Can we detect tensor B modes using galaxy delensing?

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Great Lakes Cosmology Workshop, June 1, 2007
CMB temperature and polarization spectra
The lensing contamination:

Convolution in Fourier space between E modes and the lensing potential:

\[C_{l}^{WL} = \int \frac{d^2 l'}{(2\pi)^2} \left[ (\vec{l} - \vec{l}') \cdot \vec{l}' \right]^2 \sin^2[2(\phi_{l'} - \phi_{l})] C_{|\vec{l}-\vec{l}'|}^{\psi} C_{l'}^{E}.\]
Unlensed E mode

Lensed E mode

Deflection field

Lensing B mode

The lensing potential estimator

\[ \hat{\phi}_i(\theta) = \int_0^\chi_\infty W_i(\chi) \Phi^{3D}(\chi \theta, \chi) \]

redshift bin i  lensing kernel

\[ \hat{\phi}_{\text{CMB}}(l) = \sum_i \alpha_i(l) \hat{\phi}_i(l) \]

projected potential of source bin i

\[ R(l) \equiv \hat{\phi}_{\text{CMB}}(l) - \phi_{\text{CMB}}(l) \]
The variance of the residual:

for LST:  
$n = 30 \text{ gal/sqarcmin}$

for SNAP & BOX:  
$n = 100 \text{ gal/sqarcmin}$
Can we delens the CMB using this estimator?
$r_{\text{min}}$ as a function of CMB instrumental noise

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**Graph Description:**

- The graph illustrates $r_{\text{min}}$ as a function of $w^{-1/2}$ (μK arcmin).
- The x-axis represents $w^{-1/2}$ (μK arcmin), while the y-axis shows $r_{\text{min}}$ on a logarithmic scale.
- Different lines represent different setups:
  - No delensing
  - LST
  - SNAP
  - SNAP with $z_{\text{max}} = 5$
  - SNAP with $z_{\text{max}} = 10$
  - SNAP with $z_{\text{max}} = 20$

- The Planck results are denoted by a diamond symbol.
- The CMBpol results are denoted by a star symbol.

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**Notes:**

- The graph compares the performance of different setups in terms of $r_{\text{min}}$.
- The x-axis values range from 1 to 100, with corresponding $w^{-1/2}$ values.
- The y-axis values range from $10^{-6}$ to $10^{-1}$.

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**Keywords:** CMB, instrumental noise, $r_{\text{min}}$, Planck, CMBpol.
Dependence of $r_{min}$ on WL survey parameters

CMBpol noise level

$7 \times 10^{-5}$

$8 \times 10^{-6}$

$n$ (galaxies/arcmin$^2$)

Log(1+$z$)
Conclusions

- low foreground residuals + low instrumental noise delensing with galaxies surveys can be useful.

- for accurate delensing, one needs a survey that goes at least up to $z_{\text{max}}$ of 20; but the source concentration, $n$, need not high.

- galaxy delensing does NOT require high resolution in the CMB maps.

- galaxy delensing does not suffer from foreground problems.