Recent studies on gauge fields using CMB and galaxy correlators

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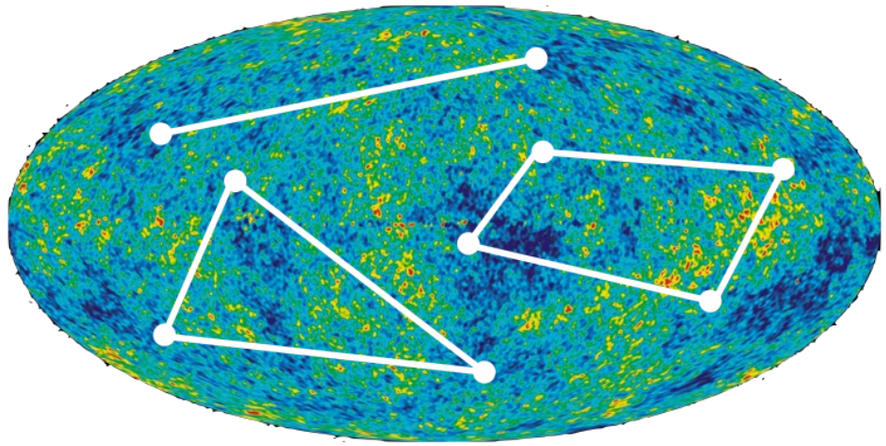
Theoretically, (spin-1) gauge fields coupled to axions generate characteristic (and sizable) P-odd non-Gaussianities at primordial stages!

- GW sector ➡ [Fujita, Murai, Obata, MS: JCAP 01, 007 (2022)]
- scalar sector ➡ [Fujita, Murata, Obata, MS: JCAP 05, 127 (2024)]

cross-area paper: B01xB06

➡ probing P-odd signals in higher-order CMB correlators is also important!



☆bispectra $\langle a_{\ell_1 m_1} a_{\ell_2 m_2} a_{\ell_3 m_3} \rangle$

target P-odd signals: $\ell_1 + \ell_2 + \ell_3 = \begin{cases} \text{odd} & \text{in, e.g., TTT, EEE} \\ \text{even} & \text{in, e.g., BBB} \end{cases}$

☆trispectra $\langle a_{\ell_1 m_1} a_{\ell_2 m_2} a_{\ell_3 m_3} a_{\ell_4 m_4} \rangle$

target P-odd signals: $\ell_1 + \ell_2 + \ell_3 + \ell_4 = \text{odd}$ in, e.g., TTTT, EEEE

3-pt correlators (bispectra) violate parity ?

model-independent null tests in [Philcox, MS: PRD 109, 063522 (2024)]
➡ no significant P-odd signals (< 1.5σ)!

⭐Limits on an amplitude parameter of P-odd GW bispectrum $f_{\rm NL}^{ttt}$

WMAP T [MS, Liguori, Fergusson: JCAP 01, 007 (2015)]	$(80 \pm 110) \times 10^2$
Planck T + E [Planck Collaboration: A&A 641, A9 (2020)]	$(1 \pm 18) \times 10^2$
Planck T + E + B [Philcox, MS: PRD 109, 063522 (2024)] [Philcox, MS: arXiv 2409.10595]	$(-0 \pm 14) \times 10^2$

e.g., $\mathscr{L} = -\frac{1}{2}(\partial\phi)^2 - V(\phi) - \frac{1}{4}F^2 - \frac{\alpha}{4f}\phi F\tilde{F}$ ➡ $\xi = \frac{\alpha|\dot{\phi}|}{2fH} < 3.3$

4-pt correlators (trispectra) violate parity ?

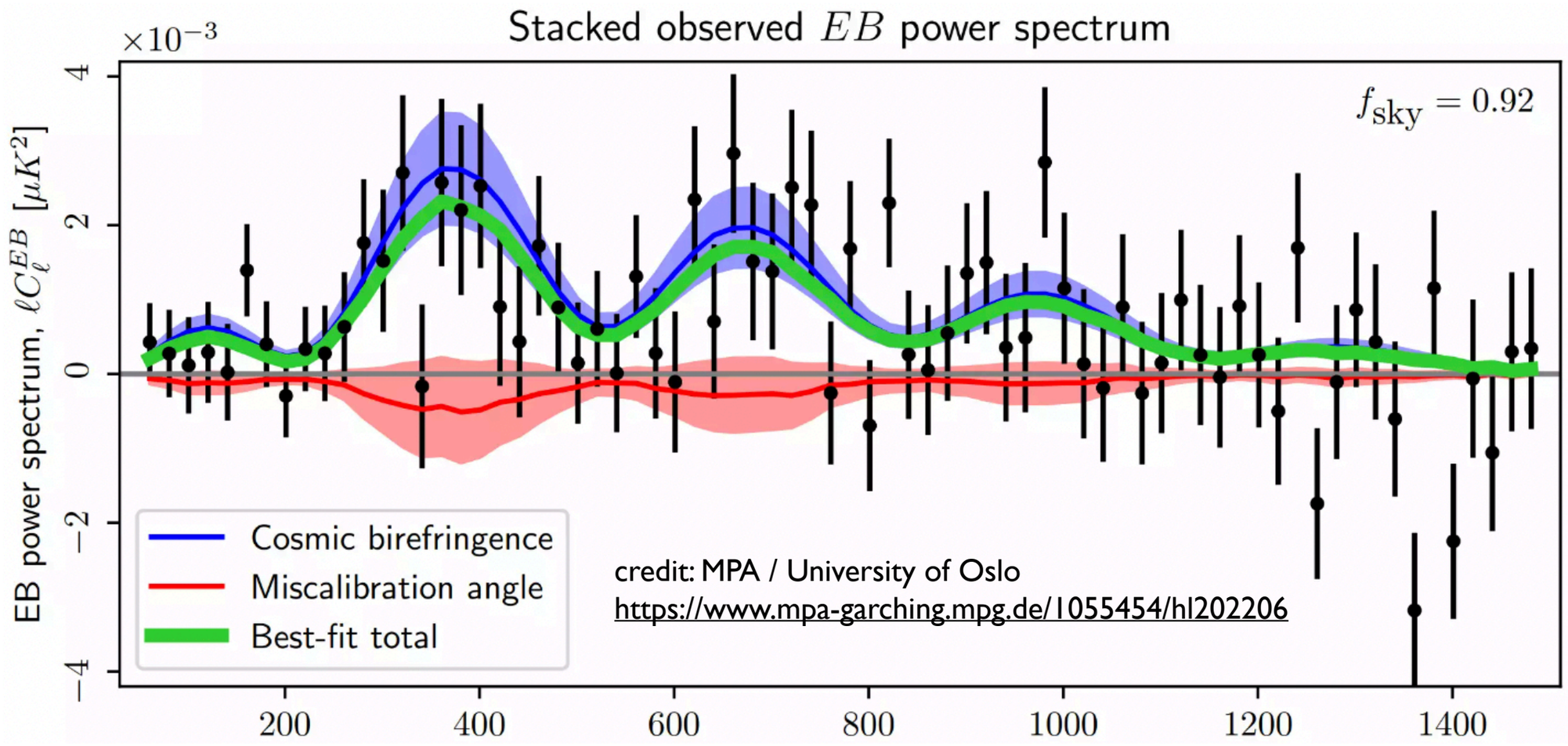
model-independent null tests in [Philcox, MS: PRD 109, 083514 (2024)]
➡ no significant P-odd signals (< 0.4σ)!

⭐Limits on an amplitude parameter of P-odd scalar trispectrum $d_1^{\rm odd}$

BOSS δ_g [PRD 106, 063501 (2022)]	$(-13 \pm 35) \times 10^3$
Planck T [Philcox, MS: PRD 109, 083514 (2024)]	$(45 \pm 33) \times 10^3$
Planck T + E [Philcox, MS: PRD 109, 083514 (2024)]	$(-3.1 \pm 9.8) \times 10^3$

e.g., $\mathscr{L} \supset f(\phi)\left(-\frac{1}{4}F^2 + \frac{\gamma}{4}F\tilde{F}\right)$ ➡ $\frac{\rho_A}{\rho_\phi} \lesssim \begin{cases} 10^{-19} & (\gamma = 1) \\ 10^{-33} & (\gamma = 2) \end{cases}$

Observed 3~4σ EB originates from primordial chiral GWs ?



➡ Maybe no! simultaneously-made BB is too large to be consistent with the data

[Fujita, Minami, MS, Yokoyama: PRD 106, 103529 (2022)]

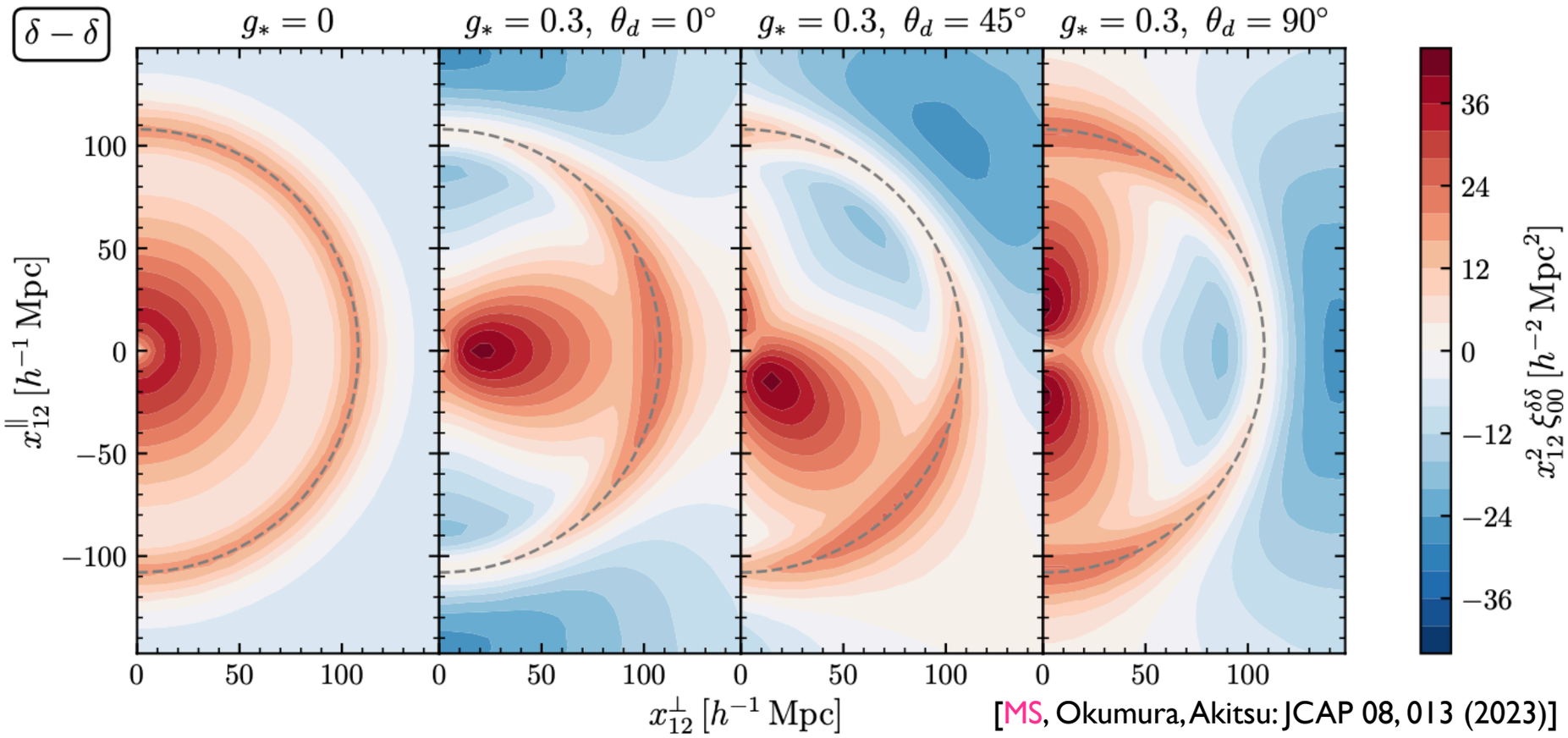
cross-area paper:
B01xB06

➡ Planck BB and other power could constrain primordial axion models tightly

[Campeti, Ozsoy, Obata, MS: JCAP 07, 039 (2022)]

gauge fields may also violate cosmic isotropy!

➡ galaxy distributions may also become statistically anisotropic



[MS, Okumura, Akitsu: JCAP 08, 013 (2023)]

formalism for (complicated) symmetry-breaking CMB correlators is also applicable to the analysis of galaxy number density, velocity and ellipticity field correlators!

- [MS, Taruya, Okumura, Akitsu: MNRAS Letters 503, L6-L10 (2021)]
- [MS, Okumura, Akitsu: JCAP 08, 013 (2023)]
- [Masaki, MS, Nishimichi, Okumura, Yokoyama: arXiv 2409.12004]

cross-area paper: C02xB06