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# From Hawaii's Mauna Kea, A Universe of Discoveries

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By DENNIS OVERBYE and MICHAEL ROSTON

Mauna Kea is a sacred place for native Hawaiians. For astronomers, it is also a vital location. From the top of this dormant volcano, telescopes have helped advance important discoveries in humanity's study of the universe. The observatories on Hawaii have contributed to several recent important scientific findings.

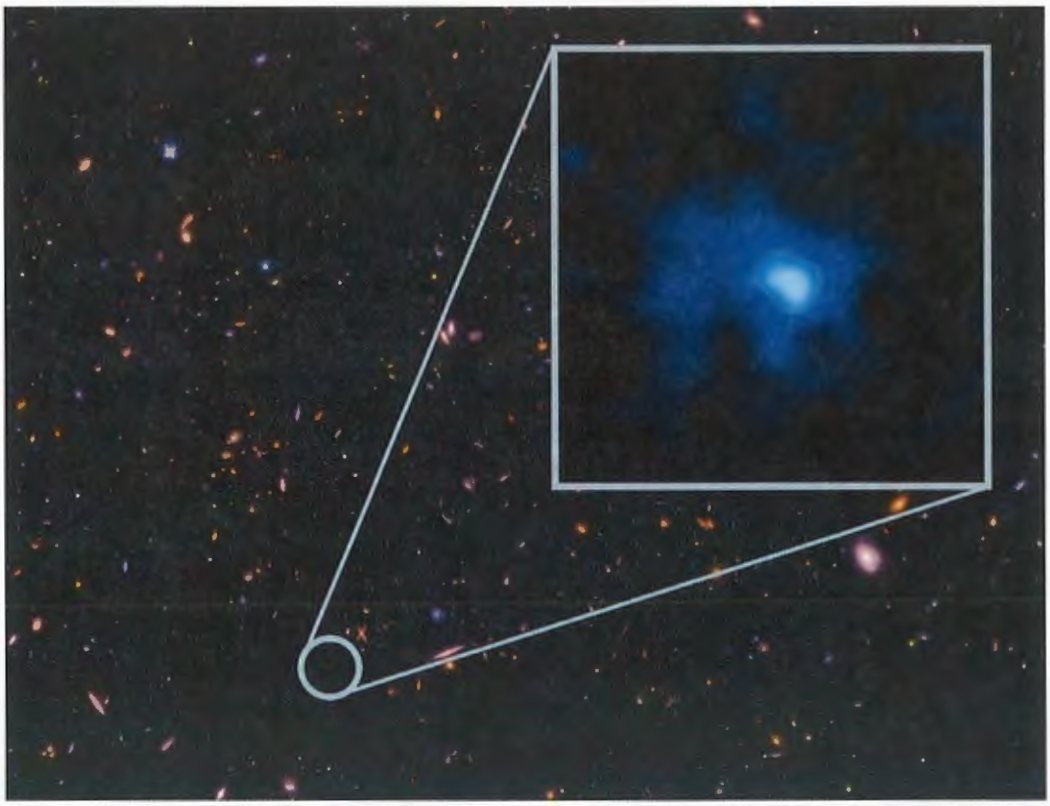
In the outskirts of disk galaxy NGC 4526 is supernova 1994d in the bottom left corner. It is a type IA exploding star, which astronomers use to estimate the speed of the expansion of the universe.
Credit: High-Z Supernova Search Team/HST/NASA

# Dark Energy and the Accelerating Universe

All of the galaxies in the universe are going places, and they're in a hurry to get there. Seemingly driven by mysterious dark energy or vacuum energy, astronomers observed that as the universe expanded, it was speeding up. And the Keck observatory at Mauna Kea played a crucial role in making this discovery.

Two rival teams of astronomers used the telescopes in Hawaii to examine a large inventory of distant type IA supernovae, which result from the collapse of white dwarf stars. The uniform brightness of these supernovae make them ideal beacons for measuring cosmic distances, which allows scientists to accurately estimate the speed of cosmic expansion.

While the competition between the two groups of researchers was fierce, leaders of both teams were awarded with the Nobel Prize in physics in 2011.



The farthest confirmed galaxy observed to date was identified in this field of galaxies recorded by the Hubble telescope.
Credit NASA/European Space Agency/Yale/University of California, Santa Cruz

# The Universe in Its Infancy

Six hundred seventy million years may seem like a long time, but that many years after the Big Bang, the universe was a mere infant. Somehow a galaxy called EGS-zs8-1 bloomed into existence at that point. It is one of the earliest galaxies for which a reliable distance was measured.

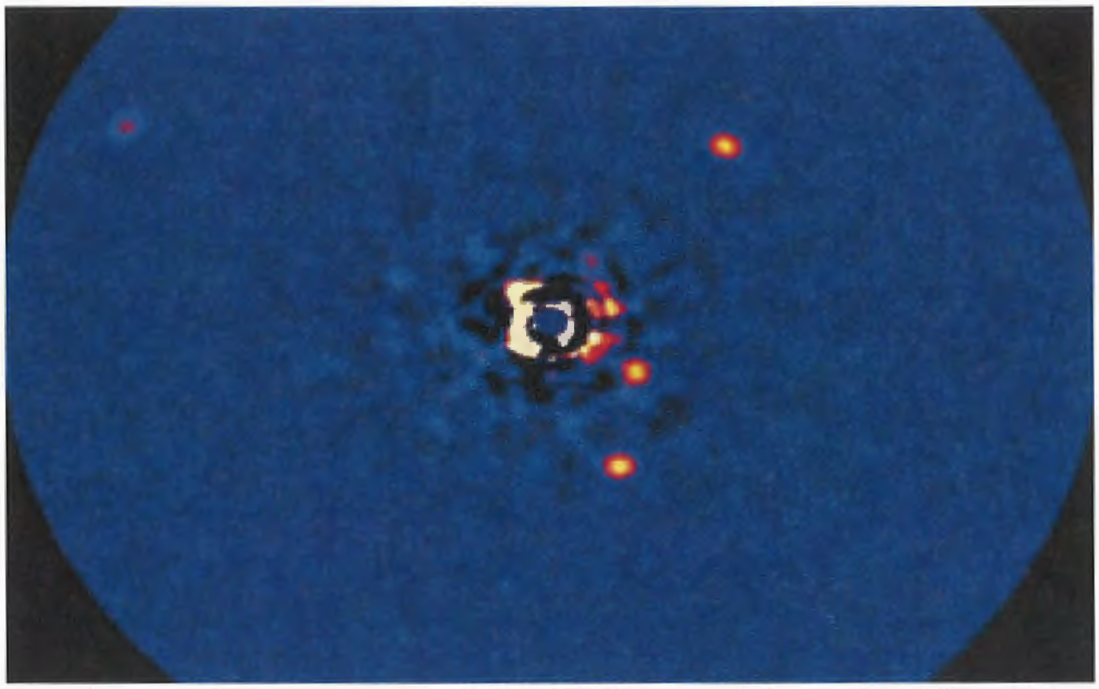
This former galactic youngster, now billions of years old, was first observed by other telescopes. To confirm its age, astronomers used a powerful spectrograph at Mauna Kea called Mosfire. This device measured the redshift, or its light broadening to longer wavelengths, of EGS-zs8-1. Studying early galaxy formation is one objective of the stalled Thirty Meter Telescope project.

This infrared image from NASA's Spitzer Space Telescope shows the center of the Milky Way galaxy, where a black hole may lurk.
Credit
NASA/JPL-Caltech

# Measuring the Milky Way's Central Behemoth

At the center of our galaxy probably lies a monstrous black hole. This supermassive trapdoor has a steady diet of matter, and it has a mass of as much as four million suns.

To determine the size of this object at the center of the Milky Way, Andrea Ghez of U.C.L.A. has studied the motions of stars as they orbit this object. Using adaptive optics on the tennis-court-size telescopes at the Keck observatory on Mauna Kea, Dr. Ghez and other astronomers were able to scrutinize stars that were much closer to the galactic center than previously observed and calculate the mass hiding in its black hole.



There may be as many as five planets orbiting around the star HR 8799, which is 130 light-years from our solar system.
Credit National Research Council of Canada, Christian Marois & Keck observatory

# 'First Glimpse of Planets Around Another Star

There are planets around our sun. One can assume there are many more planets around many other stars. Science does not assume.
Astronomers had detected the existence of planetary bodies well beyond our solar system. But seeing is believing, and studies of HR 8799, a star 130 light-years from our world, gave us one of our first glimpses of extrasolar planets.

These giants - the smallest of the three is six times the size of Jupiter - were captured using the adaptive optics of the Gemini North and Keck telescopes on Mauna Kea. There may be as many as five planets orbiting the star.

An artist's rendering of Kepler-22b. Astronomers believe the planet lies in the habitable zone of a sunlike star, and used the Keck observatories to help confirm its radius.

# Potential Habitats in the Billions

In the last two decades, planets outside the solar system have been detected by the bushel. Proxima b, which orbits our nearest neighboring star, could even be Earth-like.

Proxima b is probably far from alone among potentially habitable worlds in the universe. With NASA's Kepler spacecraft, thousands of additional Sun-like stars have been surveyed, and one team of researchers found that as many as 22 percent of them could have Earth-size planets in their goldilocks zones, meaning not too hot and not too cold. That could mean as many as 40 billion habitable worlds in our galaxy alone.

The Keck telescopes in Hawaii have served as the main tools for examining and confirming exoplanet candidates detected by Kepler. These eyes on the ground back up what scientists first think they see from the telescopes in space.