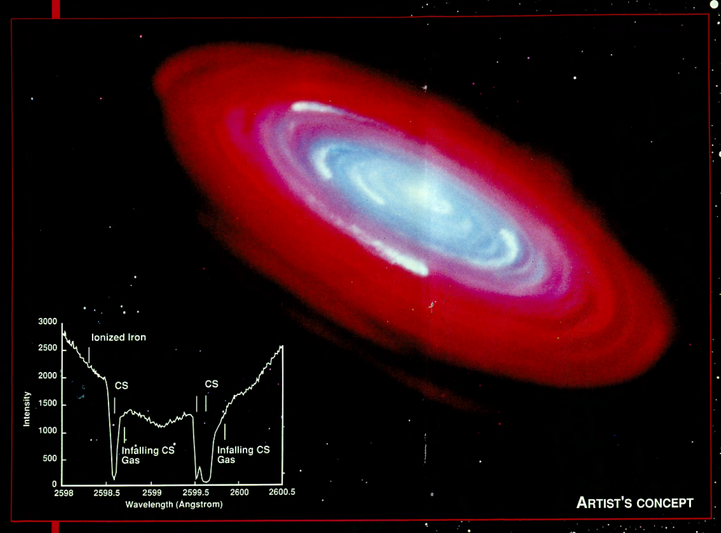
Hubble Space Telescope

A New View of the Universe - 1991

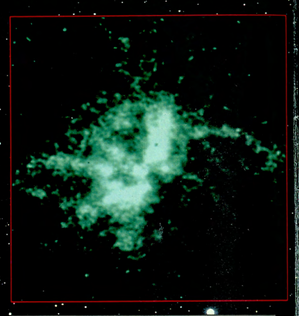
STARS



ARTIST'S CONCEPT

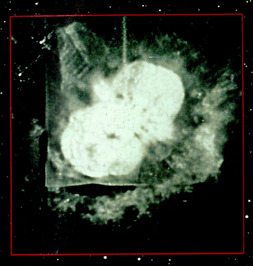
Beta Pictoris

The detailed analysis of light from nearby star Beta Pictoris reveals a complex disk of rotating gas and dust — conditions that may have existed during our Solar System's formative years.



Planetary Nebula N66

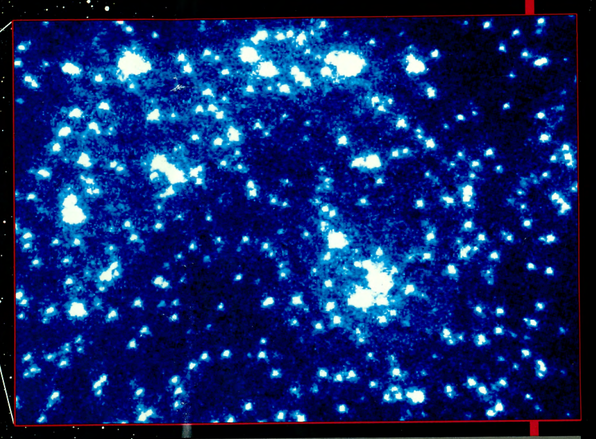
The HST image of planetary nebula N66, a cloud of gas that has been ejected from a dying star, reveals complex structures and details that have never before been seen so clearly in a galaxy beyond the Milky Way. N66 is located in the Large Magellanic Cloud.



Eta Carinae

HST images reveal new details about the structure of Eta Carinae, one of the most unstable and luminous stars in the Milky Way.

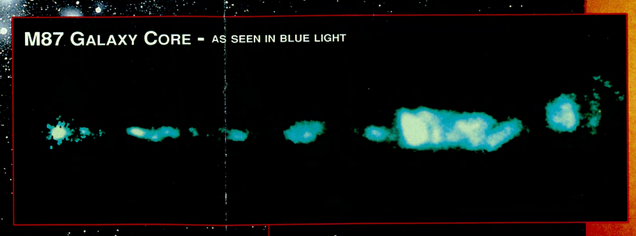
GROUND-BASED VIEW



47 Tucanae

HST observations of a very old star cluster, 47 Tucanae, reveal a surprisingly high concentration of hot, young stars. Collisions between the older stars may have created the younger ones.

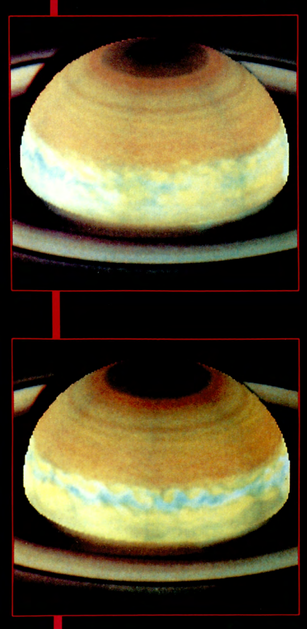
GALAXIES

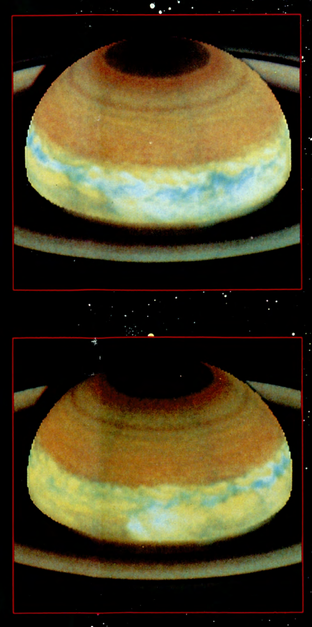


M87 Galaxy Core

The extremely bright core and accompanying jet found in M87 suggest the presence of a massive black hole, which is drawing the stars into the center of the galaxy and ejecting enormous jets of luminous gas.

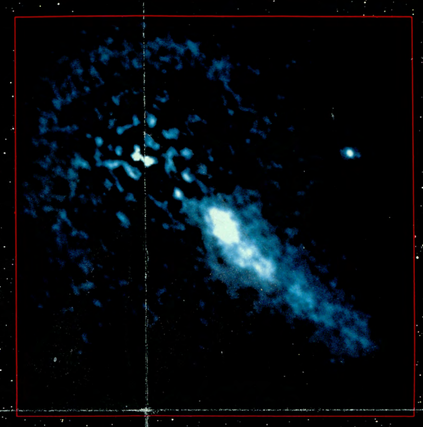
GROUND-BASED VIEW OF M87





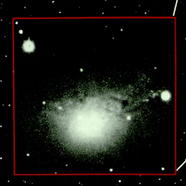
Saturn Storm

These four images, recorded on consecutive HST orbits, were taken from a time-lapse film that shows the progress of a major storm system on Saturn.

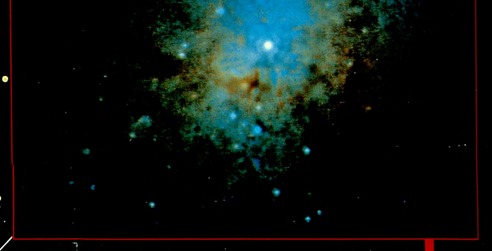


Braided Galactic Jet

A plasma jet ejected from the core of radio galaxy 3C 66B appears in an HST image to be braided, like a twisted pair of wires. Until now, such a structure had not been seen in an optical jet.



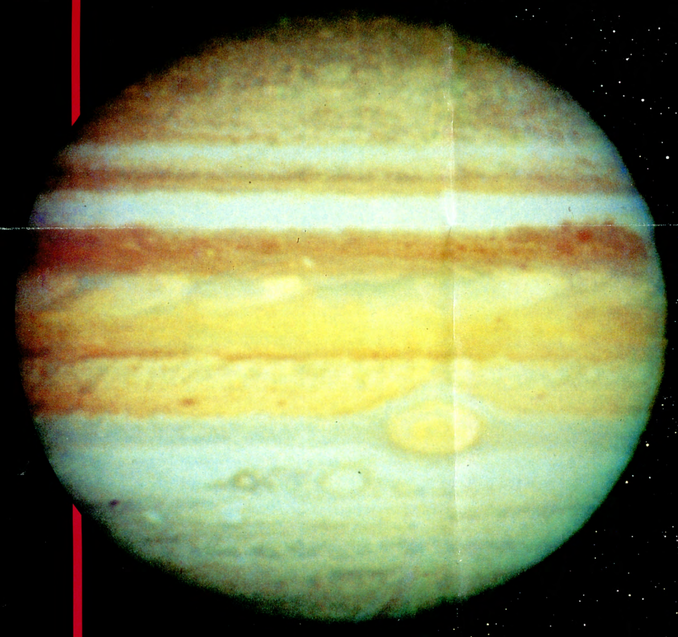
GROUND-BASED VIEW



NGC 1275 Globular Clusters

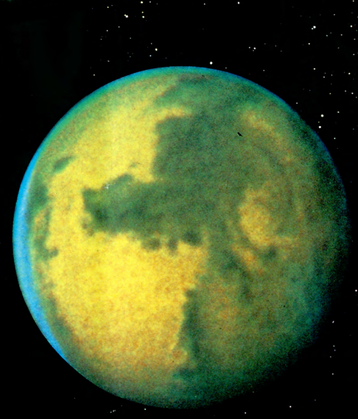
HST detected nearly 50 young star clusters at the center of NGC 1275. These objects may be globular clusters in the process of forming — an event never before seen.

THE UNIVERSE



Color Jupiter

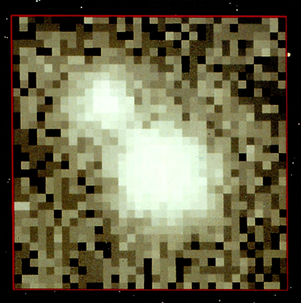
HST images of Jupiter reveal details of its complex and turbulent atmosphere that change from minute to minute.



Mars

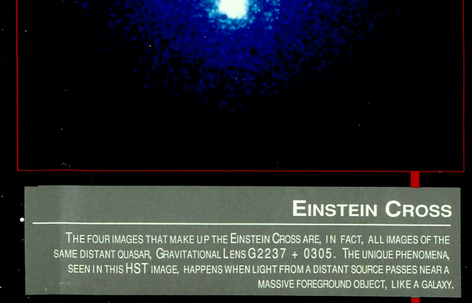
HST images obtained from low-Earth orbit can be used to monitor daily weather changes on Mars.

PLANETS



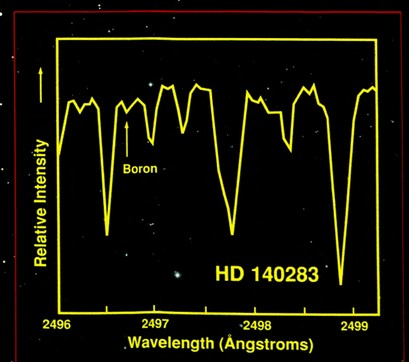
Gravitational Lens

According to Einstein's relativity laws, gravitational fields of intervening galaxies will bend light from distant quasars to produce multiple images of the quasars. The effect, Gravitational lensing, is confimed in this HST image of Quasar 1208 + 101.



Einstein Cross

The four images that make up the Einstein Cross are, in fact, all images of the same distant quasar, Gravitational Lens G2237 + 0305. The unique phenomena, seen in this HST image, happens when light from a distant source passes near a massive foreground object, like a galaxy.



The Creation of Elements

HST spectral measurements of an ancient star, HD 140283 located 100 light years away, revealed the rare element boron. The element may date back to the creation of the Milky Way, or it may be much older, dating back to the birth of the Universe.

SPACE TELESCOPE SCIENCE INSTITUTE

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Hubble Space Telescope
A New View of the Universe - 1991

Stars

Stars are born in great clouds of gas. They produce energy by nuclear fusion. Some die in cataclysmic explosions called supernovae. NASA's Hubble Space Telescope is providing new insights into the lifecycles of the stars.

Beta Pictoris

Data recorded by HST's Goddard High Resolution Spectrograph (GHRS) are enabling detailed studies of the structure and dynamics of a gas cloud in orbit around the star Beta Pictoris. Earlier ground- and space-based observations yielded evidence that a protoplanetary disk of hot gas and dust nearly 80 billion miles across surrounds this star. Observations made by the GHRS on two separate occasions, just 23 days apart, detected a dramatic change in the structure of the disk's inner core. The spectrograms showed the telltale dips caused by the heated gas. They also showed that the dips had changed their shapes over this 23-day period. Astronomers interpret this as evidence that the core of the disk, about the diameter of Earth's orbit, contains clumps of circumstellar (CS) gas that are spiraling into the star, leaving behind comet-like streamers. Further studies of these clumps might uncover new clues on how planets are formed and details about the planet-forming environment.

Eta Carinae

One of the most massive and luminous stars in the Milky Way galaxy is Eta Carinae, located 9,000 light years away. This star has more than 100 times the mass and 4 million times the brilliance of our Sun. This variable star flared up in 1843, briefly shining as the second brightest star in the night sky. The flare-up ejected a shell of gas that now extends more than 4 trillion miles across. By using images obtained by HST's Wide Field/Planetary Camera, astronomers have discovered details of how the eruption took place. For instance, some of the gas was blown out of the stellar poles at speeds of 3 million miles per hour, forming an unusual jet-like feature. Stellar jets are often associated with star-forming regions where a disk of orbiting gas helps to focus or shape outflowing gas. No such disk has been detected around Eta Carinae, suggesting that some new process might be producing its polar jet.

47 Tucanae

HST's Faint Object Camera (provided by the European Space Agency) produced this high-resolution ultraviolet image of the core of the globular cluster 47 Tucanae, 15,000 light years away. The image is remarkable because it reveals a concentration of hot blue stars, called blue stragglers. Scientists did not expect to find them there because globular clusters typically contain up to 10 million very old stars that have evolved into cooler red giants. In fact, star formation within these clusters is believed to have ceased some 15 billion years ago. However, based on HST observations that resolved 21 massive blue stragglers near the core of 47 Tucanae, astronomers now theorize that blue stragglers may be formed by mergers of old red stars, yielding massive new hot stars or double (binary) star systems.

Planetary Nebula N66

Although massive stars end their lives in spectacular explosions called supernovae, stars like our own Sun die a far less violent death. As their dense, fuel-depleted cores collapse under their own weight, their outer layers expand into space, forming smoke-ring-like nebulae several light years across. Thousands of these planetary nebulae have been cataloged within the Milky Way galaxy, where their proximity to the Sun allows detailed study and imaging. HST observations of the planetary nebula N66, in the Large Magellanic Cloud 170,000 light years distant, make it possible to compare planetary nebulae in the Milky Way with those in a nearby galaxy. This image, obtained by the Faint Object Camera, reveals complex structures within the nebula as small as 0.08 light year across. None of these features had ever been seen with ground-based telescopes. At the center is the dense, white dwarf core of the original star glowing brilliantly at visible and ultraviolet wavelengths.

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HUBBLE SPACE TELESCOPE

Space Shuttle Discovery deployed the Hubble Space Telescope on April 24, 1990, placing the long-awaited observatory in an orbit 610 kilometers (380 miles) above Earth's surface. Designed to study the universe in near-infrared, visible and ultraviolet wavelengths, this school bus-sized observatory is the largest telescope ever placed in orbit. HST has firmly established itself as a uniquely powerful observatory and has contributed significantly to scientists' understanding of the cosmos.

Galaxies

Galaxies are vast collections of a few billion to more than a trillion stars. NASA's Hubble Space Telescope is probing galactic structure as never before, providing intriguing evidence of massive black holes in galactic centers.

The Core and Jet of M87

Some of the most enigmatic phenomena in the Universe take place within the central cores of active galaxies, holding millions of stars in a region no more than a few light years across. The giant elliptical galaxy Messier 87 in the constellation Virgo, 52 million light years away, is the nearest of these galaxies. From within its core, a thin jet of hot plasma held together by strong magnetic fields extends nearly 5,000 light years into space. Astronomers speculate that M87 and other galaxies like it harbor massive black holes that trigger the ejection of great jets of heated gas at nearly the speed of light.

HST observations of M87 have recently uncovered evidence suggesting the presence of a massive black hole nearly 3 billion times the mass of the Sun, lurking within the galactic core. A bright, pinpoint nucleus indicates a rising concentration of matter consistent with the black hole model. "It looks like a duck, but we haven't heard it quack yet," said Hubble astronomer Tod Lauer of the National Optical Astronomy Observatories. The black hole may "quack" when HST — with its spherical aberration corrected during a servicing mission by Shuttle astronauts — takes critical spectral measurements of the galaxy's crowded core. The two images were produced by the Wide Field/Planetary Camera (in red light) and the Faint Object Camera (in blue light).

NGC 1275

NGC 1275 is located in the constellation Perseus, 200 million light years away. Its chaotic appearance has led many to believe that it was involved in some spectacular galaxy-altering event more than 100 million years ago. Wide Field/Planetary Camera observations of this galaxy's central region have revealed more than 50 massive and luminous star clusters that may be related to the so-called globular clusters in the Milky Way, but they are much younger. Globular clusters are aggregations of up to 10 million stars packed within a region less than 100 light years across. In the Milky Way, these clusters are typically more than 8-10 billion years old. Understanding the origin of these clusters has been hampered by the lack of any young globulars to study in detail. The proto-globular clusters in NGC 1275 may fill an important gap in understanding the evolution of star systems.

Braided Galactic Jet

HST's Faint Object Camera (built by the European Space Agency) produced this image of a 10,000 light year long plasma jet emanating from the core of galaxy 3C 66B, 270 million light years away. The optical jet, produced by energetic activity in the galactic core, consists of two spiral filaments of plasma. Notable details of the jet are its braided structure and two sharp bends and kinks 3,000 and 8,000 light years out from the core. The kinks may be produced by fluctuations in the energy output from the core, a complex magnetic field around the jet, or collisions with dense regions of interstellar gas. Astronomers believe that a supermassive black hole at the center of 3C 66B may be the source powering the jet. Such jets are typically detectable only at radio wavelengths.

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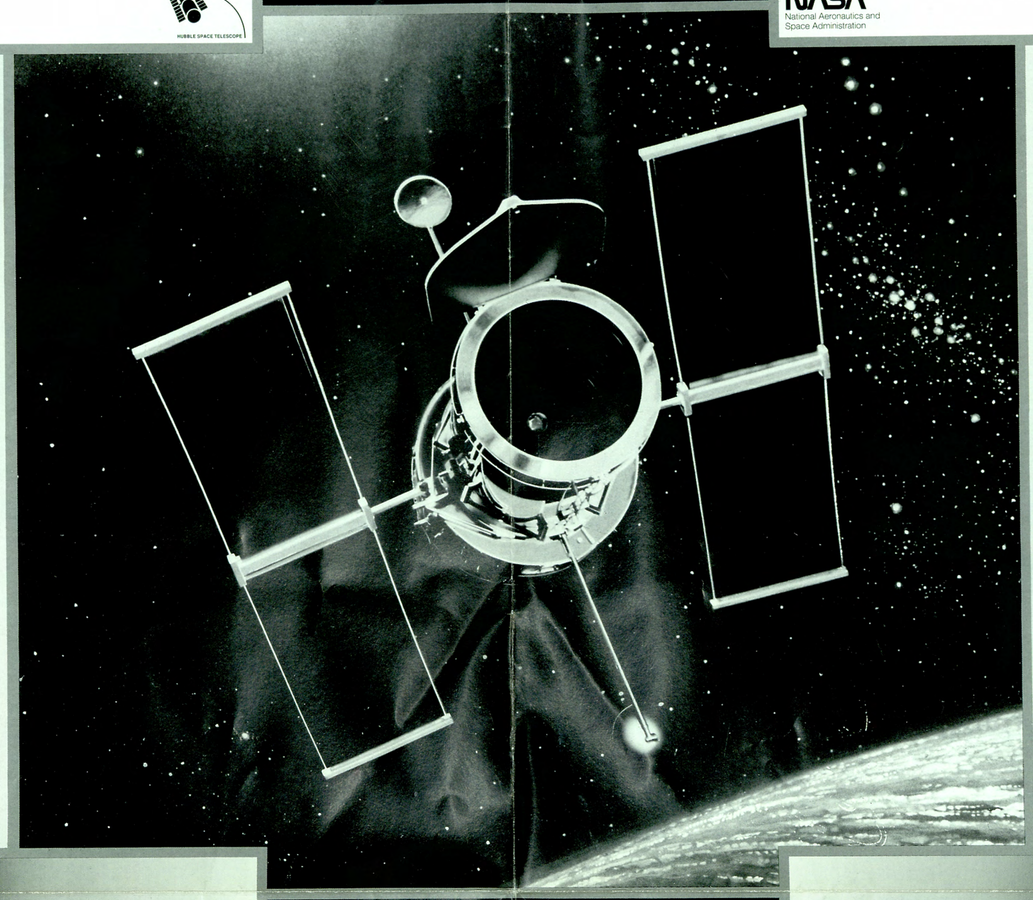

Planets

High-resolution imaging using NASA's Hubble Space Telescope allows detailed study of the planets, including the monitoring of planetary weather.

Saturn Storm

HST's Wide Field/Planetary Camera produced these four images of Saturn, showing a rare mid-latitude storm encircling the planet. The images are part of a sequence of 24 taken on November 17, 1990. The color of these images approximates true color, combining data from separate exposures taken through red, green, and blue filters.

Mars

HST's Wide Field/Planetary Camera recorded this image of Mars, in which atmospheric features and surface details as small as 32 miles across are clearly visible. This image is one of a series of preliminary observations yielding pictures of Mars sharper than any ever made from Earth. The observations are part of a long-term HST program to monitor seasonal atmospheric and surface changes on Mars. This color image of the planet is a composite of individual images recorded through red, green, and blue filters.

Color Jupiter

HST's Wide Field/Planetary Camera produced this first true color image of Jupiter in May 1991. All features visible in this image are cloud formations in Jupiter's atmosphere. The image is a composite of three pictures taken in red, green, and blue light. It is part of a sequence of 45 exposures taken over 32 hours as part of an ongoing study of clouds and wind on Jupiter. The planet's famous Great Red Spot, the vortex of a violent storm that has been visible for at least 150 years, can be seen at the lower right. The image has the same resolution as Voyager pictures taken five days before the spacecraft encountered Jupiter in 1979. This level of quality makes HST a uniquely useful tool for systematically studying Jupiter's weather — information that will help scientists better understand weather on Earth.

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The Universe

Fundamental questions about the origin, evolution and fate of our Universe remain enigmatic, but results from NASA's Hubble Space Telescope are helping scientists to refine and reshape their theories.

Gravitational Lens

Einstein's theory of general relativity predicted that gravitational fields are capable of altering the paths of light rays, in much the same way as an ordinary glass lens. This prediction was confirmed during a 1919 solar eclipse, when the positions of stars near the darkened solar limb were found to have shifted from their correct positions. In the 1980's, astronomers discovered the first examples of the "gravitational lens" phenomenon occurring outside our solar system. These objects typically consisted of multiple images of what appeared to be the same quasar spread over an area of a few arcseconds. Astronomers speculated that a faint but massive galaxy located in the direction of the more distant quasar was providing the gravitational field needed to bend and refocus its light. The European Space Agency's Faint Object Camera observations of the quasar 1208+101 show not one, but two images of the quasar. A systematic survey for more of these lenses was recently completed; however, far fewer new examples were found than had been predicted. These results are now being analyzed and may provide new clues to the nature of "dark matter" — a mysterious substance thought to be more common in the Universe than stars or galaxies.

Einstein Cross

HST's Faint Object Camera produced this picture — the most detailed ever taken — of the gravitational lens G2237+0305, also known as the Einstein Cross. Gravitational lensing occurs when light from a distant object passes through or close to a massive foreground object. This picture shows four images of the same distant quasar, produced by the gravitational lensing effect of a nearby galaxy. The diffuse central object in this picture is the bright central region of the lensing galaxy. The quasar in this picture is 8 billion light years away, and the galaxy is only 400 million light years away. This particular gravitational lens produces multiple images due to the alignment of the quasar and the galaxy with the line of sight to Earth.

Creation of the Elements

HST's Goddard High Resolution Spectrograph has detected the presence of boron in the 15-billion-year-old star HD 140283, 100 light years away in our Milky Way galaxy. (Electromagnetic radiation from boron falls within the ultraviolet region of the spectrum and, hence, is not detectable on Earth.) HD 140283, one of the oldest stars in the galaxy, predictably contains mostly primordial elements created in the Big Bang — hydrogen, helium, and lithium. The presence of boron is a surprise. Astronomers have theorized that this element (the fifth lightest) was formed when cosmic rays produced by highly energetic events, occurring early in the life of the galaxy, bombarded lighter elements. The discovery of boron in HD 140283 has prompted astronomers to speculate that the element also may have been created much earlier by some other process in the first moments of the creation of the Universe. The same theories apply to beryllium, the fourth-lightest element, which has also been detected in HD 140283. The HST spectra is seen over a Palomar Observatory sky survey plate. The brightest star is HD 140283.

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