Research Report

Forty new studies published from the first data of world's biggest map of the Universe

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The first two years of data from an international team mapping the Universe has moved research forward in several areas of astronomy and physics, including the search for new objects in the solar system, studies about both nearby and highest-redshift galaxies, galaxy clusters, dark matter, and the expansion of the Universe. The 40 papers based on the HSC data have been reported in the latest special issue of *Publications of the Astronomical Society of Japan (PASJ).*

An international team including National Astronomical Observatory of Japan (NAOJ), Kavli Institute for the Physics and Mathematics of the Universe (Kavli IPMU) at the University of Tokyo, other institutes in Japan, Academia Sinica Institute for Astronomy and Astrophysics (ASIAA, Taiwan), and Princeton University, has been conducting a large-scale astronomical survey using the Hyper Suprime-Cam (HSC), an ultra-wide-field camera installed at the prime focus of the Subaru telescope in Hawaii since 2014.

This large-scale survey, HSC-SSP (Hyper Suprime-Cam Subaru Strategic Program, http://hsc.mtk.nao.ac.jp/ssp/), takes advantage of the HSC's ability to capture a large area of the sky, equivalent to nine times the area of a full moon, and will attempt to take high-resolution images of the Universe over more than 1,000 square degrees (the equivalent of more than 5,000 full moons). The international team will use the HSC image to address the mystery of the accelerating expansion of the Universe by mapping the global distribution of dark matter with unprecedented resolution. The survey is expected to continue until 2019.

One of the major results so far is the creation of a two-dimensional and three-dimensional dark matter map over an unprecedented area with an unprecedented resolution, which was led by University of Tokyo School of Science Assistant

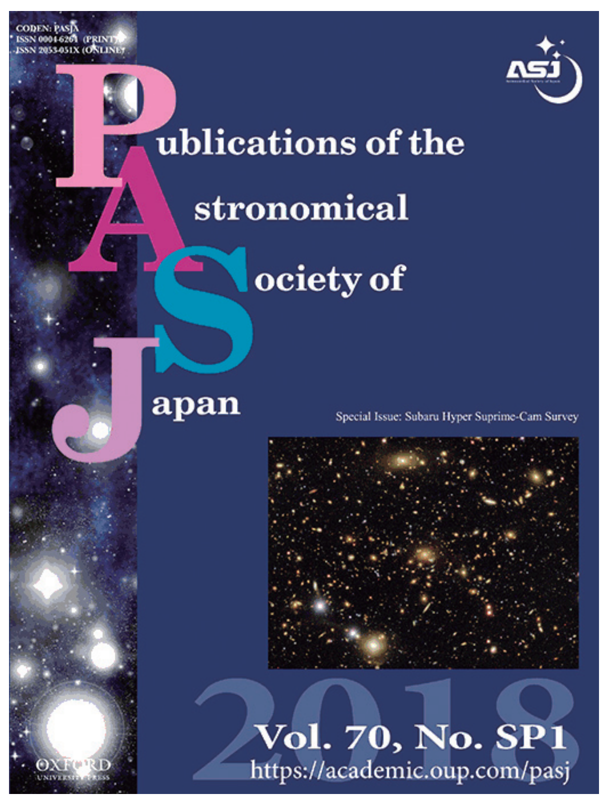

Figure 1: *Publications of the Astronomical Society of Japan* (Volume 70, Special Issue 1, 2018). (Credit: The Astronomical Society of Japan.)

Professor and Kavli IPMU Associate Scientist Masamune Oguri. It is based on the HSC data accumulated by April 2016 (16 per cent of the overall data size planned). The team first measured the weak gravitational lensing effects of galaxy images in the HSC data. Each galaxy in the HSC data has been taken with 5 color filters, each of which is transparent for a particular range of optical wavelengths. Combining these 5 colors for each galaxy, astronomers can infer a distance to each galaxy because a more distant galaxy color appears to be redder due to the "redshift" effect of wavelength caused by the expansion of the Universe. By performing gravitational lensing analysis of each galaxies as a function of distances to the galaxies, the team succeeded in reconstructing the three-dimensional map of dark matter distribution, like Computerized Tomography (CT) images in the medical field.

Figure 2 shows the dark matter distribution over an area of about one billion light years, times 250 million light years, and over a depth of eight billion light years. This is the first time a three-dimensional map over such a large volume has been built, which was made possible thanks to the high light-collecting power of the Subaru telescope.

The team expects to understand the fate of the Universe, evolution of the structure in the Universe over time, and time variation of the amount of dark energy, using the three-dimensional map of dark matter and analyzing more HSC-SSP data in the future.

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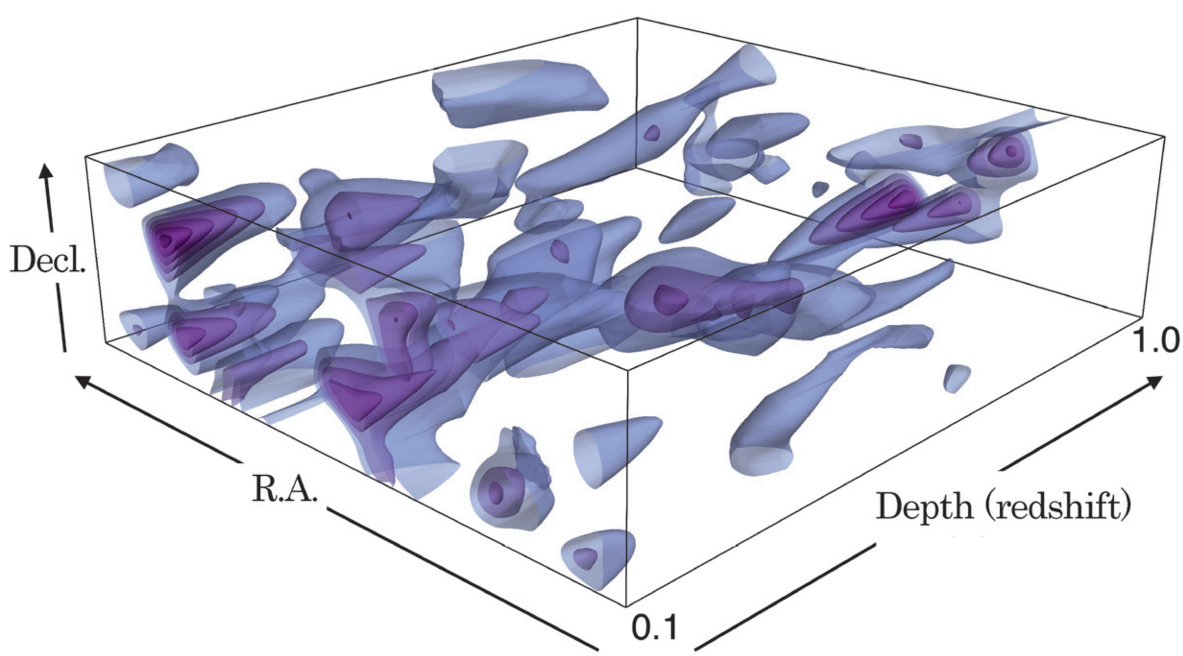

Figure 2: 3D dark matter distribution map reconstructed from measurements of gravitational weak lensing effects of galaxy images in the HSC data. Darker colors indicate higher density regions of the dark matter distribution. "R.A." and "Decl." are right ascension and declination of the celestial coordinates of the sky, and another third dimension denotes depth (redshift direction or line-of-sight direction).