Large Tensor Non-Gaussianity from Axion-Gauge Fields Dynamics (arXiv: 1707.03023)

Aniket Agrawal, Tomohiro Fujita, Eiichiro Komatsu

\[ \mathcal{L} = \mathcal{L}_{GR} + \mathcal{L}_\phi + \mathcal{L}_\chi - \frac{1}{4} F_{\mu \nu}^a F^{a \mu \nu} + \frac{\lambda \chi}{4 f} F_{\mu \nu}^a \tilde{F}^{a \mu \nu} \]

- Produces gravitational waves, over a large range of wave numbers that are highly non-Gaussian
- Without producing significant scalar non-Gaussianity
Vacuum or Sources?

- B mode => quantum gravity. Maybe not!

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Vacuum Fluctuation</th>
<th>Axion-Gauge-Fields Dynamics</th>
<th>Observable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scalar NG</td>
<td>small</td>
<td>small</td>
<td>$f_{NL}$</td>
</tr>
<tr>
<td>Scale independence of $P_h$</td>
<td>All scales</td>
<td>Over $&gt;5$ orders of $k$</td>
<td>$r$ or $P_h$</td>
</tr>
<tr>
<td>Tensor NG = $B_h/P_h^2$</td>
<td>$\sim 1$</td>
<td>$&gt;&gt;1$</td>
<td>B-mode bispectrum</td>
</tr>
<tr>
<td>Interpretation</td>
<td>QUANTUM GRAVITY</td>
<td>CLASSICAL GRAVITY, QUANTUM SOURCES</td>
<td></td>
</tr>
</tbody>
</table>
MITIGATING SYSTEMATICS IN FUTURE CMB SPACE MISSIONS

Ranajoy Banerji – APC, Paris

NORDITA, Stockholm – 17/07/2017
Next generation of CMB space missions

M6? CMB Probe?

LiteBIRD

Not only do we have to deal with foregrounds and the lensing signal.

Systematics will be a major contributor to the noise budget.

Typical sources of systematics

- Bandpass mismatch
- Beam asymmetry and misalignment
- Pointing inaccuracies
- Gain mismatch

These cause leakage of signal from Intensity to Polarisation
How do we approach the issue?

- Develop models of how the leakage projects on the timestream and polarisation maps
  \[ \mathbf{d} = \mathbf{AS} + \mathbf{T} \mathbf{y} + \mathbf{n}, \]
- Estimate and correct for the leakage signal
  \[ \mathbf{S} = \left( \mathbf{A}^T \mathbf{C}^{-1} \mathbf{F_T A} \right)^{-1} \mathbf{A}^T \mathbf{C}^{-1} \mathbf{F_T d} \]
- Requires End-2-End simulations to validate the techniques.

- Brute force estimation of leakage assuming knowledge of the beams
Extreme Scenarios

The tightest possible constraints on the power spectrum due to primordial black holes

arXiv:1706.10288

Philippa Cole
University of Sussex, United Kingdom
Supervised by Christian Byrnes
No PBHs forming in radiation domination

scale of PBHs decaying today

Planck measurement

PBHs forming in early matter phase

Planck measurement

Radiation domination, \( \delta = 0.42 \)
Investigating the bispectrum of secondary CMB sources with ACTPol

What is the bispectrum?

The data sets

KSW bispectrum estimator

\[ h_a(\sim \ell_1) h_a(\sim \ell_2) h_a(\sim \ell_3) \]

Optimal estimator for the template amplitude (ignoring the linear term as it is small for this work)

\[ \hat{f}_j = N_{j,i} 4\pi \int d\ell_1 d\ell_2 d\ell_3 \delta(\ell_1 + \ell_2 + \ell_3) b_T(\ell_1, \ell_2, \ell_3) C^{-1} a(\ell_1) C^{-1} a(\ell_2) C^{-1} a(\ell_3) \]

KSW exploits separability of the templates to allow for efficient computational evaluation

\[ b_T(\ell_1, \ell_2, \ell_3) = X(\sim \ell_1) X(\sim \ell_2) X(\sim \ell_3) \]

Komatsu and Spergel (2001)

William Coulton and the ACTPol collaboration (PU)

Bispectrum

How do we measure it?

- Deep56 field \( \sim 600 \) deg\(^2\)
- ACTPol 148GHz
- Planck 100GHz and 217GHz
# Current Measurements

<table>
<thead>
<tr>
<th>Type</th>
<th>Measured $f_{NL}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>lensing-tSZ</td>
<td>$0.68 \pm 0.41$</td>
</tr>
<tr>
<td>lensing-DSFG</td>
<td>$0.26 \pm 0.20$</td>
</tr>
<tr>
<td>lensing-ISW</td>
<td>$-6.84 \pm 9.59$</td>
</tr>
<tr>
<td>tSZ-tSZ-tSZ</td>
<td>$1.31 \pm 0.37$</td>
</tr>
<tr>
<td>tSZ-tSZ-DSFG</td>
<td>$1.54 \pm 0.62$</td>
</tr>
<tr>
<td>tSZ-DSFG-DSFG</td>
<td>$-1.23 \pm 0.86$</td>
</tr>
<tr>
<td>Poisson Radio</td>
<td>$1.00 \pm 0.14$</td>
</tr>
<tr>
<td>radio-DSFG-tSZ</td>
<td>$7.72 \pm 1.50$</td>
</tr>
<tr>
<td>DSFG Poisson and Clustered</td>
<td>$0.87 \pm 0.57$</td>
</tr>
<tr>
<td>radio-tSZ</td>
<td>$3.07 \pm 0.63$</td>
</tr>
<tr>
<td>radio-DSFG</td>
<td>$1.07 \pm 1.66$</td>
</tr>
</tbody>
</table>
SPIDER (balloon-borne CMB polarimeter) (w/ J. Gudmundsson)


Simulate temperature-to-polarization leakage + E/B mixing due to asymmetric beams.

- Jointly infer sky + beams w/ Hamiltonian Monte Carlo.
Estimate the CMB $BTT$-correlation (also $BTE$, $BEE$) w/ D. Meerburg

- Non-vanishing in parity-conserving universe
- Unconstrained observable:
  - Natural to cross-correlate low-resolution B-mode experiments w/ high resolution TT, TE, EE observations to obtain squeezed limit.
  - Constrains primordial scalar-tensor non-Gaussianity:
    \[ \langle BTT \rangle \sim \langle \gamma_\sigma(k_1)\zeta(k_2)\zeta(k_3) \rangle \]
    (e.g. see Lee, Baumann, Pimentel, 2016 for signal due to massive spin fields during inflation)

→ Working on full-sky (KSW-like) cubic estimator
  - For all combinations of T, E, B
Impact of modeling foreground uncertainties on future CMB polarization satellite experiments

Carlos Hervías-Caimapo
Anna Bonaldi
Michael L. Brown
Jodrell Bank Centre for Astrophysics, University of Manchester
Forecast on the detectability of $r=10^{-3}$.

Assuming 1% error on $\beta_{\text{syn}}$ and $\beta_{\text{dust}}$

Assuming 0.5% error on $\beta_{\text{syn}}$ and $\beta_{\text{dust}}$

Main conclusion: foregrounds characterization must be very accurate to hope to measure $r=10^{-3}$
Cluster-Scale CMB Lensing

Ben Horowitz (UC Berkeley) w/ Sherwin, Ferraro

(Zaldarriaga, Seljak 1999)

Gradient Approximation

\( \tilde{T}(\theta_y) - T(\theta_y) \approx \alpha(\theta_y) \frac{dT}{d\theta_y} \)

Lensed
Deflection
Unlensed
Gradient

Idea: Gradient of CMB is roughly constant on small scales, so essentially just divide out the gradient to get the deflection!

Matched Filter on Temperature

\( \tilde{T}(\theta) = A g(\theta) + n(\theta) \)

Filter Amplitude
Profile
“Noise”

Estimated Amplitude

\( \hat{A} = \int \Psi(\theta) \tilde{T}(\theta) d^2\theta \)
More accurate mass estimates than quadratic estimator at low noise

Assuming NFW profile with known concentration and redshift

(Preliminary)

Hu, De Deo, Vale (2007)