~~CMB Lensing and Large Scale Structure~~

Lensing Working Group Update

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Observations

1. We don't know how much polarized CMB lensing will help cosmological parameters. Need careful comparisons to see if it will improve on Planck/JDEM/ground.
2. We have not established the robustness of the convergence power spectrum and de-lensing algorithms to sky cuts and foregrounds.
3. The polarized lensing community is extremely small. The (weighted) number of people working on data processing, systematics, and foreground issues is of order unity.
4. Observations #1 and #2 are because of #3: there's (almost) nobody working on it.

Plans & needs

1. LWG will conduct a DETF-like study to quantify parameter improvements from idealized CMB lensing versus other planned projects. Should establish science case in light of recent developments.
2. We know (within plausible assumptions) how to forecast point source contamination, expected to dominate. Can only do oversimplified calculations for Galactic foregrounds. This will be a spinoff paper.
3. What is the priority level of de-lensing investigations? The mission concept is extremely open-ended. We need guidance from viewers like you. (See last slide.)

The context

On CMBPOL timescale, we “will” have:

- Planck
- Stage II/III ground surveys:
  - Optical/photometric: DES, Pan-STARRS, …
  - BAO surveys: WiggleZ, SDSS-III (or something similar), …
  - SZ: ACT, SPT
- JDEM (in some form)
- LSST?

… and maybe more

Dark energy: constant w

- Today: w to ±0.065 (1σ) from WMAP+BAO+SN (Komatsu et al 2008) with Ω_k floating
- DETF projections (including Planck + Stage II data) for Stage III (Albrecht et al 2006):
  - σ(w)~0.03
  - result essentially the same for all methods
- +JDEM or LSST: ~0.015 (×÷?)
- *Ideal* CMB experiment including lensing (Hu 2002), *assuming flatness*: σ(w)=0.06.

- CMBPol is not a constant w experiment.

Dark energy: varying w

- DETF endorsed(?) w_0,w_a parameterization:

$$w(a) = w_0 + (1-a)w_a$$

- Stage III: $\sigma(w_a) \sim 0.2$
- +JDEM or LSST: $\sigma(w_a) \sim 0.1$ (×÷?)
- Could allow more complicated a dependence, early dark energy?

- CMB lensing constraints coming soon. (LWG)

Neutrino masses

- Upper limits on m_ν: ~0.2 eV (marginalized w, WMAP5+SN+BAO; Komatsu et al 2008)
- CMBPOL projected: 0.04 eV (3' beam, 1.4 μK') … but with no external data, marginalized w, α_s, Y_{He} (Kaplinghat et al 2004)
- Clear need to understand degeneracies and compare future projects in the same model space.

Other ideas?

- Possibilities for high-l polarization:
  - Number of neutrino species. Dark radiation?
  - Scalar spectrum: α_s, $d\alpha_s/d\ln k$, WDM/C+WDM … ?
  - Modified gravity?
  - Non-Gaussianity?
  - "Neutrino" isocurvature mode?
  - Chern-Simons terms?
  - Test recombination history/exotic sources of ionization at recombination epoch.
- Some improvements will be from lensing, others from reaching CV limit on high-l E-mode, others may require both.

De-lensing options

<table>
<tr><th colspan="2">Mission strategy</th><th>Implication for de-lensing</th></tr>
<tr><td colspan="2">1. Recombination + lensing from space</td><td rowspan="2">Lots of work on higher-order correlation functions & algorithms</td></tr>
<tr><td rowspan="3">2. Recombination peak only</td><td>a) De-lensing with ground high-l B-mode</td></tr>
<tr><td>b) Partial de-lensing with LSS</td><td>Less challenging? but misses most of the lensing B-mode power</td></tr>
<tr><td></td><td>c) No de-lensing</td><td rowspan="2">Go home</td></tr>
<tr><td colspan="2">3. Reionization peak only</td></tr>
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