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Weak gravitational lensing: Solutions for key technical issues and applications in exploring fundamental problems

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Weak gravitational lensing effect causes small and coherent shape distortions (cosmic shear) on all background galaxy images, the statistics of which can be used to map out the density growth and the scale evolution of our universe on large scales. It provides a unique and model-independent way of probing cosmological models as well as certain fundamental issues, such as the nature of dark matter and dark energy. Almost all ongoing and planned large scale galaxy surveys list accurate cosmic shear measurement as their major scientific targets. Despite its physical cleanness, accurate cosmic shear measurement is well known to be difficult, due to the presence of the point spread function, noise, pixel size and several other factors at the detector level. Solutions to these technical issues are keys for fully realizing the scientific potential of weak lensing. Over the course of the last several years, we have built up a shear measurement pipeline based in Fourier space. It removes most of the known contaminants model-independently. Our image processing does not involve assumptions about the morphology of galaxy or point spread function. This important feature distinguishes our method from most of the currently popular methods. Indeed, image processing in Fourier space has a lot of advantages, including easy image alignment, well-behaved noise properties, specific requirement for CCD pixel size, fast speed, etc. We use the CFHT lens data to demonstrate the accuracy of our method. As an important application of our shear results, we showed an interesting way to probe the nature of dark energy: whether it is simply a cosmological constant or not.

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