Hubble's Advanced Camera for Surveys celebrates 20 years of discovery

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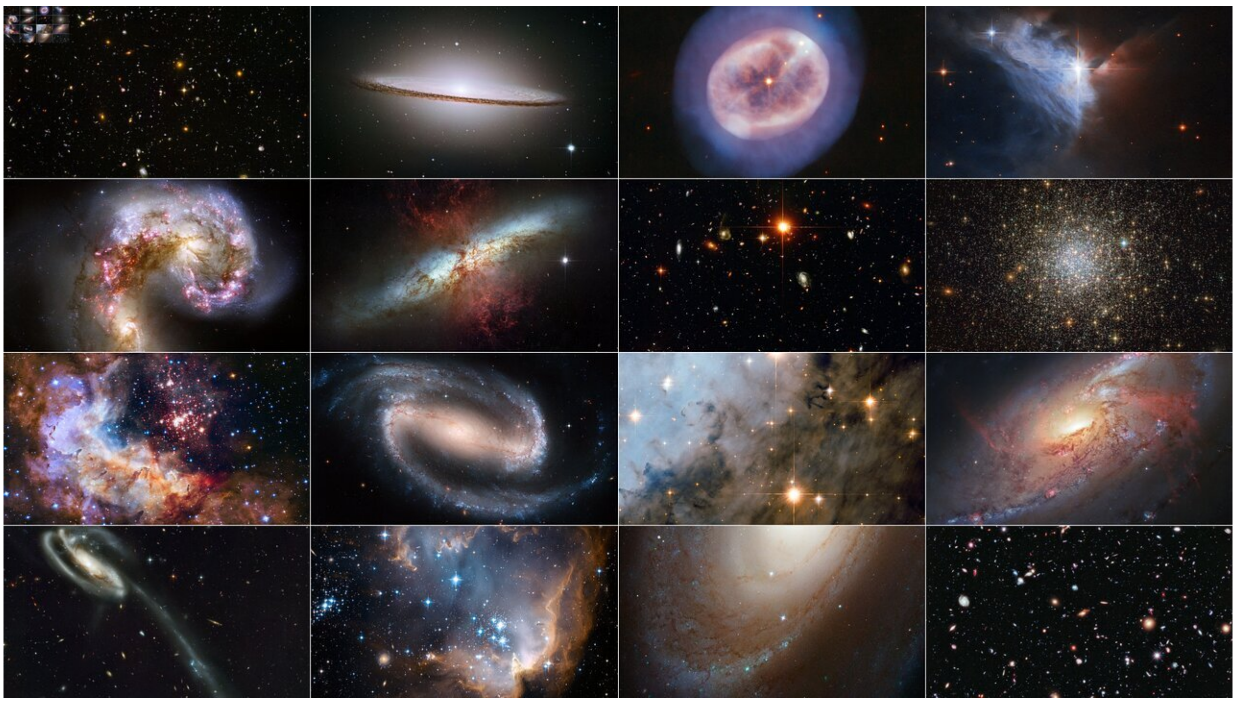

Credit: NASA/ESA

Today marks the 20th anniversary of the Advanced Camera for Surveys (ACS) aboard the NASA/ESA Hubble Space Telescope. On 7 March 2002 astronauts installed the ACS during Hubble Servicing Mission 3B, also known as STS-109. With its wide field of view, sharp image quality, and high sensitivity, the ACS delivers many of Hubble's most impressive images of deep space.

The ACS wavelength range extends from the ultraviolet, through the visible and out to the near-infrared. Its name, the Advanced Camera for Surveys, comes from its particular ability to map large areas of the sky in great detail. The ACS can also perform spectroscopy with a special optical tool called a grism.

Three subinstruments make up the ACS. The Wide Field Channel is a high-efficiency, wide-field, optical and near-infrared camera that is optimized to hunt for galaxies and galaxy clusters in the remote and ancient Universe, at a time when the cosmos was very young. The High Resolution Channel was designed to take extremely detailed (high resolution) pictures of the light from the centers of galaxies with massive black holes, though this is not currently operational, and the Solar Blind Channel blocks visible light to allow faint ultraviolet radiation to be discerned. Amongst other things, it can be used to study weather patterns on other planets and aurorae on Jupiter.

Former astronaut Mike Massimino, one of the two spacewalking astronauts who installed the ACS, remembers, "We knew the ACS would add so much discovery potential to the telescope, but I don't think anybody really understood everything it could do. It was going to unlock the secrets of the Universe."

Following its installation, the ACS became Hubble's most heavily used instrument. Amongst its many accomplishments, it helps map the distribution of dark matter, detects the most distant objects in the Universe, searches for massive exoplanets and studies the evolution of clusters of galaxies.

"There was a sense that ACS would substantially change the way astronomy from space could be done," shared Marco Chiaberge, an ESA/AURA astronomer and the calibration lead for the ACS instrument. "The surveys performed with the ACS led to groundbreaking work for fields such as galaxy evolution, large scale structures, searches for massive exoplanets, and more. The impact on the public was also immense because of its unprecedented images."

One example of this is the spectacular, disrupted galaxy called the Tadpole (UGC 10214). Astronomers photographed the Tadpole shortly after the installation of the ACS to demonstrate the camera's capabilities. With its long tail of stars, the Tadpole looked like a runaway pinwheel firework. But what was really stunning was the backdrop—a rich tapestry of 6000 galaxies captured by the ACS.

In January 2007 an electronics failure rendered the two most-used science channels on the ACS inoperable. Although the High Resolution Channel could not be repaired, thanks to engineering ingenuity spacewalking astronauts on Hubble Servicing Mission 4 (STS-125) repaired the Wide Field Channel, the workhorse responsible for 70 percent of the pre-2007 ACS science.

"Two decades into its mission, the ACS continues to deliver ground-breaking science and some of the most incredible images of the distant Universe, and everything in between," shared Dan Coe, an ESA/AURA astronomer who was part of the ACS team as an instrument scientist. "Looking back through the archive of ACS images reminds us of the vast diversity of galaxies, colors, and stories that have been shared with the world."

In its 20 years aboard Hubble, the ACS has taken about over 125 000 pictures. These observations have spawned numerous discoveries, some of which are highlighted below.

The Hubble Ultra Deep Field

In undoubtedly its most important observations, the ACS revealed a series of the deepest portraits of the Universe ever obtained by humankind. In the original Hubble Ultra Deep Field (HUDF), unveiled in 2004, the ACS teamed up with Hubble's Near Infrared Camera and Multi-object Spectrometer (NICMOS) to capture light from galaxies that existed about 13 billion years ago, some 400 to 800 million years after the Big Bang. This million-second-long exposure revealed new insights into some of the first galaxies to emerge from the so-called dark ages, the time shortly after the Big Bang when the first stars reheated the cold, dark Universe.

In later versions, the ACS teamed with other Hubble instruments to refine the depth and reach of the original HUDF. These portraits pushed humanity's view of the Universe back to within 435 million years of the Big Bang, capturing images of the earliest objects in the cosmos. They forever changed our view of the Universe and spawned innumerable collaborations.

The Frontier Fields

Following in the spirit of the HUDF, the Frontier Fields extended Hubble's reach even farther with the help of giant cosmic "lenses" in space. The immense gravity of massive clusters of galaxies warps the light from even more distant galaxies beyond, distorting and magnifying the light until those galaxies—too faint to be seen by Hubble directly—become visible. Frontier Fields combined the power of Hubble with the power of these "natural telescopes" to reveal galaxies 10 to 100 times fainter than could be seen by Hubble alone. Astronomers simultaneously used the ACS for visible-light imaging and Hubble's Wide Field Camera 3 for its infrared vision.

Over the course of three years, Hubble devoted 840 orbits around the Earth—that's 1,330 hours—to six clusters of galaxies and six "parallel fields"—regions near the galaxy clusters. Whilst these parallel fields could not be used for gravitational lensing observations, Hubble performed "deep field" observations on them—long looks far into the depths of space. Hubble peered more deeply into space than ever before, while the parallel field observations expanded our knowledge of the early Universe that began with the Hubble Deep Fields and the HUDF.

Helping the New Horizons mission by photographing Pluto

The ACS captured the most detailed images ever taken of the dwarf planet Pluto years before the New Horizons flyby. The images reveal an icy, mottled, dark, molasses-colored world undergoing seasonal surface and brightness changes. The ACS images were invaluable in planning the details of the New Horizons flyby in 2015 by showing which hemisphere looked more interesting for the spacecraft to take close-up snapshots during its brief encounter.

The mysterious Fomalhaut b

In 2008 the ACS made the first visible-light snapshot of what was initially thought to be a planet, dubbed Fomalhaut b, orbiting the nearby, bright southern star Fomalhaut. The diminutive-looking object appeared as a dot next to a vast ring of icy debris that the ACS observed to be encircling Fomalhaut. In the following years, researchers tracked the planet along its trajectory. But over time the dot became fainter and may have dropped out of sight, according to some researchers. The nature of the object is still being debated, and follow-up observations may unravel this mystery.

The light echo of V838 Monocerotis

The ACS captured an unusual phenomenon in space called a light echo, in which light from an erupting star reflects or "echoes" off the dust and then travels to Earth. The echo came from the variable star V838 Monocerotis (V838 Mon). In early 2002 V838 Mon increased in brightness temporarily to become 600 000 times brighter than the Sun. The reason for the eruption is still unclear.

Light from V838 Mon propagated outward through a cloud of dust surrounding the star. Because of the extra distance the scattered light traveled, it reached Earth years after the light from the stellar outburst itself. The ACS monitored the light from the stellar outburst for several years as it continued to reflect off shells of dust surrounding the star. The phenomenon is an analog of a sound produced when an Alpine yodeler's voice echoes off of the surrounding mountainsides. The spectacular light echo allowed astronomers to view continuously changing cross-sections of dust surrounding the star. This is a dramatic illustration of the power of the ACS and Hubble to monitor phenomena over time. The longevity and consistency of the ACS are critical for this type of research.

Galaxy cluster Abell 1689's gravitational lens

In 2002the ACS delivered an unprecedented and dramatic new view of the cosmos when it demonstrated the power of gravitational lensing. The ACS peered straight through the center of one of the most massive galaxy clusters known, Abell 1689. The gravity of the cluster's trillion stars—plus dark matter—acts as a lens in space two million light-years wide. This gravitational lens bends and magnifies the light of galaxies located far behind it, distorting their shapes and creating multiple images of individual galaxies.

The ACS's sharpness, combined with this behemoth natural lens, revealed remote galaxies previously beyond even Hubble's reach. The results shed light on galaxy evolution and dark matter in space.

Mature and "toddler" galaxies far back in time

Using the ACS to look back in time nearly 9 billion years, an international team of astronomers found mature galaxies in the young Universe. The galaxies are members of a cluster of galaxies that existed when the Universe was only 5 billion years old. This compelling evidence that galaxies must have started forming just after the Big Bang was bolstered by observations made by the same team of astronomers when they peered even farther back in time. The team found galaxies a mere 1.5 billion years after the birth of the cosmos. The early galaxies reside in a still-developing cluster, the most distant proto-cluster ever found.

The ACS was built especially for studies of such distant objects. These findings further support observations and theories that galaxies formed relatively early in the history of the cosmos. The existence of such massive clusters in the early Universe agrees with a cosmological model wherein clusters form from the merger of many sub-clusters in a Universe dominated by cold dark matter. The precise nature of cold dark matter, however, is still not known.

Clues about the accelerating universe and dark energy

Astronomers using the ACS have found supernovae that exploded so long ago they provide new clues about the accelerating Universe and its mysterious "dark energy." The ACS can pick out the faint glow of these very distant supernovae. The ACS can then dissect their light to measure their distances, study how they fade, and confirm that they are a special type of exploding star, called a Type Ia supernova, that are reliable distance indicators. Type Ia supernovae glow at a predictable peak brightness, which makes them reliable objects for calibrating vast intergalactic distances.

In 1998 Hubble astronomers found just such a far-off supernova that provided the unexpected revelation that galaxies appeared to be moving away from each other at an ever-increasing speed. They've attributed this accelerating expansion to a mysterious factor known as dark energy that is believed to permeate the Universe. Since its installation, the ACS has been hunting Type Ia supernovae in the early Universe to provide supporting evidence.

"The Advanced Camera for Surveys has opened our eyes to a deep and active universe for two decades," said Jennifer Wiseman, NASA's Hubble Senior Project Scientist. "We are anticipating still more discoveries with this camera, in conjunction with Hubble's other science instruments, for many years to come."

Provided by ESA/Hubble Information Centre