APR14-2014-000212

Abstract for an Invited Paper
for the APR14 Meeting of
the American Physical Society

CMB Lensing Cross Correlations

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A new generation of experiments designed to conduct high-resolution, low-noise observations of the Cosmic Microwave Background (CMB) —including ACTpol, *Planck*, POLARBEAR and SPTpol— are producing exquisite measurements of the gravitational lensing of the CMB. Such measurements, covering large fractions of the sky, provide detailed maps of the projected mass distribution extending to the surface of the CMB's last scattering. Concurrently, a large number of deep, wide-area imaging and spectroscopic surveys (e.g., the Dark Energy Survey (DES), *WISE* all-sky survey, Subaru HyperSuprimeCam Survey, LSST, MS-DESI, BigBoss, etc.) are, or will soon be, providing maps of the distribution of galaxies in the Universe. Correlations of such tracer populations with lensing data allows new probes of where and how galaxies form in the dark matter skeleton of the Universe. Recent correlations of maps of galaxy and quasar densities with lensing convergence maps have produced significant measurements of galaxy bias. The near-term prospect for improvements in such measurements is notable as more precise lensing data from CMB polarization experiments will help to break cosmological and astrophysical parameter degeneracies. Work by the *Planck*, SPT, and POLARBEAR collaborations has also focused on the correlation of the Cosmic Infrared Background (CIB) with CMB lensing convergence maps. This correlation is particularly strong as the redshifts of the CIB and CMB lensing kernel are well matched. Such correlations probe high-redshift structure, constraining models of star-formation and the characteristic mass scale for halos hosting CIB galaxies and have also been used to demonstrate the first detection of CMB B-mode polarization — an important milestone in CMB observations. Finally, combining galaxy number density, cosmic shear and CMB lensing maps has the potential to provide valuable systematic tests for upcoming cosmological results from large optical surveys such as LSST.