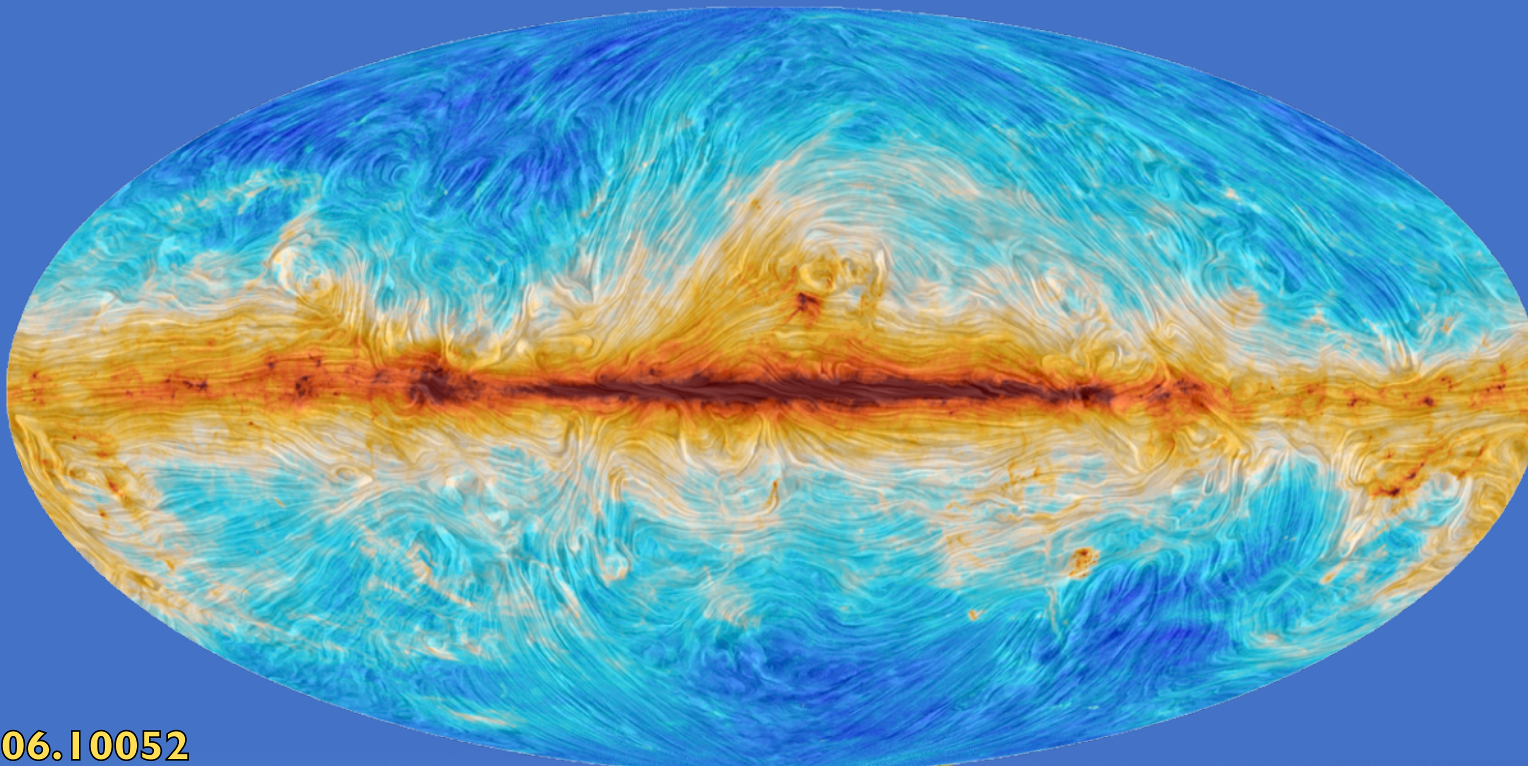
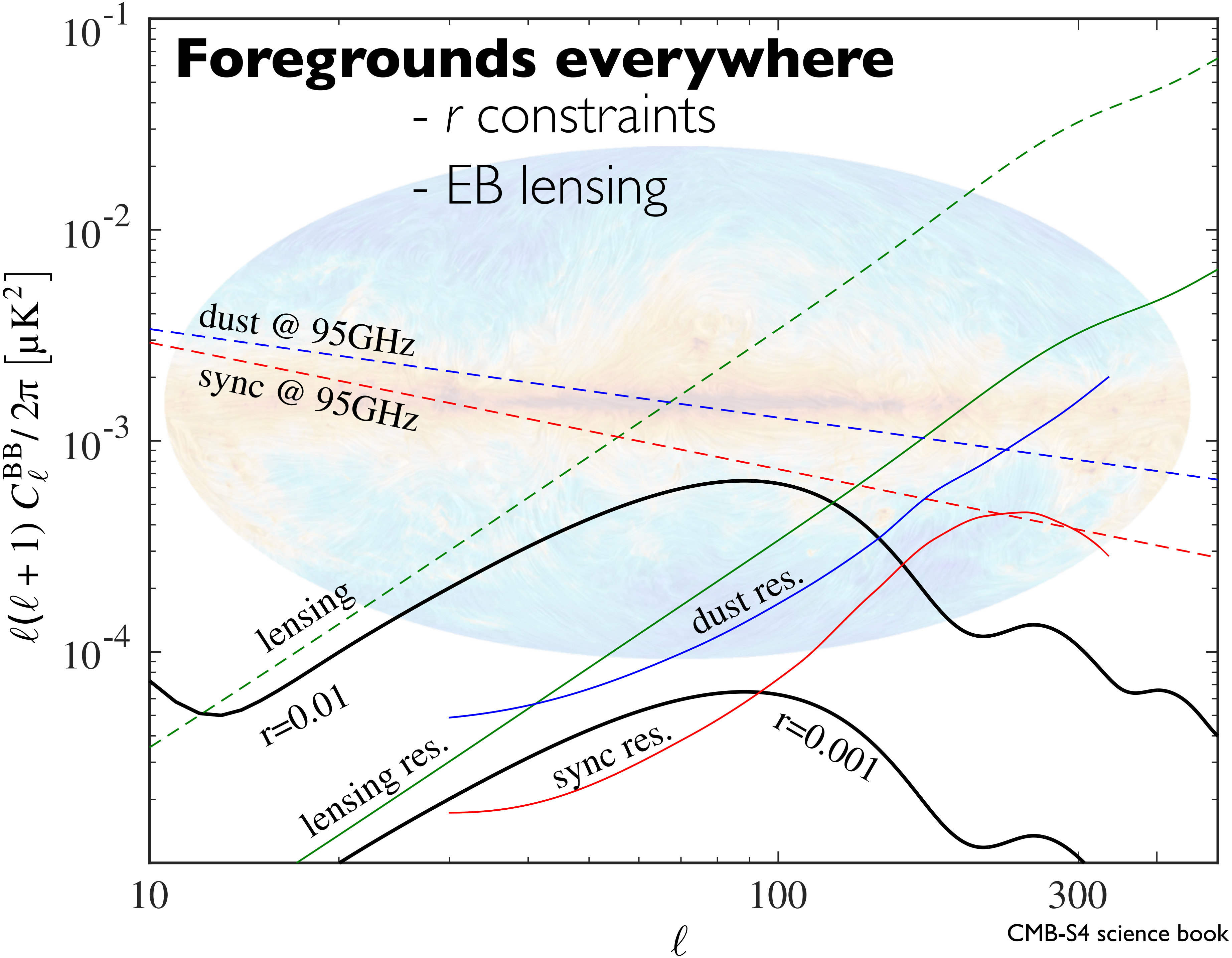
Modeling of small-scale non-Gaussian Galactic foregrounds



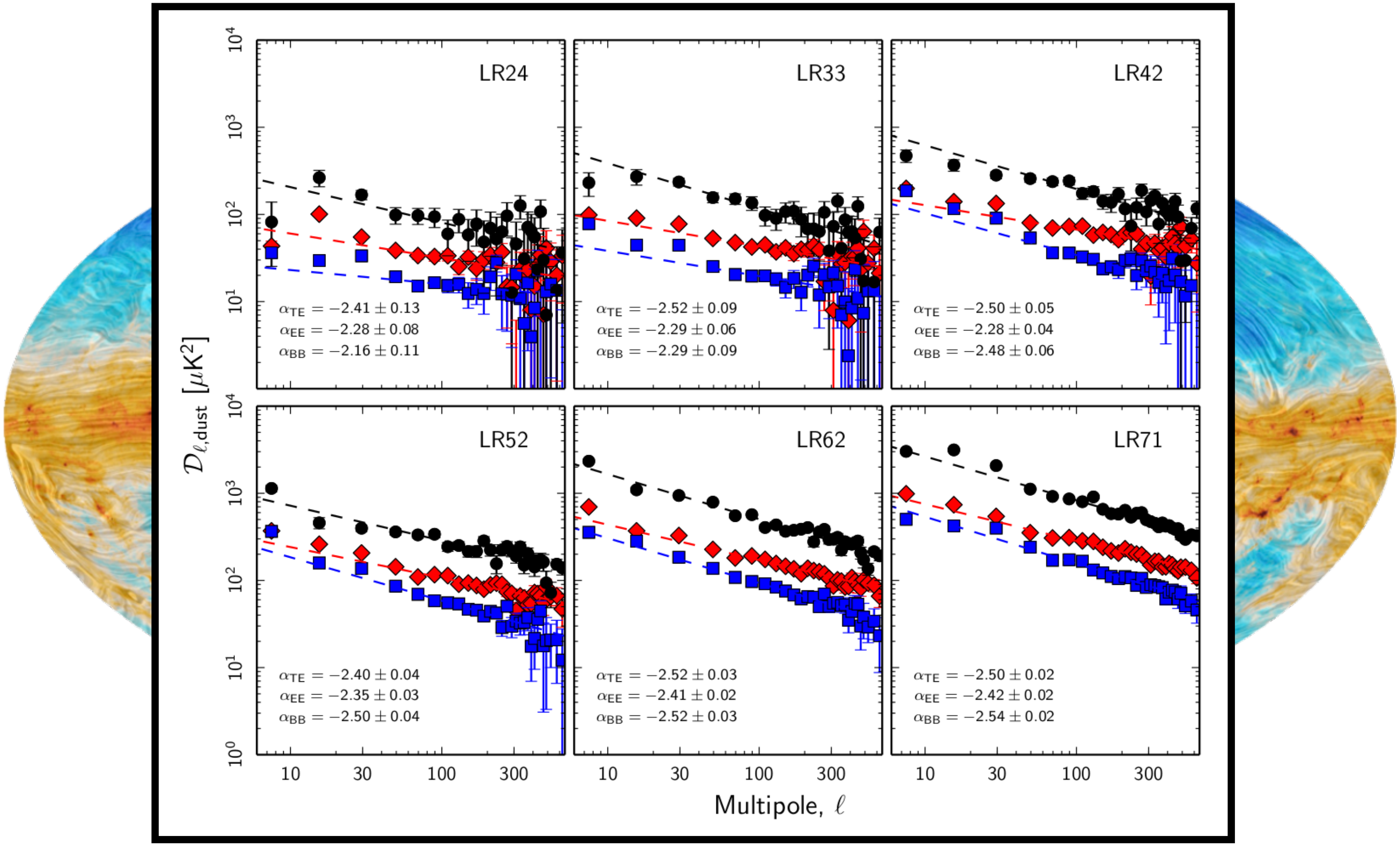
arXiv:1906.10052

Kevin M. Huffenberger (FSU)
also Aditya Rotti (Manchester)
David C. Collins (FSU)



Foregrounds everywhere
- r constraints
- EB lensing
dust @ 95GHz
sync @ 95GHz
lensing
r=0.01
dust res.
lensing res.
sync res.
r=0.001
10^{-1}
10^{-2}
10^{-3}
10^{-4}
$\ell(\ell+1)\,C_\ell^{BB}/2\pi\ [\mu K^2]$
10
100
300
ℓ
CMB-S4 science book

Dust power spectrum properties

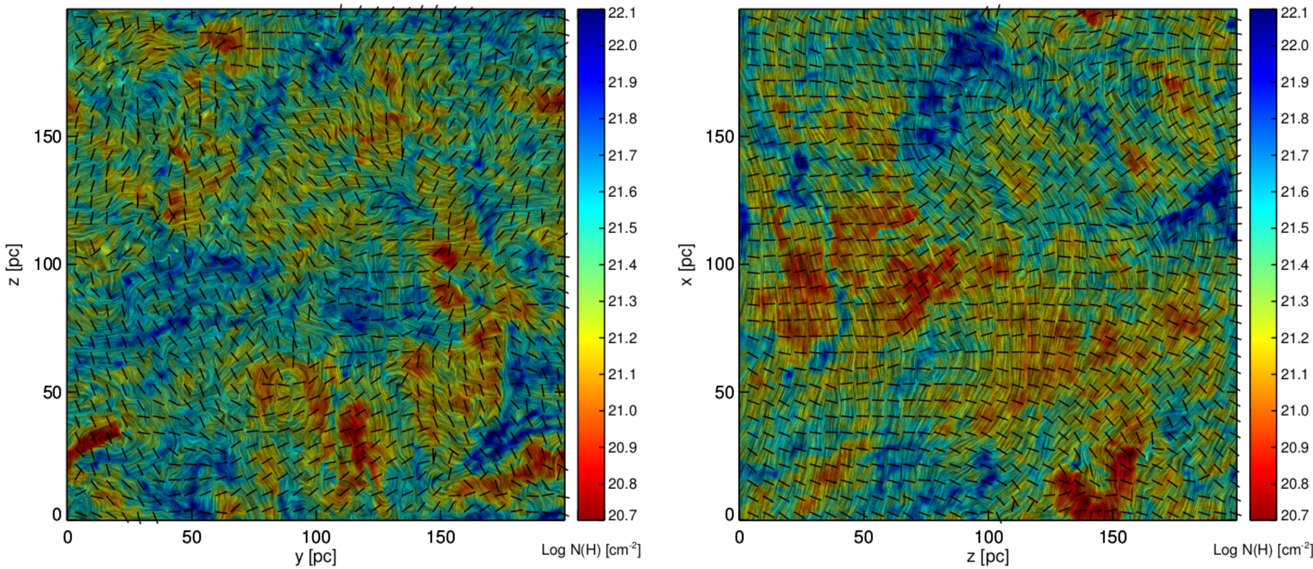


$C_l^{BB} \propto l^{-2.42}$ $\qquad$ $C_l^{BB} / C_l^{EE} = 0.5$ $\qquad$ $r^{TE} = 0.36$

$r^{TB} = 0.05$

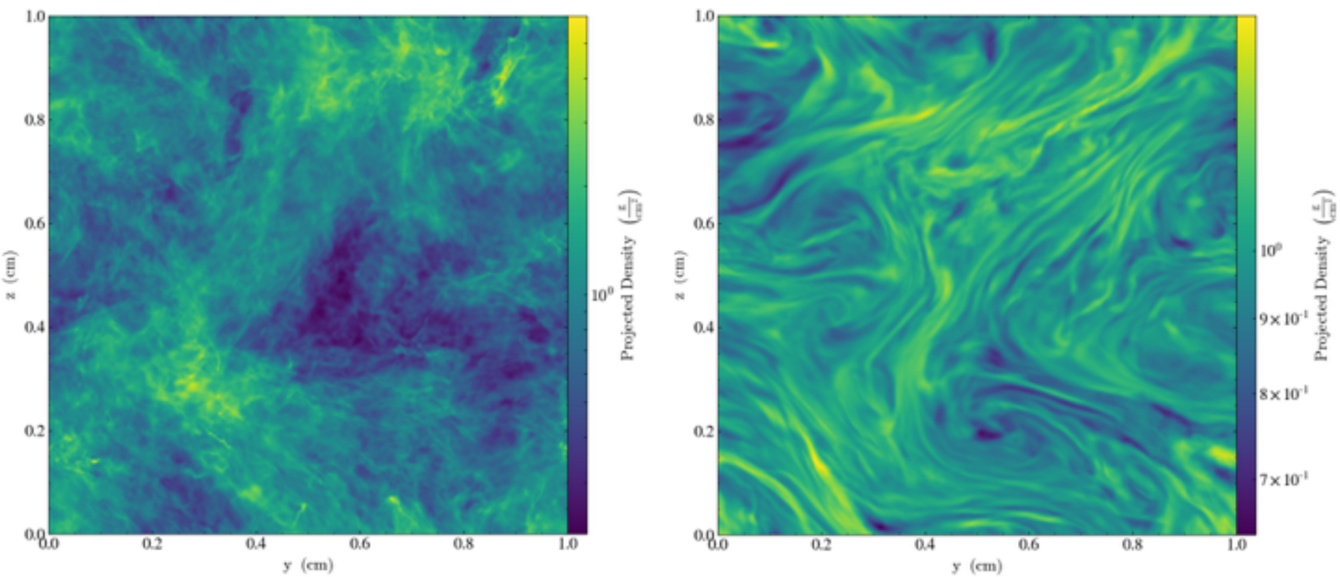
Planck 2016, 2018

MHD sims show non-Gaussianity



... but many sky models are Gaussian on small scales.

Kritsuk, Flauger et al 2017

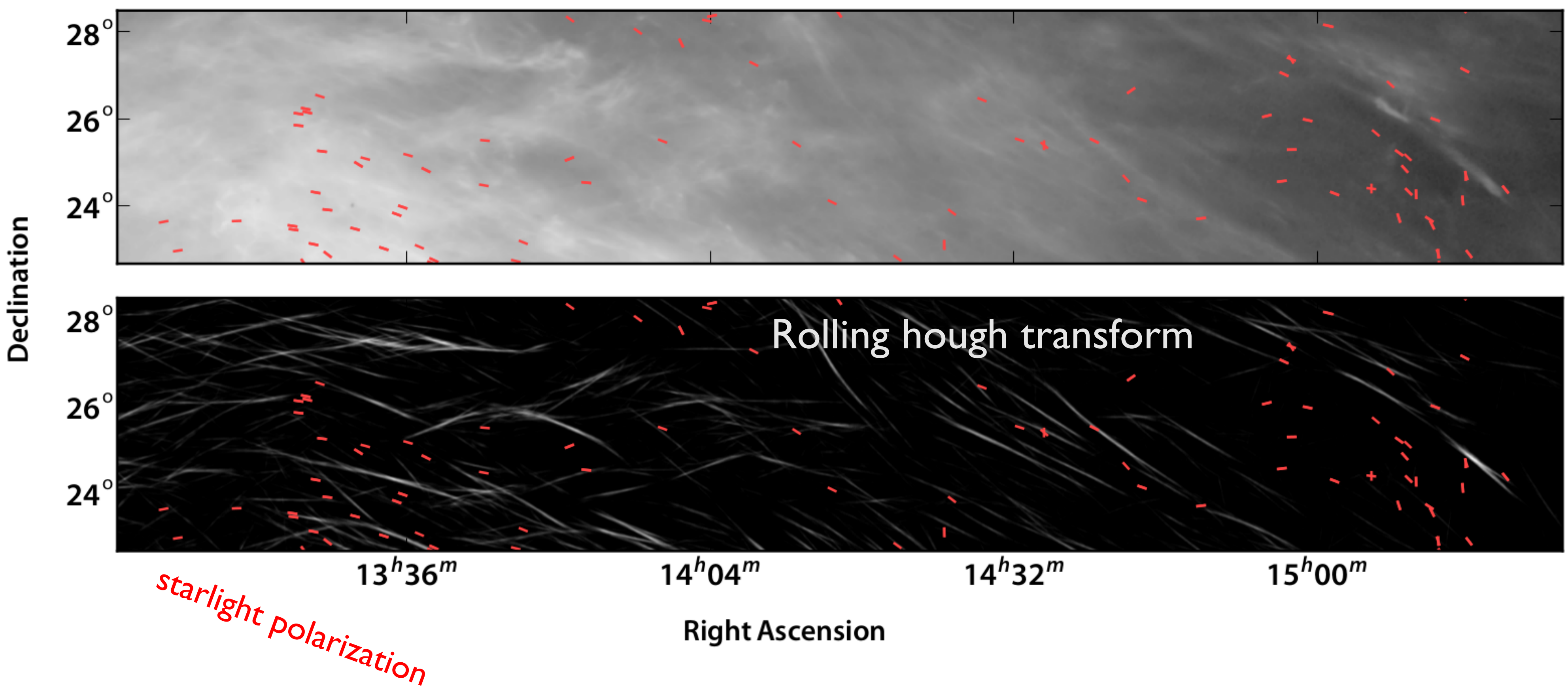


David Collins, Kye Stalpes (FSU)

Can we gain insight with simpler models?

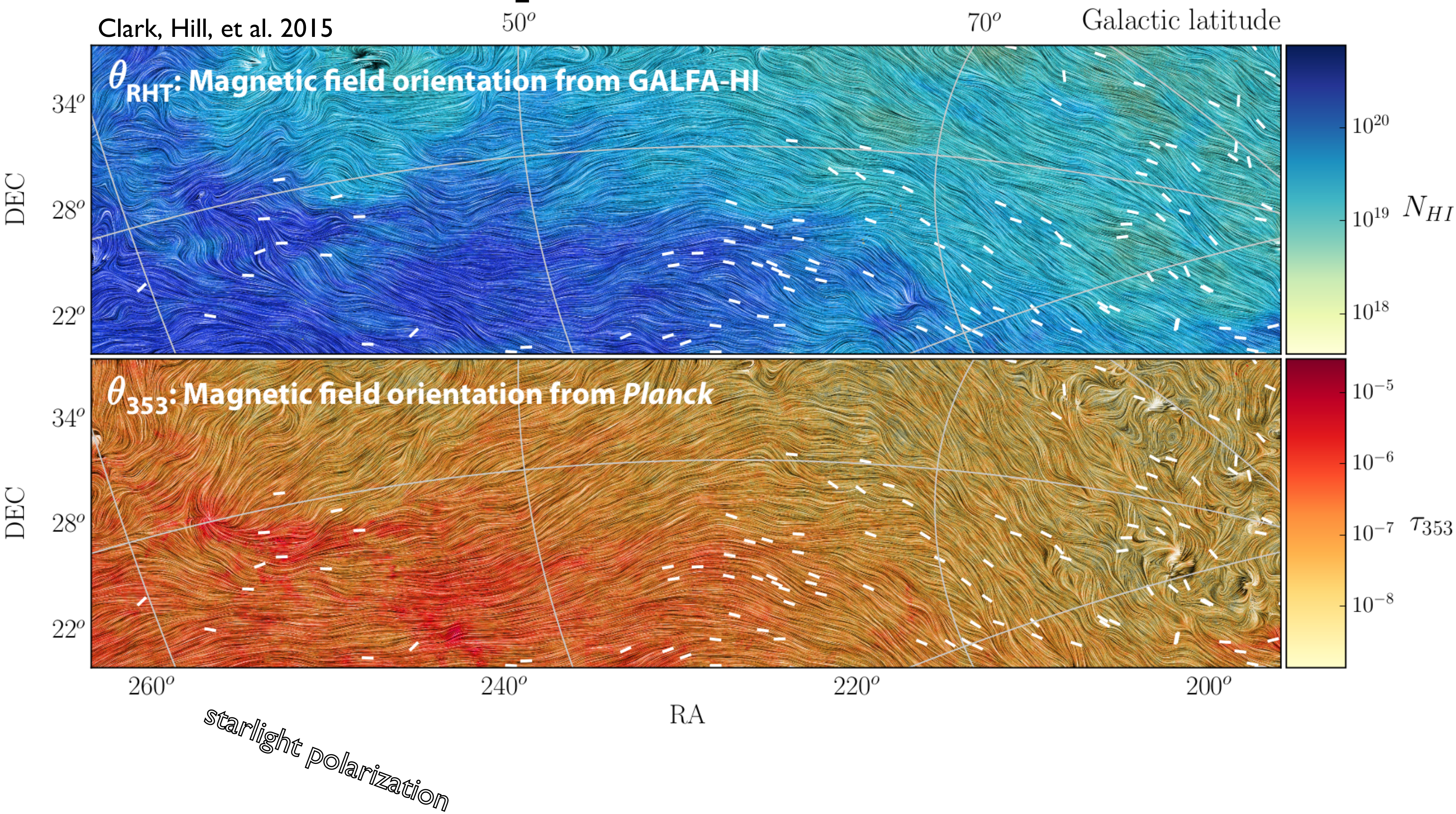
Fibers in neutral hydrogen

Clark+ 2014

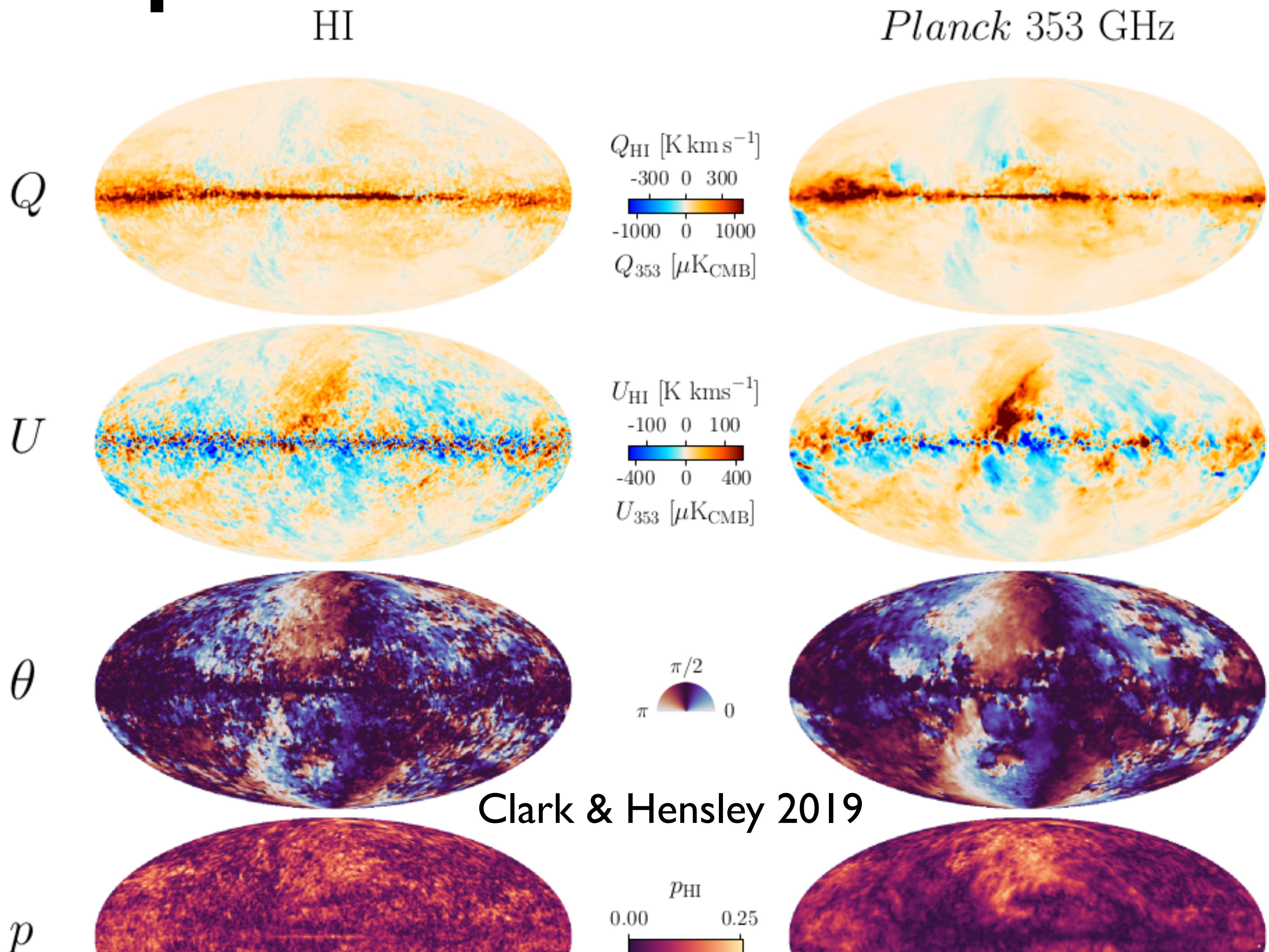


Filament orientation correlates to Planck dust polarization

Clark, Hill, et al. 2015



HI-pol. model with r > 0.75



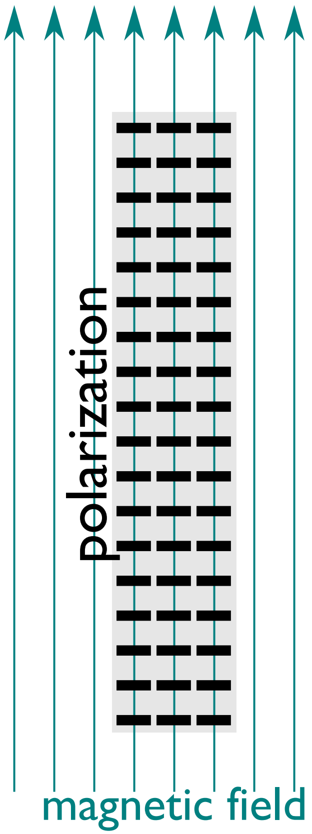
Clark & Hensley 2019

If the foreground was all filaments, what properties reproduce the power spectra?

What are implications for lensing, other statistics?

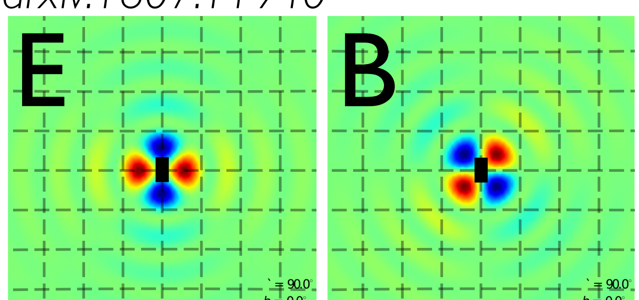
I don't have the answer yet.

Polarization of magnetized filament

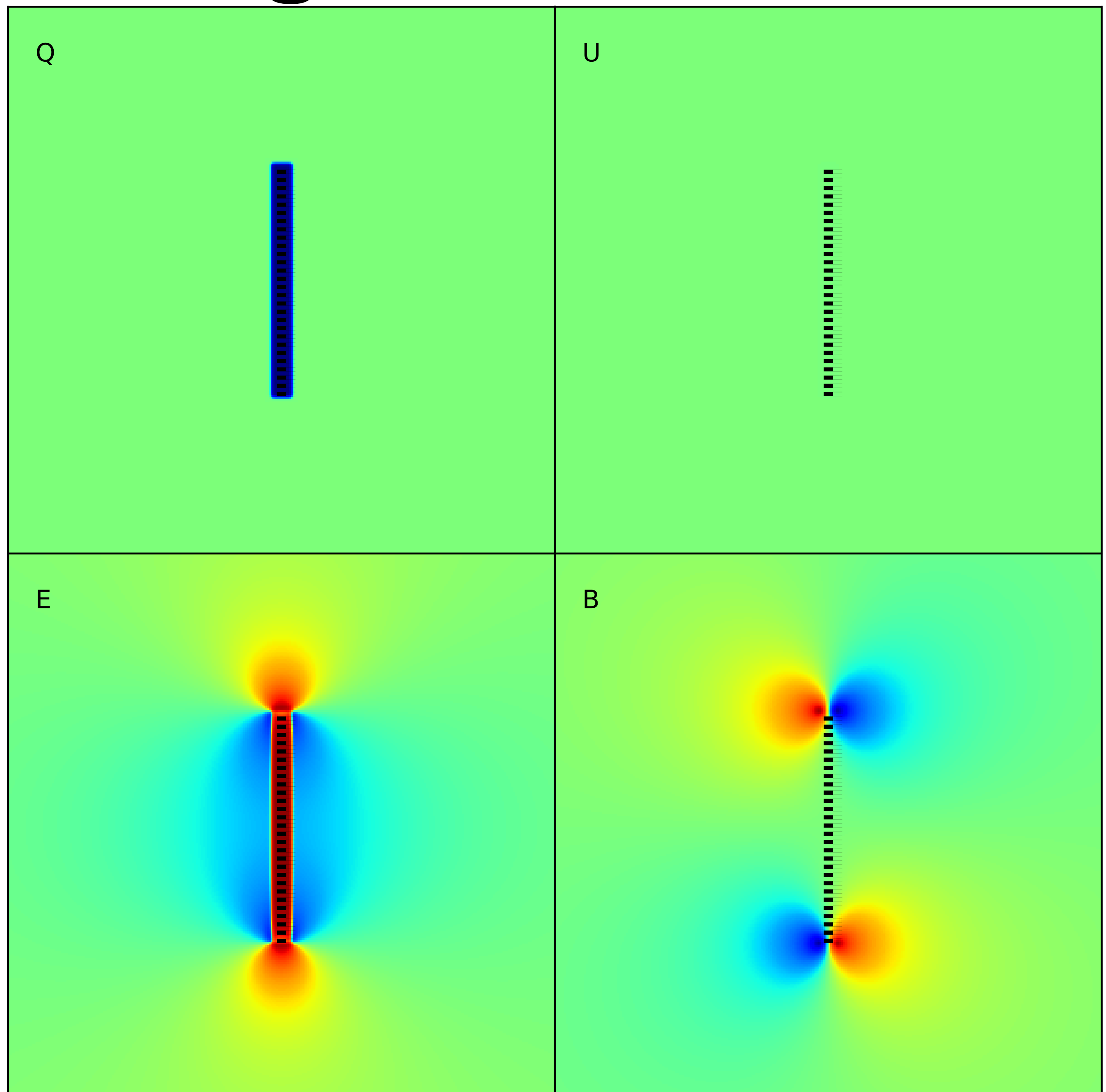


Rotti & Huffenberger

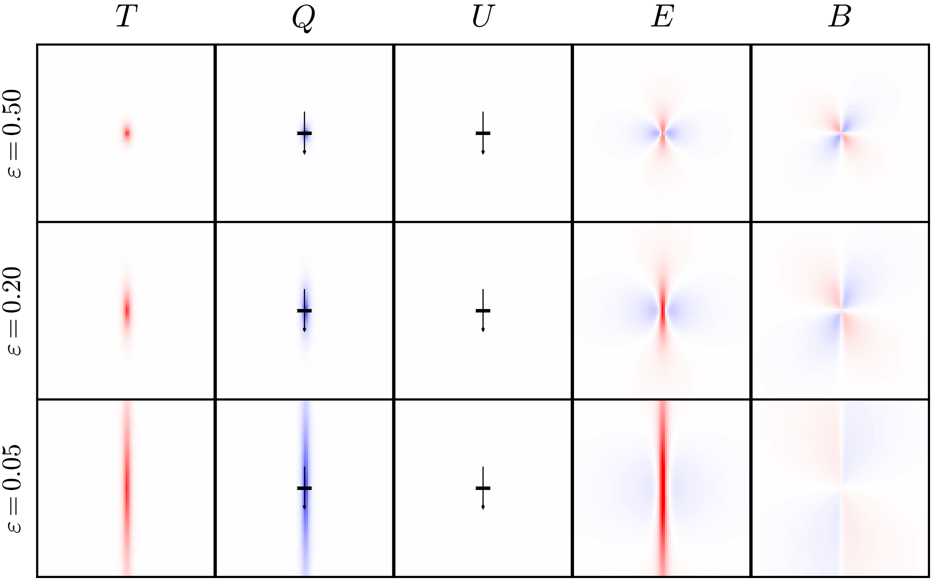
arxiv:1807.11940



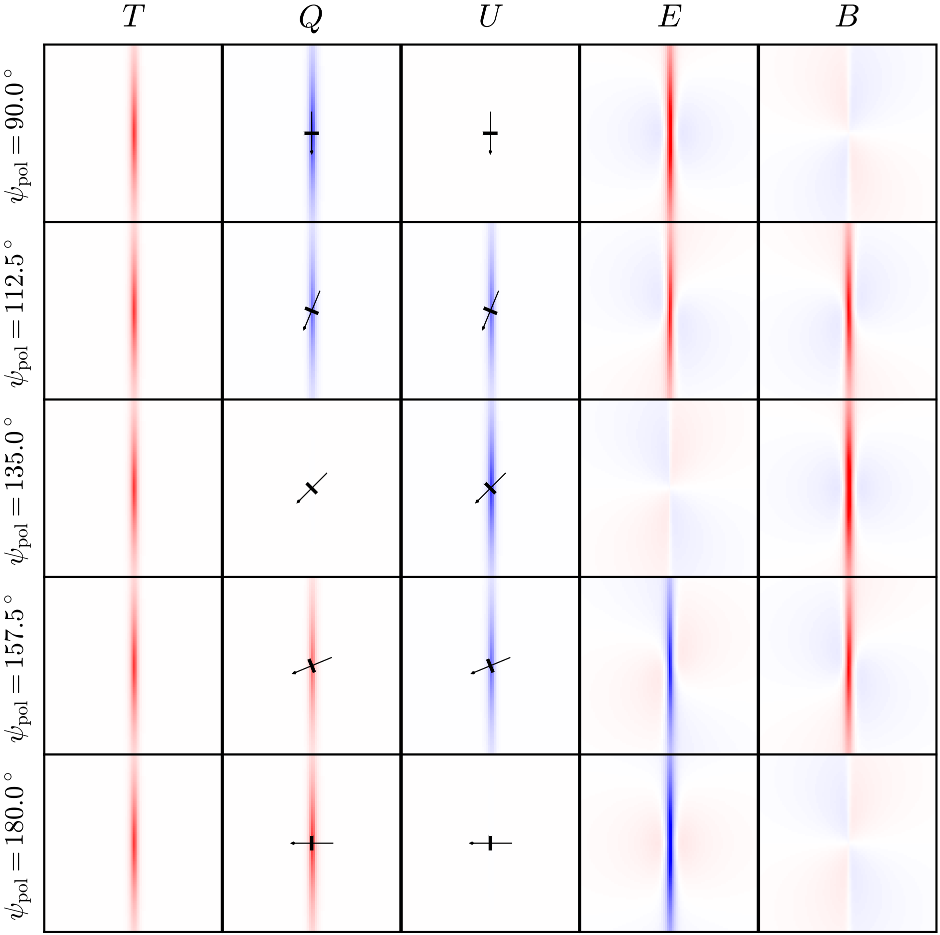
Green's Function pol→EB



Polarized Filament



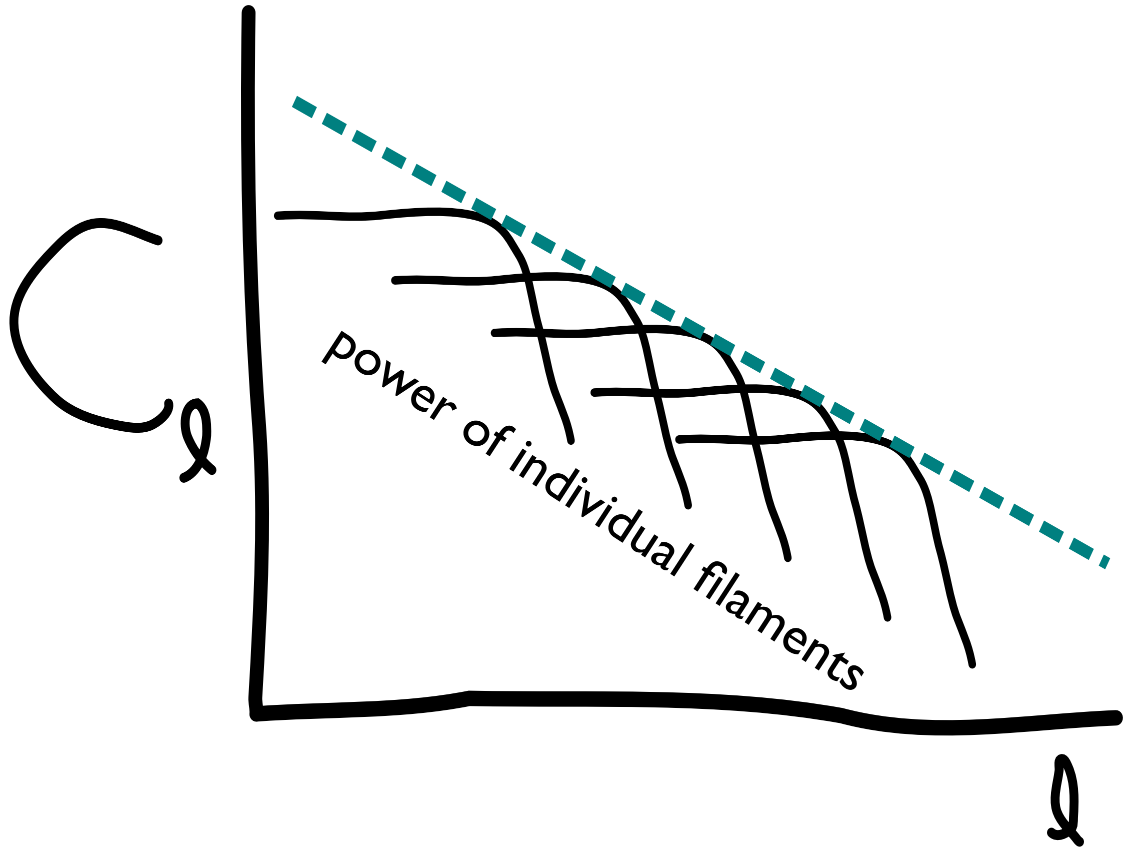
T
Q
U
E
B
$\varepsilon = 0.50$
$\varepsilon = 0.20$
$\varepsilon = 0.05$



T
Q
U
E
B
$\psi_{\rm pol} = 90.0^\circ$
$\psi_{\rm pol} = 112.5^\circ$
$\psi_{\rm pol} = 135.0^\circ$
$\psi_{\rm pol} = 157.5^\circ$
$\psi_{\rm pol} = 180.0^\circ$

Filament (halo) model

Huffenberger, Rotti, Collins 2019
arXiv:1906.10052



$$C_\ell^{EE} = \frac{1}{2\pi}\int d\phi_\ell \int d\alpha\; n(\alpha)\; |E(\boldsymbol{\ell},\alpha)|^2,$$

$$C_\ell^{BB} = \frac{1}{2\pi}\int d\phi_\ell \int d\alpha\; n(\alpha)\; |B(\boldsymbol{\ell},\alpha)|^2,$$

$$C_\ell^{TE} = \frac{1}{2\pi}\int d\phi_\ell \int d\alpha\; n(\alpha)\; T(\boldsymbol{\ell},\alpha)E(\boldsymbol{\ell},\alpha)^*$$

integrate over population of filaments

Slope scaling relation

$$C_\ell = \int d\alpha_0 \; n(\alpha_0)\alpha_0^q F(\alpha_0^r \ell)$$

$$n(\alpha_0) \propto \alpha_0^p$$

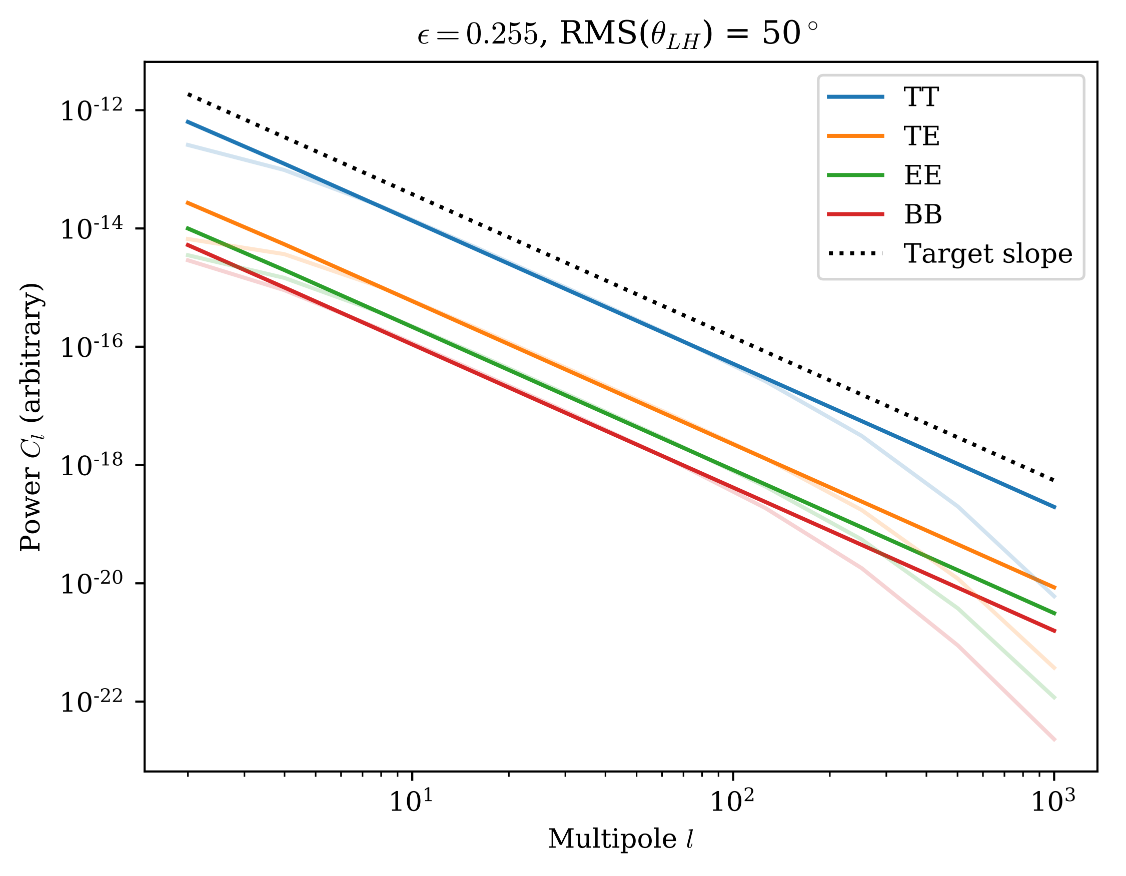
$$\Bigg\} \quad C_\ell \propto \ell^{-(p+q+1)/r}$$

For the size of filament:

q = 6 (solid angle, column density)

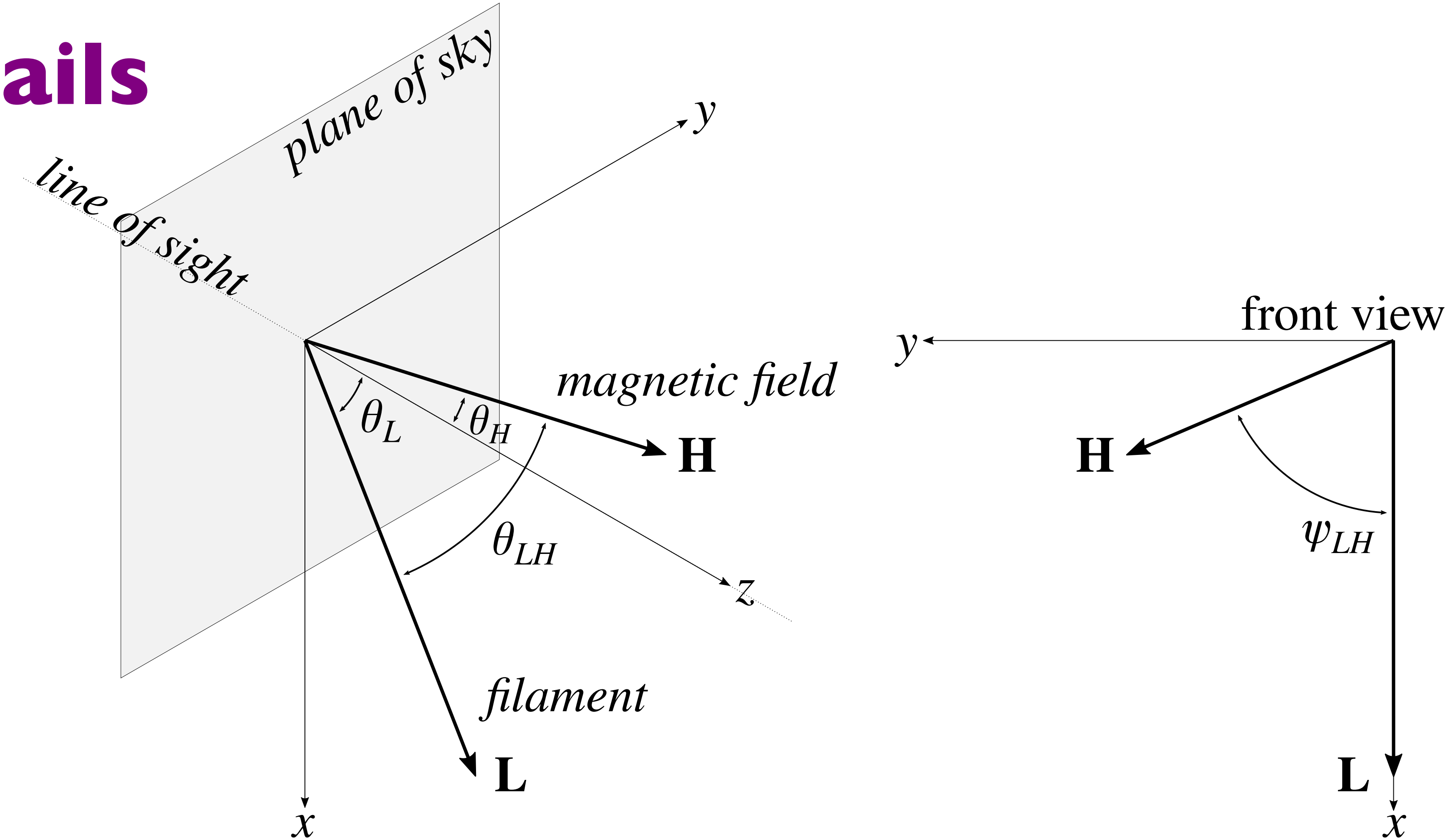
r = 1 (trigonometry)

$C_l \propto l^{-2.42}$ implies $n(L) \propto L^{-4.58}$

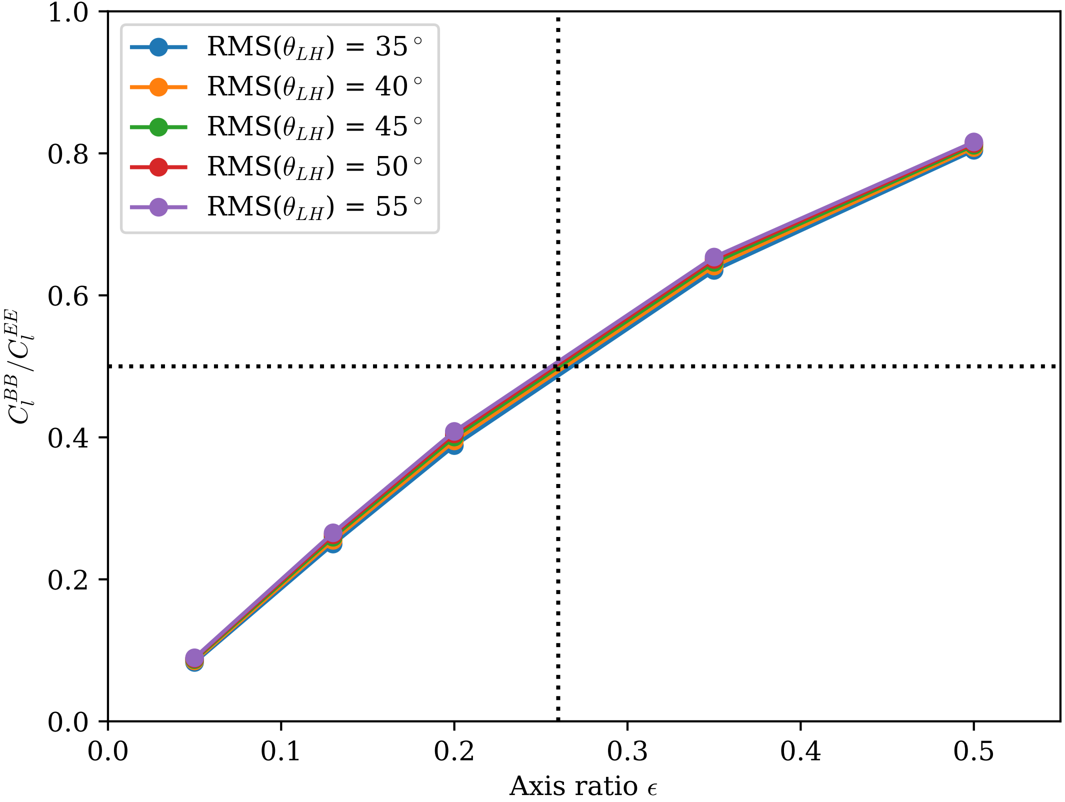


$\epsilon = 0.255$, RMS(θ_{LH}) = 50°
TT
TE
EE
BB
Target slope
Power C_l (arbitrary)
Multipole l
10^{-12}
10^{-14}
10^{-16}
10^{-18}
10^{-20}
10^{-22}
10^{1}
10^{2}
10^{3}

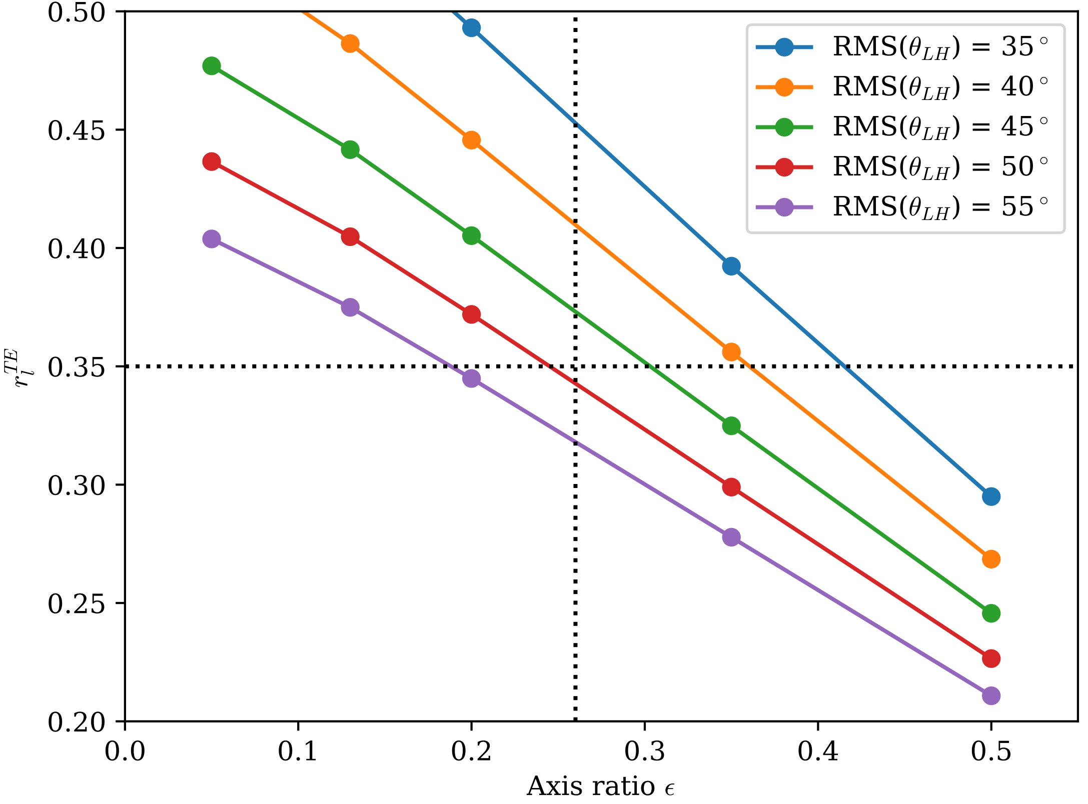
Details



- Filaments in all orientations
  - Column density
  - Polarization fraction
- Magnetic field angular separation (Gaussian)



RMS(θ_{LH}) = 35°
RMS(θ_{LH}) = 40°
RMS(θ_{LH}) = 45°
RMS(θ_{LH}) = 50°
RMS(θ_{LH}) = 55°
C_l^{BB}/C_l^{EE}
Axis ratio ϵ
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.1
0.2
0.3
0.4
0.5



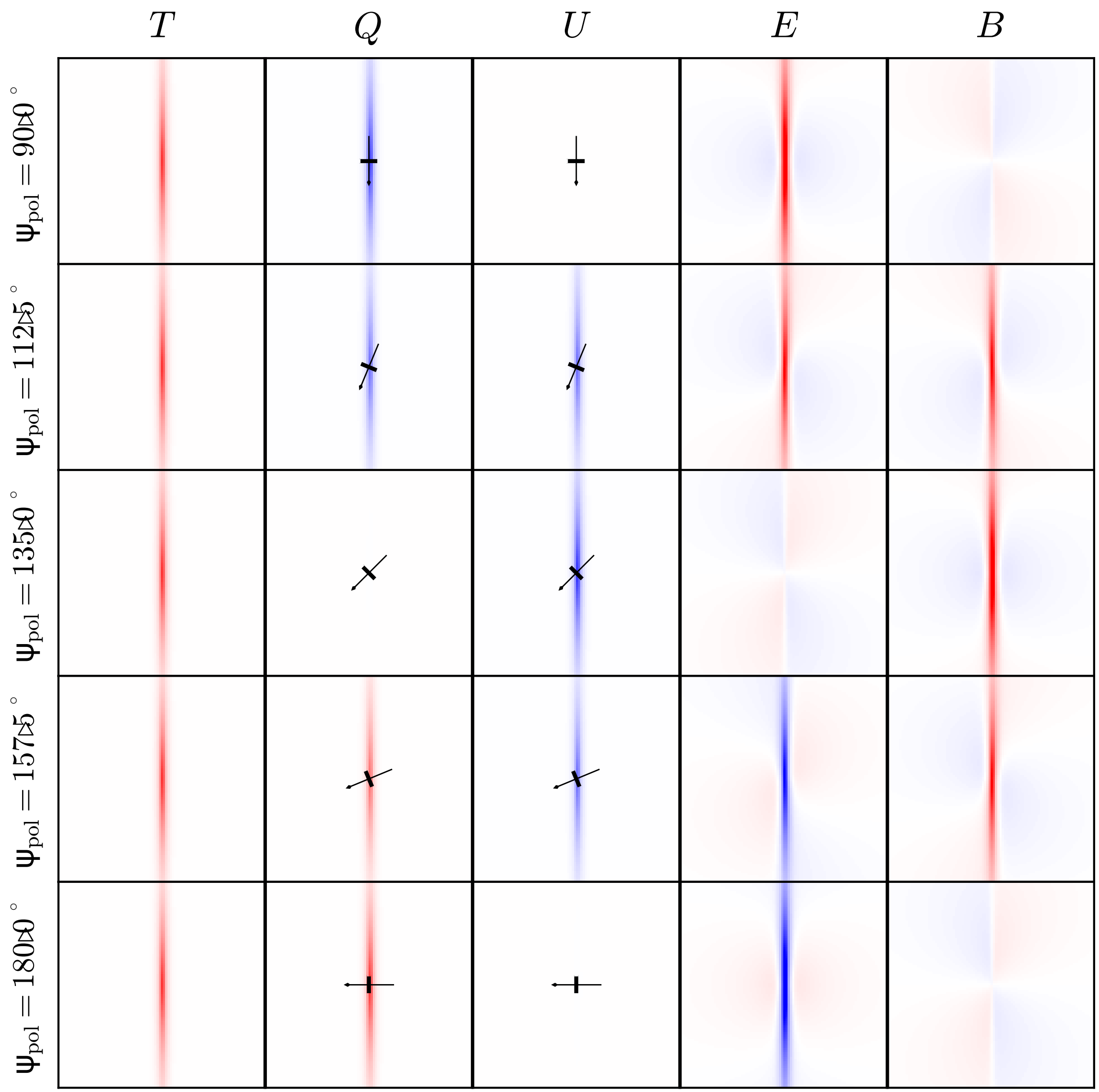
RMS(θ_{LH}) = 35°
RMS(θ_{LH}) = 40°
RMS(θ_{LH}) = 45°
RMS(θ_{LH}) = 50°
RMS(θ_{LH}) = 55°
0.50
0.45
0.40
0.35
0.30
0.25
0.20
r_l^{TE}
0.0
0.1
0.2
0.3
0.4
0.5
Axis ratio ϵ

TB correlation?

Not naturally...

Favor counter-clockwise twists of filament relative to magnetic field.

55-45 vs. 50-50



Lensing bias

Lensing pow. spectrum: 4-point func. of *T*,*E*,*B*

Can compute <TEEB>,<TBTB>, etc. and weight appropriately...

Dependence on profile? Filament 2-pt correlations?

Easier to generate realizations of filaments? (see "Sky Modeling," parallel 4)

Conclusions

Filament models provides intuition about the possible non-gaussian structure of pol. foregrounds.

Concrete relationships exist between power spectrum observables and the filament population.

4-pt measures can quantify foreground bias to lensing. (Also look for FG residuals.)