Bayesian estimates of CMB gravitational lensing

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Abstract: Gravitational lensing studies have become a powerful probe of dark matter, the invisibility of which provides the main obstacle for detection. In particular, the ground based Atacama Cosmology Telescope (ACT) and the South Pole Telescope (SPT) have mapped the cosmic microwave background (CMB) at such unprecedented resolution as too allow a detection of weak gravitational lensing from the CMB alone. The CMB shows a picture of radiation fluctuations frozen at the instant the universe became transparent. Estimating the gravitational lensing of the CMB is important for two reasons. First, if the CMB is mapped at a sufficient resolution one can use weak lensing estimates to construct a map of dark matter in the sky. Second, weak lensing estimates can be used, in principle, to un-distort the observed lensed CMB and construct the original unlensed CMB radiation fluctuations. Both of these maps, the unlensed CMB radiation field and the dark matter field, are deep probes into the nature of cosmology and cosmic structure.

Keywords and phrases: CMB, gravitational lensing, Bayesian, Gibbs.

Over the past year, the data from two ground based telescopes, ACT and SPT, have resulted in the first direct detection of weak lensing from the CMB alone, see Das et al. (2011) and van Engelen et al. (2012). In the coming years, the data from the Plank satellite and new instrumentation being installed on these telescopes (ACTpol and SPTpol) will begin probing this lensing a much greater scale. This will eventually help cosmologists gain an understanding of gravity waves, dark matter and dark energy. Unfortunately, the estimators which have been developed for weak lensing are still not fully understood. The state-of-the-art estimator, the quadratic estimator developed by Hu and Okomoto (2001, 2002), works in part through a delicate cancelation of terms in an infinite Taylor expansion of the lensing effect on the CMB. The effect of this cancelation is particularly sensitive to foreground contaminants and sky masking, which if not fully accounted for, limit the statistical inference obtainable from these studies. We propose a new Bayesian estimator which has the potential to revolutionize the way weak lensing studies are done.