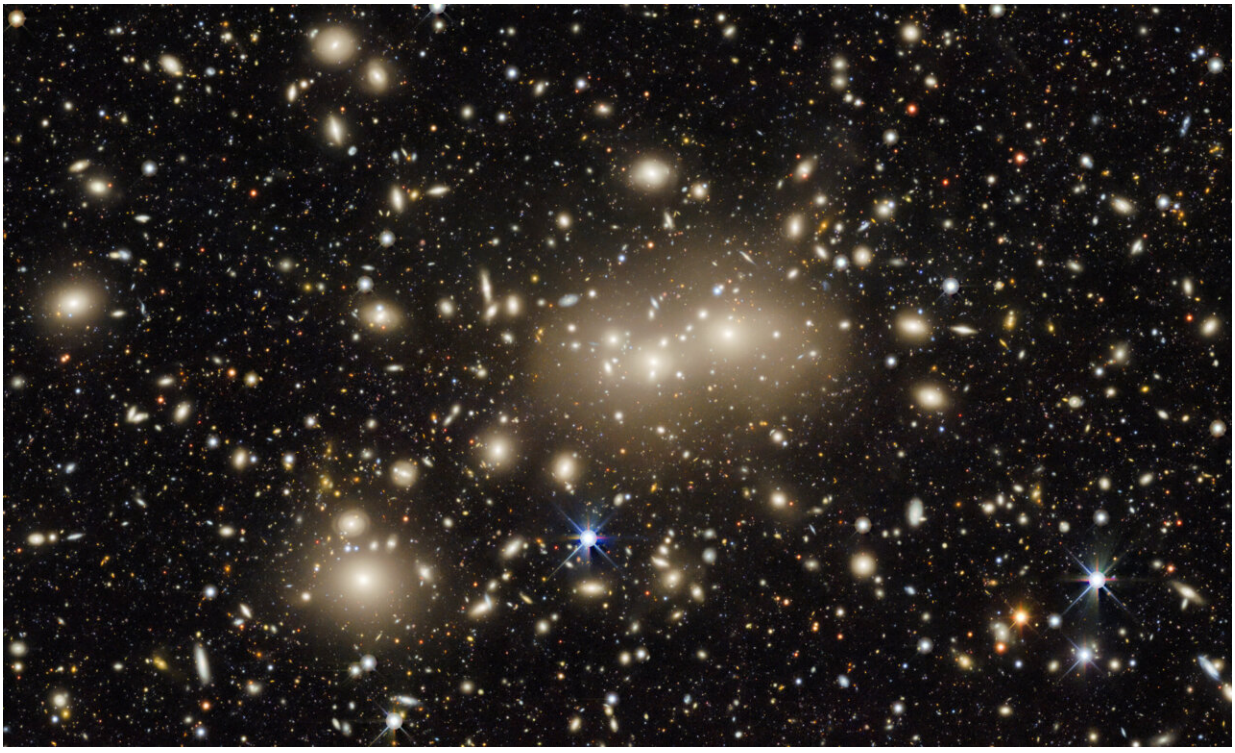
Over one billion galaxies blaze bright in colossal map of the sky

February 23 2023



This is an image centered on a relatively nearby galaxy cluster dubbed Abell 3158; light from these galaxies had a redshift value of 0.059, meaning that it traveled approximately 825 million years on its journey to Earth. The image is a small part of the DESI Legacy Imaging Surveys — a monumental six-year survey covering nearly half the sky. Credit: DESI Legacy Imaging Survey/KPNO/NOIRLab/NSF/AURA; Image processing: M. Zamani & D. de Martin (NSF's NOIRLab)

The universe is teeming with galaxies, each brimming with billions of stars. Though all galaxies shine brightly, many are cloaked in dust, while others are so distant that to observers on Earth they appear as little more than faint smudges. By creating comprehensive maps of even the dimmest and most-distant galaxies, astronomers are better able to study the structure of the universe and unravel the mysterious properties of dark matter and dark energy. The largest such map to date has just grown even larger, with the tenth data release from the DOE's Dark Energy Spectroscopic Instrument (DESI) Legacy Imaging Survey.

The DESI Legacy Imaging Survey expands on the data included in two earlier companion surveys: the Dark Energy Camera (DECam) Legacy Survey and the Beijing-Arizona Sky Survey. Jointly, these three surveys imaged 14,000 square degrees of the sky visible from the northern hemisphere, using telescopes at NSF's NOIRLab's Kitt Peak National Observatory (KPNO) and Cerro Tololo Inter-American Observatory (CTIO) in Chile.

This ambitious six-year effort involved three telescopes, one petabyte of data, and 100 million CPU hours on one of the world's most powerful computers at the US Department of Energy's National Energy Research Scientific Computing Center.

This effort culminated in the largest two-dimensional map of the sky ever created. With collective observations by the Mosaic-3 camera on the Nicholas U. Mayall 4-meter Telescope and the 90Prime camera on the University of Arizona Bok 2.3-meter Telescope, both located at KPNO, as well as the DOE-built Dark Energy Camera (DECam) on the Víctor M. Blanco 4-meter Telescope at CTIO in Chile.

One of the main purposes of this map is to identify roughly 40 million target galaxies for the five-year DESI Spectroscopic Survey, which is aimed at understanding dark energy by precisely mapping the expansion

history of the universe over the last 12 billion years. The DESI project has selected its targets and the spectroscopic survey is currently underway. However, the team is looking to create the most comprehensive map of the sky that they can, so more images and improved processing have been added to the Legacy Surveys to include data that were previously missing.

Most notably, the tenth data release focuses on integrating new imaging from DECam of the southern extragalactic sky, especially in areas away from the Milky Way's disk, which are ideal for looking far into the cosmos.

With the addition of southern sky images in the new data release, the Legacy Surveys have been expanded to over 20,000 square degrees, nearly half the sky. In addition, the new release includes images of the sky taken in an additional color filter, able to sample infrared light just redder than what the human eye can see. The additions to the map's footprint and wavelength coverage will in turn make the data useful to a wider demographic of scientists.

"The addition of near-infrared wavelength data to the Legacy Survey will allow us to better calculate the redshifts of distant galaxies, or the amount of time it took light from those galaxies to reach Earth," said Alfredo Zenteno, an astronomer with NSF's NOIRLab.

"This is essential for surveys at radio and X-ray wavelengths that need the complete 'optical' view to identify the origin of the emission, like clusters of galaxies and active supermassive black holes," said Mara Salvato, a researcher at the Max Planck Institute for Extraterrestrial Physics (MPE) and spokesperson for the DECam eROSITA Survey (DeROSITAS).

The bulk of these additional DECam observations are from the

DeROSITAS team, which includes scientists from NSF's NOIRLab, the University of La Serena, MPE and Ludwig Maximilians University Munich in Germany; the DECam Local Volume Exploration Survey; and the final (sixth) year of the Dark Energy Survey. The team also scoured the NSF NOIRLab data archive to use any public data of the sky that already existed or was being collected by other researchers.

It's not only scientists who benefit from the growing archive of astronomical data coming out of the Legacy Surveys. The publicly available data make it possible for astronomy enthusiasts and curious individuals to digitally peruse the universe around us.

"Anyone can use the survey data to explore the sky and make discoveries," said Arjun Dey, an astronomer with NSF's NOIRLab. "In my opinion it is this ease of access which has made this survey so impactful. We hope that in a few years the Legacy Surveys will have the most complete map of the entire sky, and provide a treasure trove for scientists well into the future."

NOIRLab will host these data products in the Astro Data Archive, from the original images taken at the telescopes to the catalogs that report the positions and other properties of stars and galaxies. Astro Data Lab, which is part of the Community Science and Data Center (CSDC) at NSF's NOIRLab, also serves the catalogs as databases, which astronomers can easily analyze using the Astro Data Lab tools and services, and cross-match them with other datasets, giving more opportunities for discovery. In addition, Astro Data Lab provides astronomers with example scientific applications and tutorials to assist with their research.

Provided by NOIRLab