Exploring the Non-Gaussianity of the Cosmic Infrared Background and Its Gravitational Lensing

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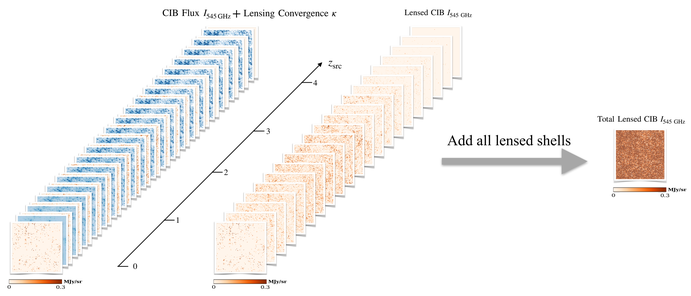
Introduction

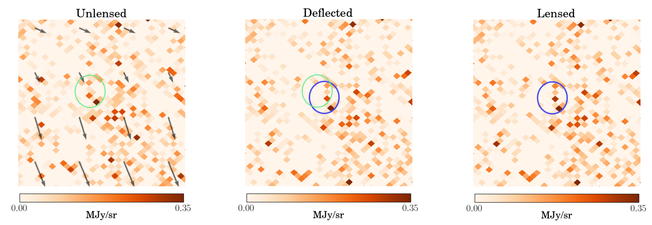
- Cosmic Infrared Background (CIB): a tracer of star-forming galaxies, as well as a CMB foreground
- Broadly extended from $z = 0$ to 4, intrinsically non-Gaussian
- CIB 2-point and 3-point measured by *Planck*, SPT and ACT

Methodology

Lensing
- Using Websky Peak Patch simulations
- Splitting the CIB into $\Delta z = 0.2$ shells and lensing each shell with its corresponding κ

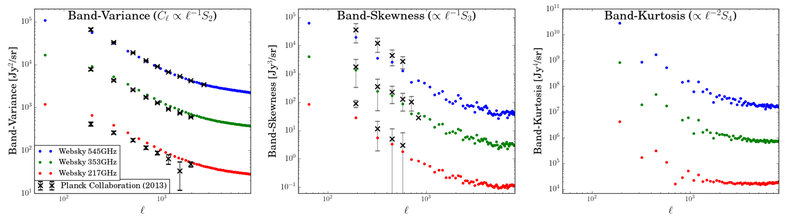


- Deflection-then-magnification method
  1. Galaxies deflected by an amount given by $\nabla\phi_{z_i}$
  2. Galaxies then magnified by $\mu = [(1-\kappa)^2 - \gamma^2]^{-1}$



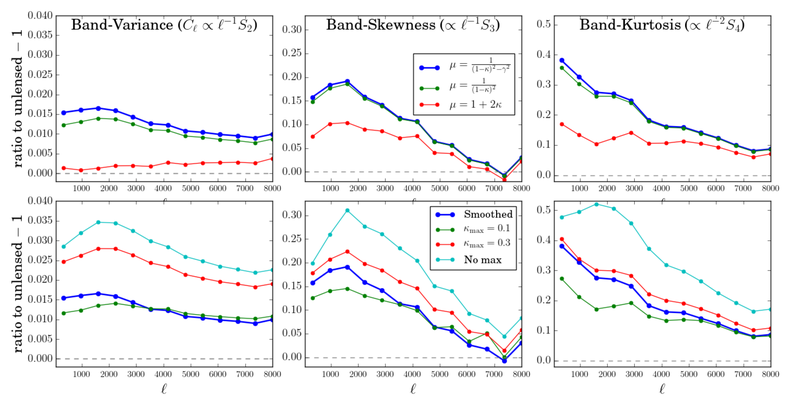
Filtered Statistics (Roughly equilateral)
- Band-filtered within ℓ-bands, then n-point statistics calculated within each band
- Statistics then converted to their respective poly-spectra
- $C_{\ell_c} \approx S_2^{\ell_c}\left(\sum_{\ell_c-\Delta\ell/2}^{\ell_c+\Delta\ell/2}\frac{2\ell+1}{4\pi}\right)^{-1}, \quad \because S_2^{\ell_c} = \sum_{\ell_c-\Delta\ell/2}^{\ell_c+\Delta\ell/2}\frac{2\ell+1}{4\pi}C_\ell$
- $b_{\ell_c,\ell_c,\ell_c} \approx 2\sqrt{3}\pi^3 S_3^{\ell_c}(\Delta\ell)^{-3}\ell_c^{-1} \propto S_3^{\ell_c}\ell_c^{-1}$
- $t_{\ell_c,\ell_c,\ell_c,\ell_c} \propto S_4^{\ell_c}\ell_c^{-2}$

Result I. Unlensed Websky vs. Planck



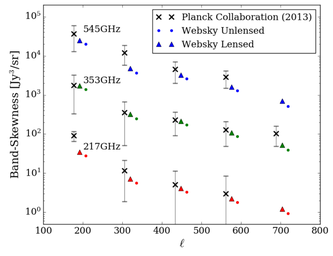
- *Planck* flux cuts applied to exclude bright, nearby sources
- Websky CIB bispectra are generally within *Planck* error bars => nontrivial!!

Result II. Impact of Lensing on Non-Gaussianity

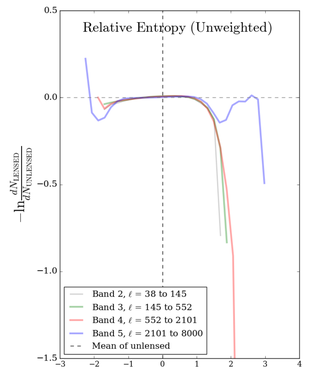


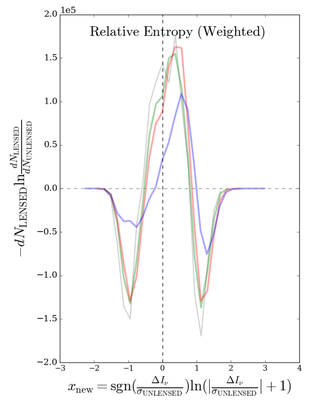
- Small power spectrum increase (~1.5%, default) as expected by Schaan et al. (2018), while 3-point and 4-point increases substantially at large scales
- Using the weak-lensing approximation $\mu \approx 1 + 2\kappa$ does not capture the full change in non-Gaussianity due to lensing
- Results sensitive to treatment of κ maps (smoothing/setting a $\kappa_{\max}$ cut)

- Websky lensed bispectra values closer to *Planck values*
  - Lensing could partially explain why unlensed Websky values are lower than *Planck's*



Result III. Relative Entropy





- Motivated from KL-divergence
  $-\sum P \ln \frac{P}{Q}$ (P, Q : PDFs)
- Define $q_{\mathrm{lens,\ CIB}}$, analogous to A_L for CMB
  $[\ln dN_{\mathrm{UNLENSED}} - \ln dN_{\mathrm{LENSED}}]_{\ell-\mathrm{band}}$
  $= q_{\mathrm{lens,\ CIB}} \times [\mathrm{Template}_{\mathrm{UNWEIGHTED}}]_{\ell-\mathrm{band}}$
- Can plot a *spectra* of $q_{\mathrm{lens,\ CIB}}$ - tweak parameters and iterate until flat to constrain parameters

Conclusion

- Websky CIB maps capture equilateral bispectra reasonably well
- CIB lensing increases power spectrum by ~1.5% and the 3-point and 4-point by 10~20% or more
- Relative entropy can be used to probe both intrinsic CIB parameters and lensing
- CIB non-Gaussianity provides extra information on top of its power spectrum
- Lensing pipeline can be used for any 3-D intensity fields
- CIB non-Gaussianity affects detection of primordial non-Gaussianity
- Change in CIB non-Gaussianity due to lensing could be important for next-generation surveys (like CMB-S4!)