Research Report

Ready to Go for "Cosmic Census" Project with the World's Most Powerful Camera, Hyper Suprime-Cam

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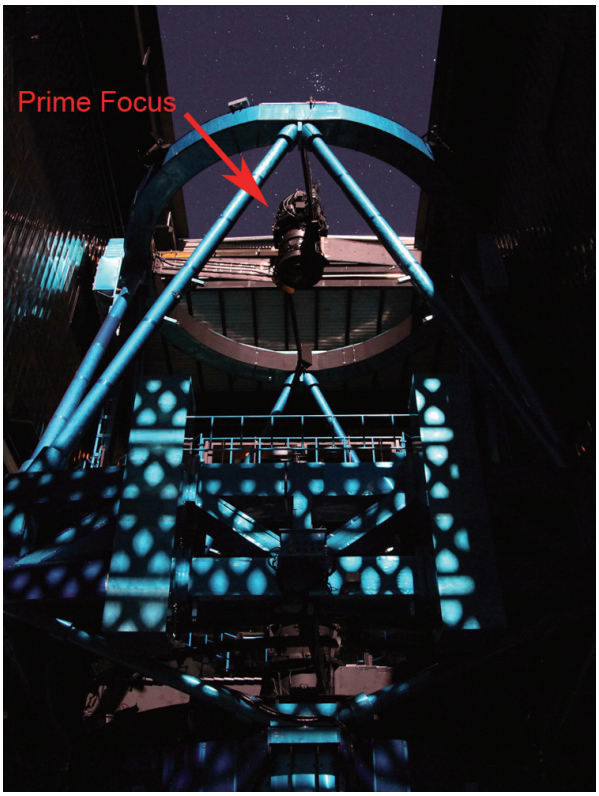
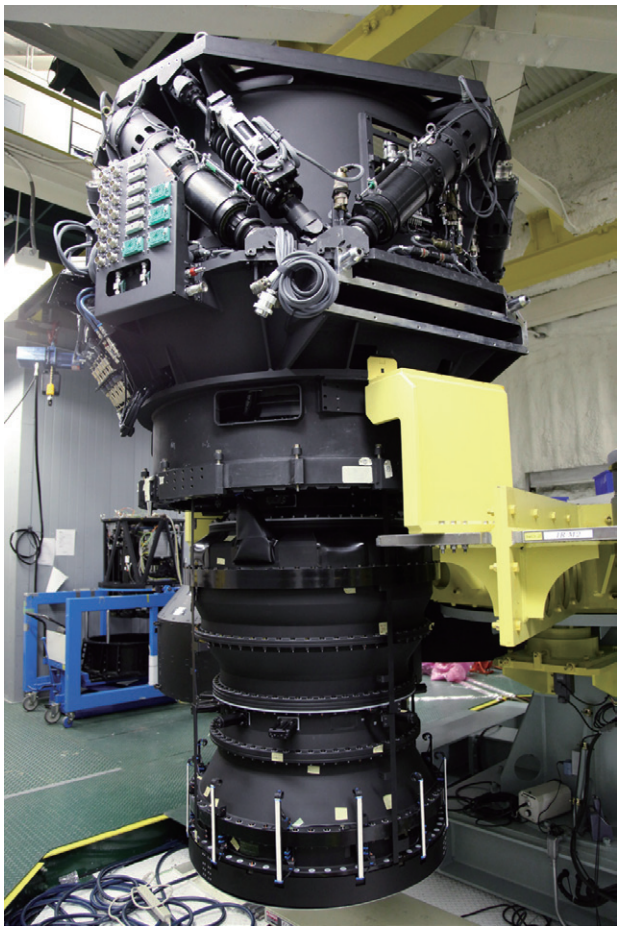
The HSC international collaboration released stunning images of the Andromeda Galaxy (M31) which are among the first to emerge from a new wide-field prime-focus camera installed on the 8.2 m Subaru Telescope at the 4,200 m summit of Mt. Mauna Kea in Hawaii. The camera is called the Hyper Suprime-Cam (HSC), which has been promoted by an international collaboration between NAOJ, Kavli IPMU, other Japanese institutes, Princeton University, and Taiwanese institutes. The HSC camera is designed to take advantage of the full accessible field-of-view of the Subaru Telescope, 1.5 degrees in diameter, which is about 7 times wider than the current camera Suprime-Cam. The HSC is 3 meters tall, weighs 3 tons, and has about 9 billion pixels—the largest camera in the world. The combination of the HSC with the Subaru Telescope's sharp imaging, wide field-of-view, and large mirror represents a giant step into a new era of observational cosmology and astronomy.

The HSC team is planning to conduct a "cosmic census" of hundreds of millions of galaxies over a wide solid angle of the sky in sufficient depth to probe the distant Universe. By measuring the distortions in the shapes of distant galaxies due to the gravitational pull of dark matter, we can reconstruct the distribution of dark matter, the invisible material that makes up about a quarter of the mass and energy of the Universe. In turn, we will study how the distribution of dark matter has evolved with cosmic time in an expanding universe, enabling us to explore the nature of dark energy that is thought to cause the cosmic acceleration expansion. The HSC capabilities allow the galaxy survey (cosmic census) project to be carried out for a 5–year duration, starting from early 2014. This survey is the largest-ever galaxy survey carried out with the Subaru Telescope, and it is only possible with HSC within a timescale of 5 years, because it otherwise requires more than 35 or 1,000 years for the current Subaru camera or the Hubble Space Telescope, respectively.

The Andromeda images are truly exciting. The sharp images of stars across the entire region of the field of view demonstrate the HSC's outstanding power. The Andromeda Galaxy, also known as



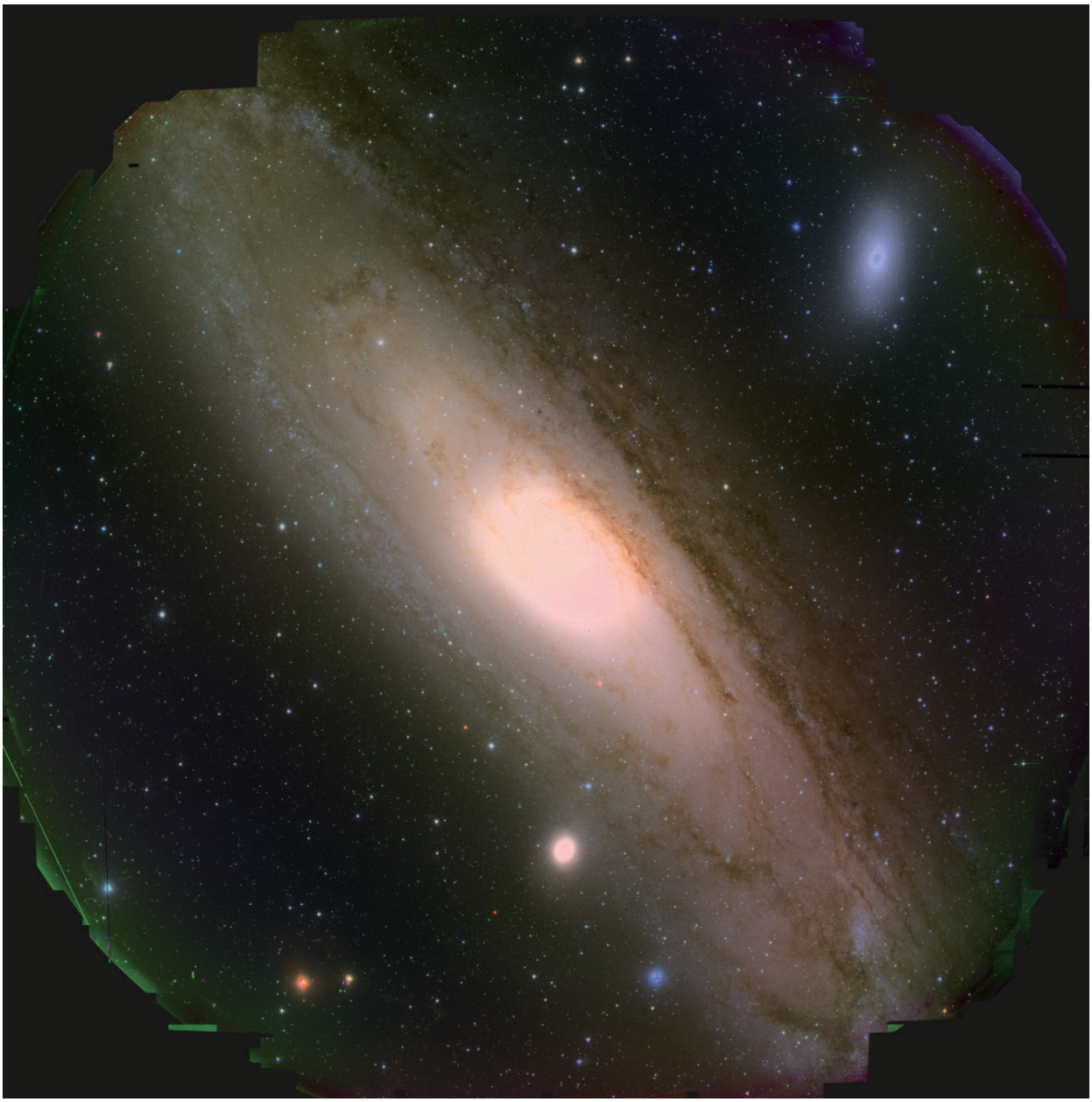


The 8.2m Subaru Telescope and the HSC camera. The image on the left shows the position of HSC (without the filter exchange unit or FEU) when mounted on the inner, top ring of the Subaru Telescope. This location is at prime focus, and HSC is 15 meters above the primary mirror. (Credit: NAOJ). The image on the right is the 3m tall HSC camera. (Credit: NAOJ)

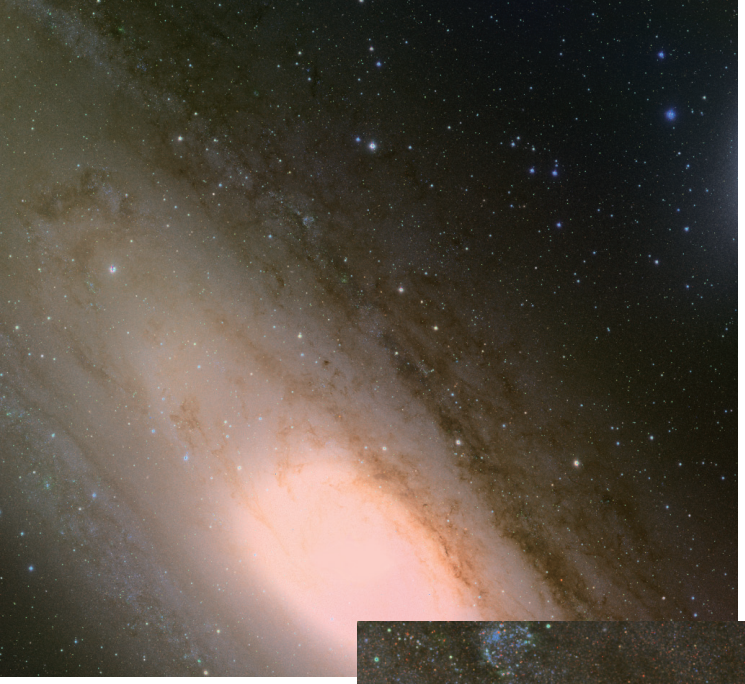
Messier 31 (therefore called M31 in short), is 2.5 million light years from Earth and is the spiral galaxy nearest to our own Milky Way Galaxy. It is visible to the naked eye on moonless nights, even in areas with moderate light pollution. Astronomers find it interesting because it is similar to the Milky Way and can provide valuable information about how our own galaxy formed. Since the entire galaxy is visible in the new images, it is possible to determine from the color of the galaxy's stars how those star populations change from the interior to the edge of the galaxy. The image was reduced with the sophisticated data processing software pipeline that has been developed in preparation for the HSC galaxy survey project, under the initiatives of researchers at Princeton University, Kavli IPMU, and NAOJ. The exposure times for g, r, and i-band filters —each of which selectively transmits light in a particular range of wavelengths—were 10, 12, and 16 minutes, respectively; and these three colors have been allocated to blue, green, and red, to make the color image.

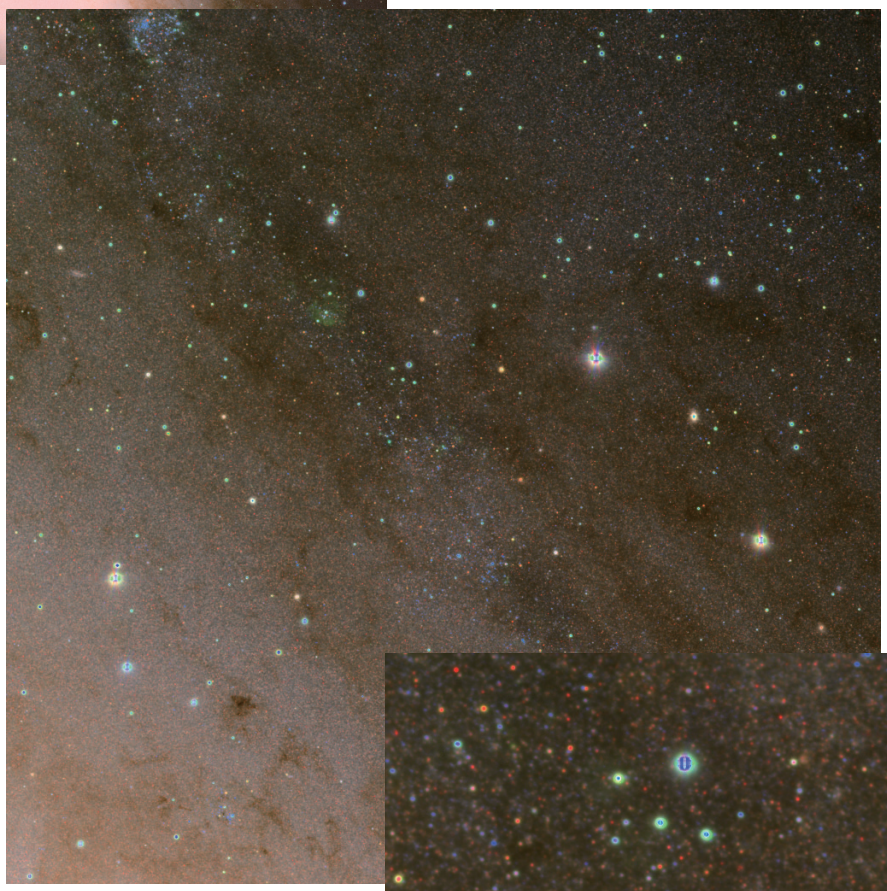
HSC is also the first step of the Subaru Measurements of Images and Redshifts (SuMIRe) project, where our Kavli IPMU Director Hitoshi Murayama is the Principal Investigator. Another component of SuMIRe is a multi-object spectrograph, the Prime Focus Spectrograph (PFS), which is currently in the process of development and instrumentation. The PFS will share the wide field corrector of HSC,

and plan to make a spectroscopic observation for a few millions of galaxies selected from the galaxy catalog provided by the HSC survey, where the spectroscopic data can determine distances to the galaxies and study the physical properties of stellar and gas compositions in each galaxy. The combination of imaging and spectroscopic galaxy data for the same region of the sky is extremely powerful to study mysterious nature of dark matter and dark energy. We are finally about to start our long journey of the massive Subaru cosmic census project.



The full view of the Andromeda Galaxy taken by HSC. The HSC mounted on the Subaru Telescope can observe an extremely wide field of view, equal to 9 times the area of the full moon. The color image was made by combining the data of three filters (g, r, and i), each of which selectively transmits light in a particular range of wavelengths. Note that some parts at the edge region appear to be strange color since the boundary area of the image circle is hard to process and observed area is not perfectly coinciding between the 3 bands. (Credit: HSC Collaboration / Kavli IPMU)





2, 8, and 32 magnified images, respectively. Individual stars in the Andromeda Galaxy can be identified, and galaxies behind the Andromeda are also identified. (Credit: HSC Collaboration / Kavli IPMU)