Full-sky ray-tracing simulation of weak lensing

With the support by the National Natural Science Foundation of China, the research team led by Prof. Kang Xi (康熙) at the Purple Mountain Observatory, Chinese Academy of Sciences, obtained the full-sky weak-lensing mock catalogue using a high-resolution N-body simulation and the state-of-the-art galaxy formation model. The results have been published in *The Astrophysical Journal* (2018, 853: 25).

In the context of general relativity, photos emitted from distant galaxies are continuously deflected by the intervening mass field of large-scale structures. This weak gravitational lensing effect will produce some coherent distortions of the observed galaxy images, which can be measured to probe the matter distribution in the universe. As a promising probe of detecting dark matter, weak-lensing measurement has been the main goal of many ongoing and upcoming galaxy surveys. However, one of the most serious astrophysical systematic effects in the era of accurate weak-lensing analyses is the intrinsic alignment (IA) of galaxies. Nowadays, there have been numerous investigations on galaxy IA, while it is still difficult to effectively distinguish different galaxy IA models and to assess their impact on the derived cosmological parameters.

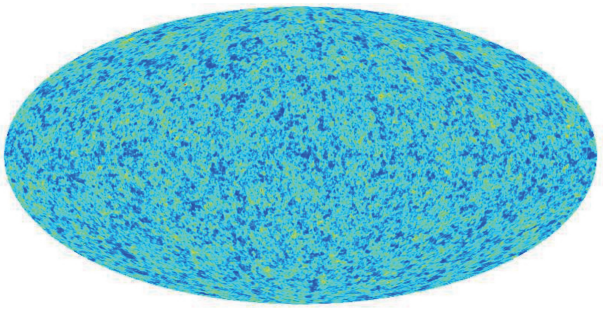

Figure 1 The full-sky map of the dark matter density up to redshift one (or 7.8 billion light years from us) along the line-of-sight. Using this map, one can immediately obtain the lensed image of a source galaxy at $z=1$.

Using the full-sky ray-tracing method, Kang's group produced the largest weak-lensing mock catalog (Figure 1) from the ELUCID *N*-body simulation run by Shanghai Jiao Tong University (SJTU) and the University of Science and Technology of China (USTC). Model galaxies in the simulation are produced using the semi-analytical model developed by Kang's group. With the mock catalog, one can examine different models of galaxy IA and study the dependence of statistic measurements on both sky-coverage and depth in the survey. Therefore, such an approach is very important for theoretically modeling and maximizing the science returns of ongoing and future weak-lensing surveys.

Kang's group found that the predicted tomographic shear correlations agreed well with the observational results from the largest, ongoing KiDS-450 (Kilo-Degree Survey with 450 square degrees, see Figure 2). This is the first achieved attempt to reproduce the observational results from weak-lensing simulation. Moreover, they found that a non-negligible positive correlation between the gravitational shear signal and the intrinsic galaxy orientation (GI) was mainly induced by spiral galaxies. A positive GI is not expected from the widely used galaxy IA model. They clearly pointed out that future weak-lensing surveys must consider the contribution of different types of galaxy in more detail. Their mock catalog is now available upon request and to be publicly released very soon.

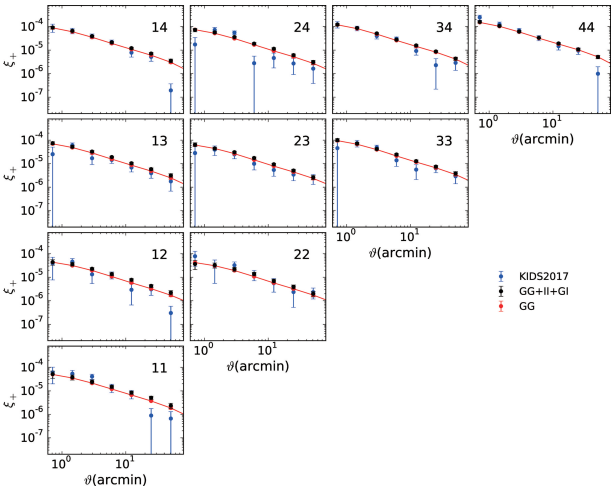

Figure 2 The tomographic correlations of the galaxy shear. The blue circles represent the observational results from KiDS-450. The black circles are the model results. Good agreements can be seen.