Mapping Dark Matter by HSC via Weak Lensing

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Since the first discovery in 2001, 'Cosmic Shear: weak lensing by Large Scale Structure (LSS)' has become a standard tool to examine the LSS and its evolution. Because sparse sampling of background galaxies is sufficient (5 to 10 galaxies/arcmin^2), observation of relatively large and bright galaxies are only required. Thus, it is regarded as one of the most promising tool to probe the growth rate. However, because the observation does not directly map LSS, the discrimination of the signal from noise is not so straightforward.

Clusters of galaxies, on the other hand, is a classical probe of the growth rate but the key is how to sample clusters and measure the mass. Weak lensing could be potentially powerful again here but observation ally more demanding. In order to locate the dark matter concentration directly via lensing, sufficiently higher resolution mass map is crucial which requires high number density of faint background galaxies. Suprime-Cam has been one of the ideal facility instruments because it features unique combination of the large aperture and the sharp imaging which enables precise measurement of faint galaxies. Hyper Suprime-Cam (HSC) is developed to make the survey speed even faster and to realize a very wide survey (> 1000 deg^2).

HSC saw the first light in January 2013 and engineering observations followed. After the initial round of adjustments we obtained the scientific images on two contiguous HSC fields. The figure on the right shows the dark matter map reconstructed from the shapes of 220,000 galaxies over the field using weak lensing technique. The density reflects the strength of lensing signal. The locations of significant peaks on the map (signal-to-noise ratio > 4.5) are marked by circles where we expect the existence of dark matter concentrations.

We could also expect that galaxies are attracted by the dark matter gravity and these concentration would be recognized as clusters of galaxies. This expectation is indeed verified by the cross-correlation of the peaks on the mass map and clusters identified by multi-color images where color sequences of member galaxies are searched using CAMIRA algorithm. We confirmed that all the significant peaks accompany clusters of galaxies. This suggests the reliability of the mass map.

We are able to estimate the redshift to the dark matter concentration using the colors of associated galaxies. On the histogram inserted at the lower-right corner of the figure, we show the redshift distribution of the clusters. Two spikes are clearly visible which should stem from LSS accidentally located along the line of sight. This clearly suggests that we would have to observe much much wide field so that the local structures are averaged to obtain useful cosmological information.

This is exactly what we are working on right now. We started a wide field observation campaigns in March, 2014 as one of the Subaru Strategic Program in collaboration with more than 200 CoIs. We plan to cover 1400 deg^2 and it would take about five years to complete. Our primary objective of the survey is to test the currently standard ΛCDM with unprecedented precision. In particular, we are interested in whether modification of the Einstein's gravity theory is necessary because weak lensing technique, among other techniques such as SNIa and BAO, uniquely probes the effect of gravity. We will certainly measure the cosmic shear as other lensing survey projects do. In addition, using the same data, we will be able to detect more dark matter concentrations which, we expect, enables us to make a unique contribution to observational cosmology.

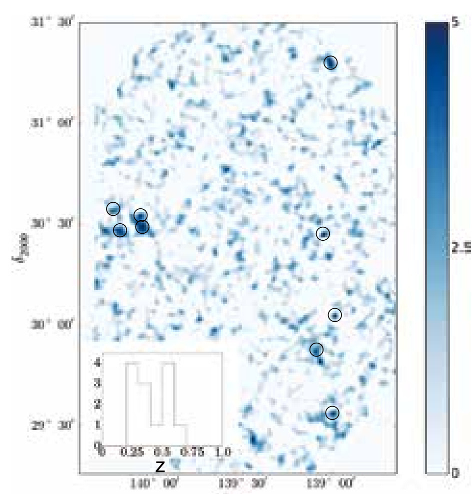

Figure 1: Weak lensing mass map (contour). Peak positions are designated by circle where dark matter halos are located. Histogram shows the redshift distribution of the halos estimated by the color of associated galaxies to these halos.

References

[1] http://www.subarutelescope.org/Projects/HSC/j_index.html
[2] Miyazaki, S., Oguri, M., Hamana, T., et al.: 2015, *ApJ*, **807**, 22.