galaxies is called the Hubble Ultra Deep Field. The snapshot includes galaxies of various ages, sizes, shapes, and colors. The smallest, reddest galaxies, about 100, may be among the most distant known, existing when the universe was just 800 million years old. The nearest galaxies--the larger, brighter, well-defined spirals and ellipticals--thrived about 1 billion years ago, when the cosmos was 13 billion years old.
Credit: NASA, ESA, and S. Beckwith (STScI) and the HUDF Team

The Universe's First Growth Spurt

When the universe was very young — something like a hundredth of a billionth of a trillionth of a trillionth of a second (whew!) — it underwent an incredible growth spurt. During this burst of expansion, which is known as inflation, the universe grew exponentially and doubled in size at least 90 times.

"The universe was expanding, and as it expanded, it got cooler and less dense," David Spergel, a theoretical astrophysicist at Princeton University in Princeton, N.J., told SPACE.com.

After inflation, the universe continued to grow, but at a slower rate. As space expanded, the universe cooled and matter formed.

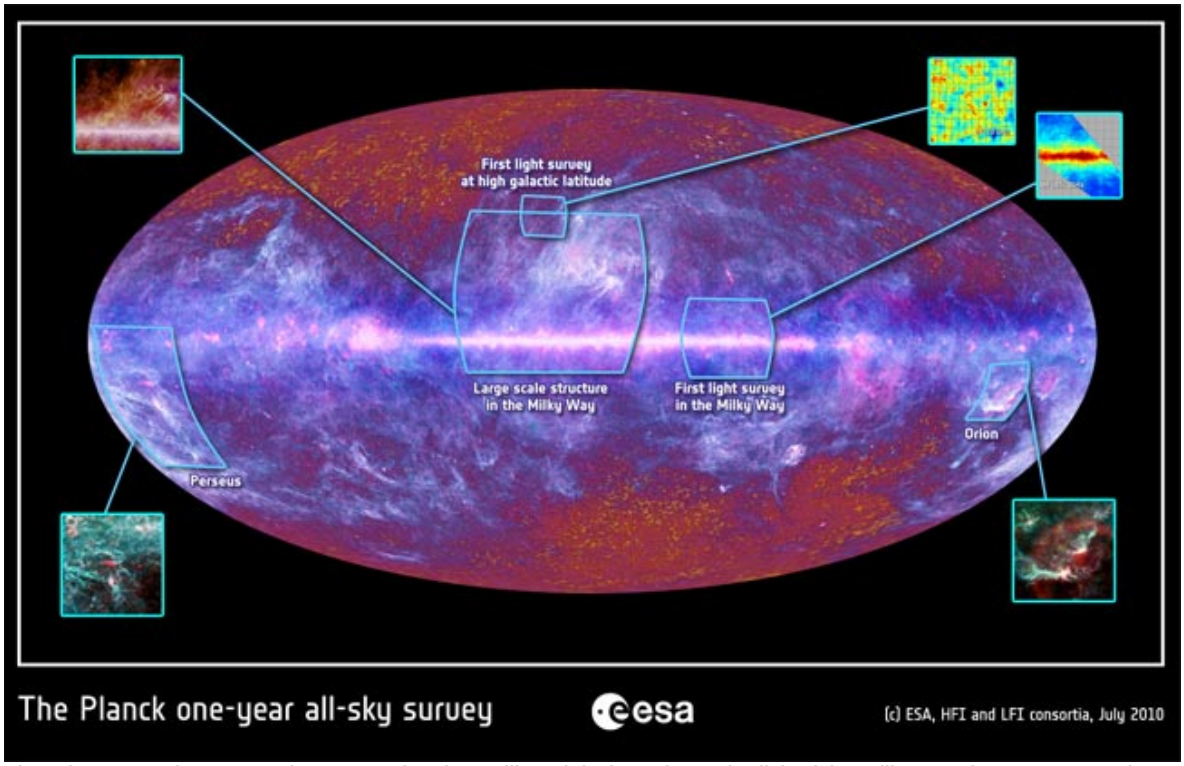


WMAP has produced a new, more detailed picture of the infant universe. Colors indicate "warmer" (red) and "cooler" (blue) spots. The white bars show the "polarization" direction of the oldest light. This new information helps to pinpoint when the first stars formed and provides new clues about events that transpired in the first trillionth of a second of the universe.
Credit: NASA/WMAP

Too Hot to Shine

Light chemical elements were created within the first three minutes of the universe's formation. As the universe expanded, temperatures cooled and protons and neutrons collided to make deuterium, which is an isotope of hydrogen. Much of this deuterium combined to make helium.

For the first 380,000 years after the Big Bang, however, the intense heat from the universe's creation made it essentially too hot for light to shine. Atoms crashed together with enough force to break up into a dense, opaque plasma of protons, neutrons and electrons that scattered light like fog.



The microwave sky as seen by ESA's Planck satellite. Light from the main disk of the Milky Way is seen across the center band, while radiation left over from the Big Bang is visible on the outskirts of the image
Credit: ESA/ LFI & HFI Consortia

Let There Be Light

About 380,000 years after the Big Bang, matter cooled enough for electrons to combine with nuclei to form neutral atoms. This phase is known as "recombination," and the absorption of free electrons caused the universe to become transparent. The light that was unleashed at this time is detectable today in the form of radiation from the cosmic microwave background.

Yet, the era of recombination was followed by a period of darkness before stars and other bright objects were formed.


The optical image that confirmed that 2XMM J083026+524133 is a distant cluster of galaxies, taken by the Large Binocular Telescope in Arizona. The X-ray emission from the cluster of galaxies is shown in blue at the centre of the image. The individual galaxies in the cluster are the small dots inside the blue glow.
Credit: ESA XMM-Newton/EPIC, LBT/LBC, AIP (J. Kohnert)

Emerging from the Cosmic Dark Ages

Roughly 400 million years after the Big Bang, the universe began to come out of its dark ages. This period in the universe's evolution is called the age of re-ionization.

This dynamic phase was thought to have lasted more than a half-billion years, but based on new observations, scientists think re-ionization may have occurred more rapidly than previously thought.

During this time, clumps of gas collapsed enough to form the very first stars and galaxies. The emitted ultraviolet light from these energetic events cleared out and destroyed most of the surrounding neutral hydrogen gas. The process of re-ionization, plus the clearing of foggy hydrogen gas, caused the universe to become transparent to ultraviolet light for the first time.

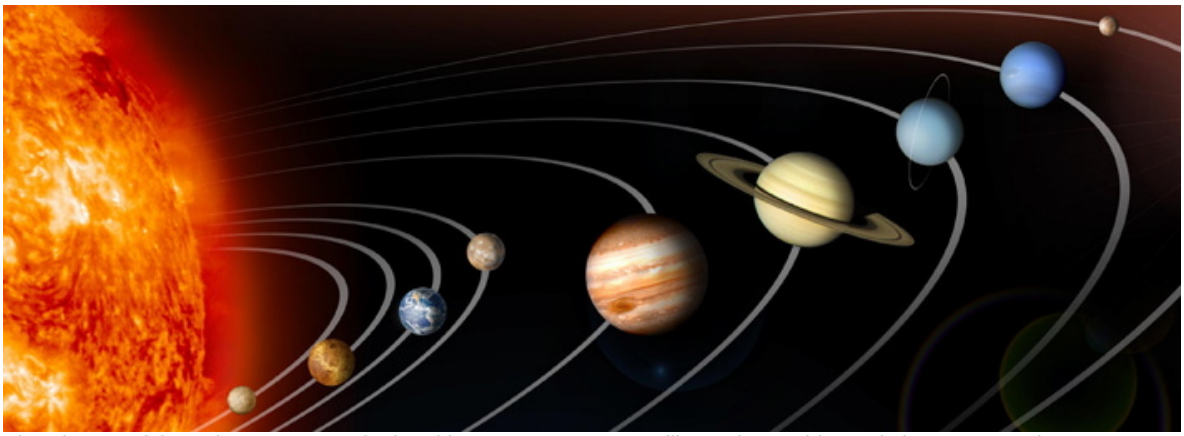

Friday, May 6, 2011: This Hubble Space Telescope image of the M15 Globular Cluster spans about 120 light years. Over 100,000 stars make up this relic from the early years of our galaxy, and the ball of stars continues to orbit the Milky Way's center. M15 lies about 35,000 light years away toward the constellation of the Winged Horse (Pegasus).

—Tom Chao
Credit: ESA, Hubble, NASA

More Stars and More Galaxies

Astronomers comb the universe looking for the most far-flung and oldest galaxies to help them understand the properties of the early universe. Similarly, by studying the cosmic microwave background, astronomers can work backwards to piece together the events that came before.

Data from older missions like WMAP and the Cosmic Background Explorer (COBE), which launched in 1989, and missions still in operation, like the Hubble Space Telescope, which launched in 1990, all help scientists try to solve the most enduring mysteries and answer the most debated questions in cosmology.

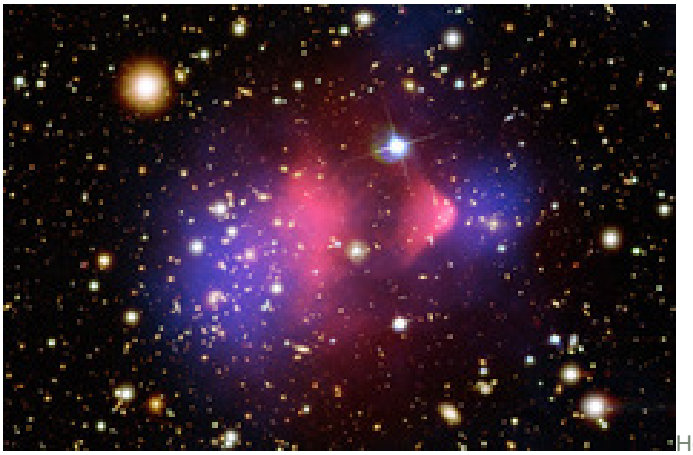


The planets of the solar system as depicted by a NASA computer illustration. Orbits and sizes are not shown to scale.
Credit: NASA

Birth of Our Solar System

Our solar system is estimated to have been born a little after 9 billion years after the Big Bang, making it about 4.6 billion years old. According to current estimates, the sun is one of more than 100 billion stars in our Milky Way galaxy alone, and orbits roughly 25,000 light-years from the galactic core.

Many scientists think the sun and the rest of our solar system was formed from a giant, rotating cloud of gas and dust known as the solar nebula. As gravity caused the nebula to collapse, it spun faster and flattened into a disk. During this phase, most of the material was pulled toward the center to form the sun.



Hot gas detected by Chandra in X-rays is seen as two pink clumps that contain most of the normal matter in the two clusters. The bullet-shaped clump on the right is hot gas from one cluster, which passed through the hot gas from the other larger cluster. Other telescopes were used to detect the bulk of the matter in the clusters, which turns out to be dark matter (highlighted in blue).
Credit: X-ray: NASA/CXC/CfA/M.Markevitch et al.; Optical: NASA/STScI; Magellan/U.Arizona/D.Clowe et al.; Lensing Map: NASA/STScI; ESO WFI; Magellan/U.Arizona/D.Clowe et al.

The Invisible Stuff in the Universe

In the 1960s and 1970s, astronomers began thinking that there might be more mass in the universe than what is visible. Vera Rubin, an astronomer at the Carnegie Institution of Washington, observed the speeds of stars at various locations in galaxies.

Basic Newtonian physics implies that stars on the outskirts of a galaxy would orbit more slowly than stars at the center, but Rubin found no difference in the velocities of stars farther out. In fact, she found that all stars in a galaxy seem to circle the center at more or less the same speed. [Full Story]

This mysterious and invisible mass became known as dark matter. Dark matter is inferred because of the gravitational pull it exerts on regular matter. One hypothesis states the mysterious stuff could be formed by exotic particles that don't interact with light or regular matter, which is why it has been so difficult to detect.

Dark matter is thought to make up 23 percent of the universe. In comparison, only 4 percent of the universe is composed of regular matter, which encompasses stars, planets and people.

This NASA Hubble Space Telescope image shows the distribution of dark matter in the center of the giant galaxy cluster Abell 1689, containing about 1,000 galaxies and trillions of stars.

Credit: NASA, ESA, D. Coe (NASA Jet Propulsion Laboratory/California Institute of Technology, and Space Telescope Science Institute), N. Benitez (Institute of Astrophysics of Andalusia, Spain), T. Broadhurst (University of the Basque Country, Spain), and H. Ford

The Expanding and Accelerating Universe

In the 1920s, astronomer Edwin Hubble made a revolutionary discovery about the universe. Using a newly constructed telescope at the Mount Wilson Observatory in Los Angeles, Hubble observed that the universe is not static, but rather is expanding.

Decades later, in 1998, the prolific space telescope named after the famous astronomer, the Hubble Space Telescope, studied very distant supernovas and found that, a long time ago, the universe was expanding more slowly than it is today. This discovery was surprising because it was long thought that the gravity of matter in the universe would slow its expansion, or even cause it to contract.

Dark energy is thought to be the strange force that is pulling the cosmos apart at ever-increasing speeds, but it remains undetected and shrouded in mystery. The existence of this elusive energy, which is thought to make up 73 percent of the universe, is one of the most hotly debated topics in cosmology.

Image of X-Ray and optical data from Supernova 1E 0102.2-7219. The light coming from distant supernovas helps astrophysicists map out the universe and determine its rate of expansion.
Credit: NASA

Still a Lot to Learn

While much has been discovered about the creation and evolution of the universe, there are enduring questions that remain unanswered. Dark matter and dark energy remain two of the biggest mysteries, but cosmologists continue to probe the universe in hopes of better understanding how it all began.