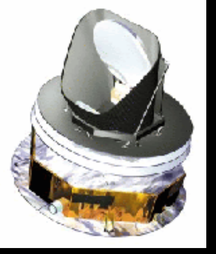
B06: DM–CMB

The Dark Matter (DM) Search using the Cosmic Microwave Background (CMB)

Eiichiro Komatsu (Max Planck Institute for Astrophysics / Kavli IPMU)

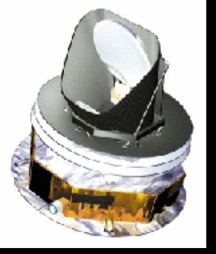
Symposium, April 24, 2025



ESA's Planck

Credit: ESA

Temperature (smoothed)



ESA's Planck

Credit: ESA

Temperature (smoothed) + Polarisation

Our focus: Polarisation!

The Team

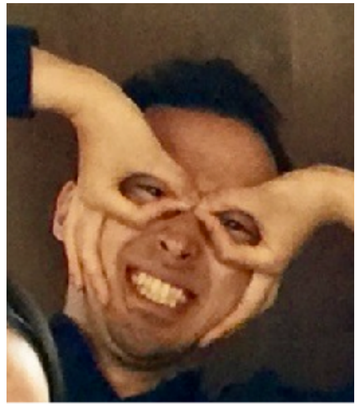
A small yet “dream team”

Eiichiro Komatsu
(MPA / Kavli IPMU)

- 研究代表者

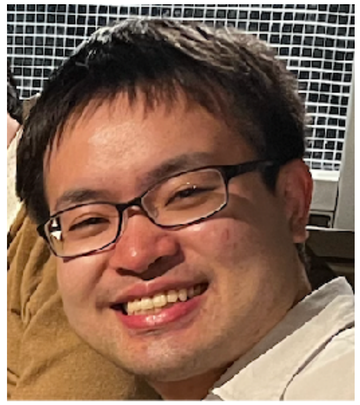
Maresuke Shiraishi
(Suwa Univ. Sci.)

- 研究分担者



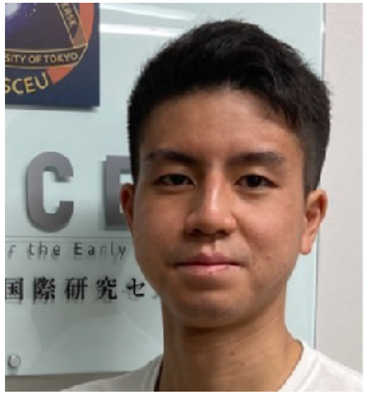
Ippei Obata
(KEK)

Toshiya Namikawa
(Kavli IPMU / Cambridge)



Kai Murai
(Tohoku Univ.)

- 研究協力者



Fumihiro Naokawa
(Univ. Tokyo)

- 研究協力者

Summary Statistics (11.2020 – 3.2025)

Productive years!

- **55 papers** published in peer-reviewed journals
  - More than **1800 citations**
  - Press coverage (Komatsu, Namikawa, Naokawa)
- **92 conference presentations** (52 invited; 62 international)
- **7 workshops** organised (every year from 2021)
- **17 outreach talks**
- **6 prizes**
- Successful scientific career for young researchers (everyone but the PI!)

The Science Targets: Examples

How can we use the CMB polarisation to learn about the DM?

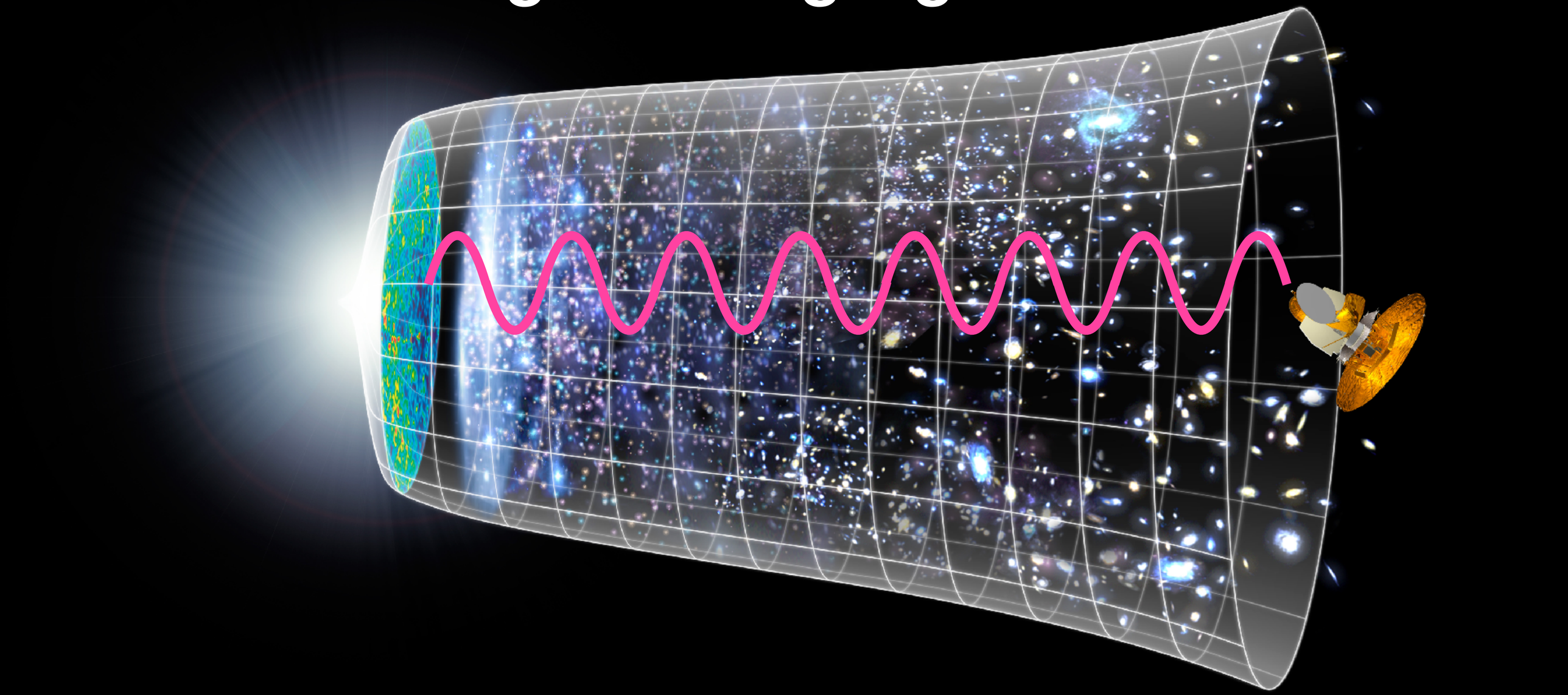
- **Do the DM fields violate parity symmetry?**

- Why not? The weak interaction violates parity symmetry.
- E.g., axionlike fields.
- **Example project:** *How does the parity-violating DM field affect the propagation of polarised light of the CMB (Cosmic Birefringence).* ***A lot of progress thanks to this grant.***

- **Do the DM fields have a higher spin?**

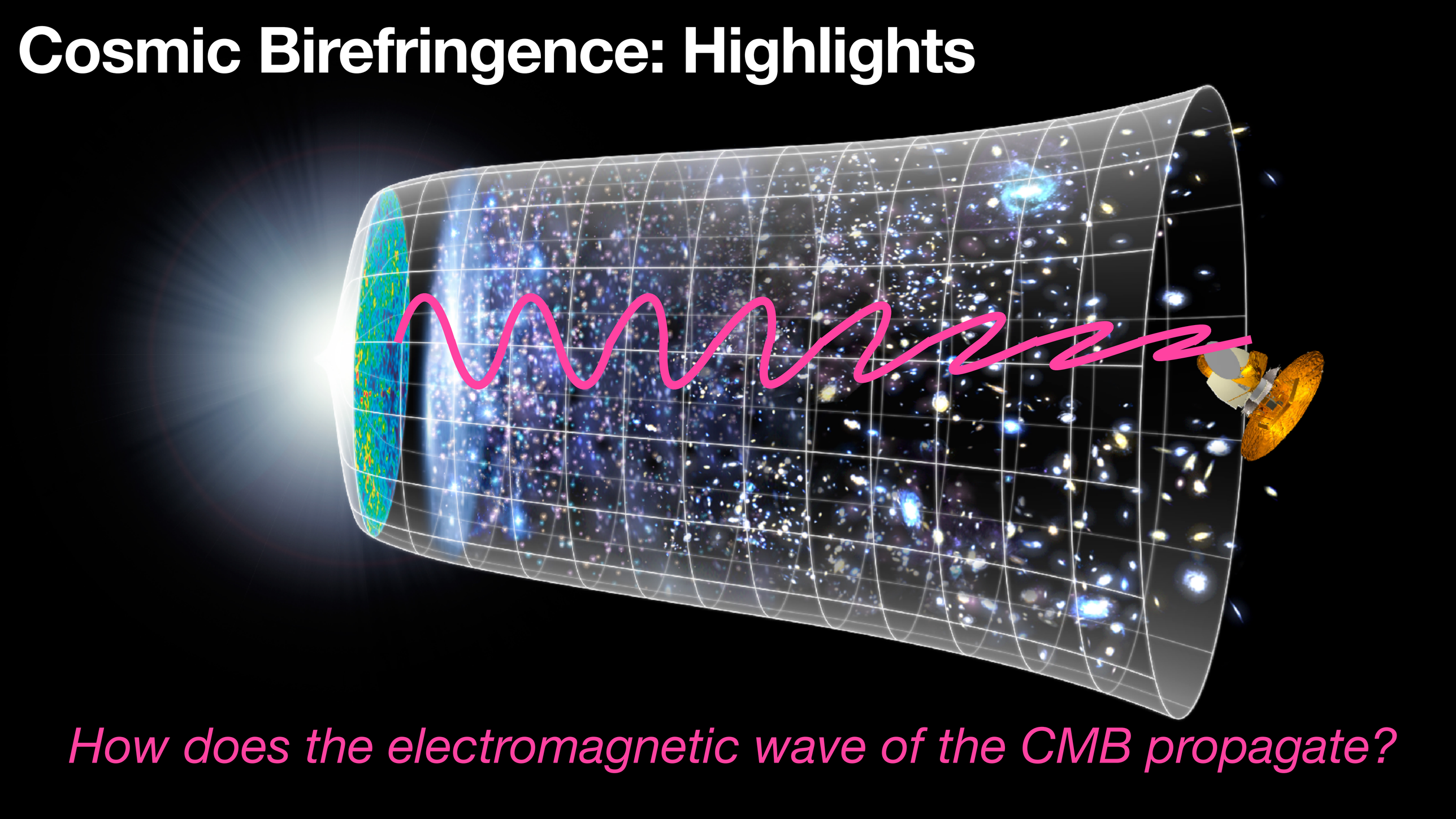
- Why not? The Higgs field is the only known field of elementary particles with zero spin.
- **Example project:** *Do higher-spin fields generate new features in primordial non-Gaussianity observed in the CMB polarisation?*

Cosmic Birefringence: Highlights



How does the electromagnetic wave of the CMB propagate?

Cosmic Birefringence: Highlights



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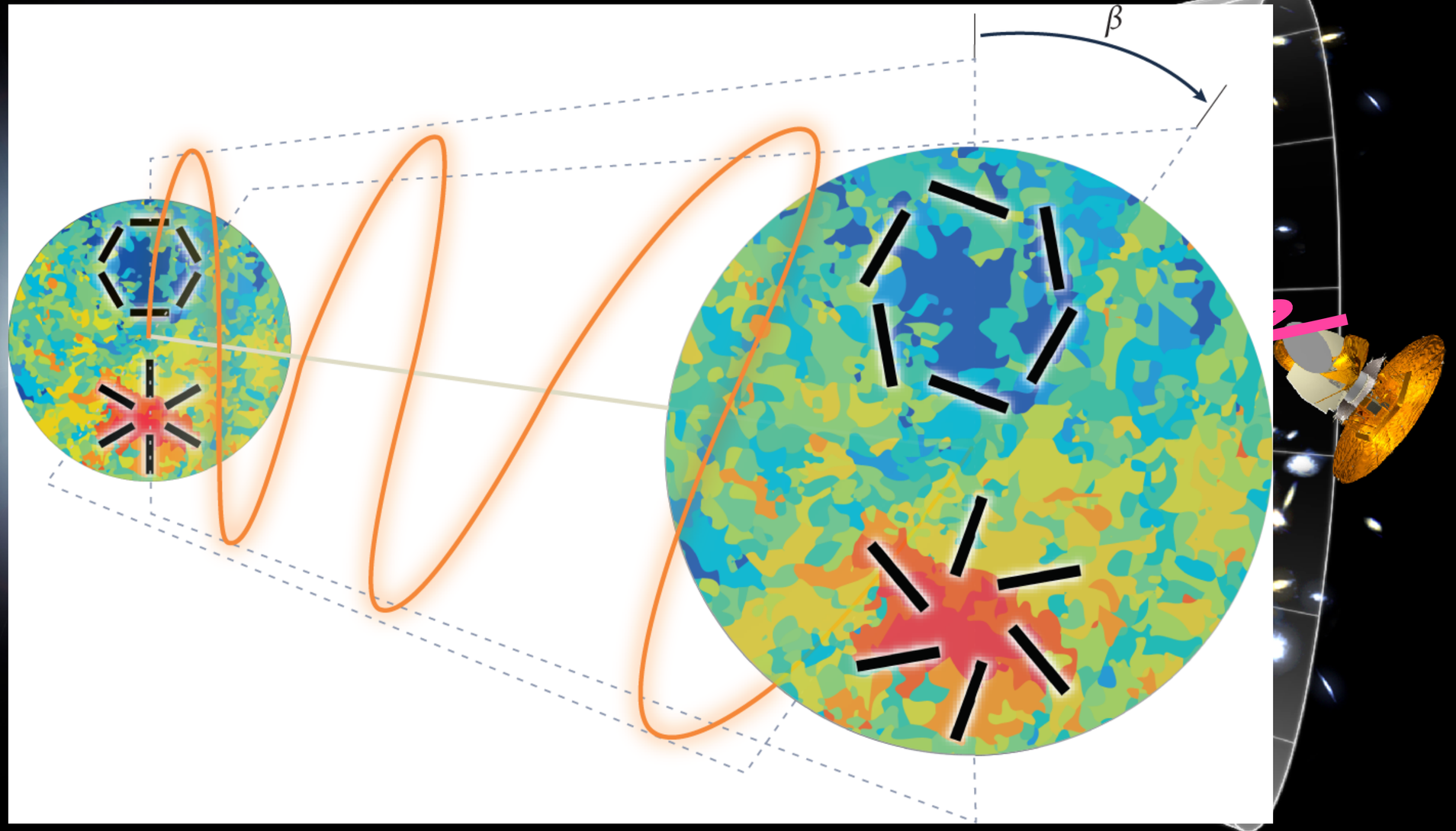
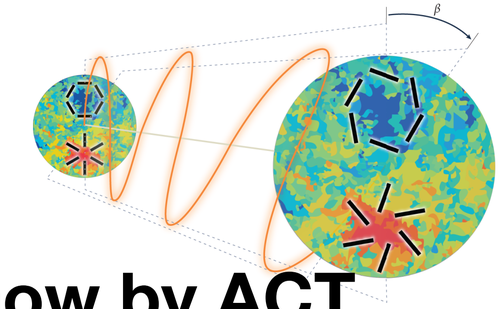


How does the electromagnetic wave of the CMB propagate?

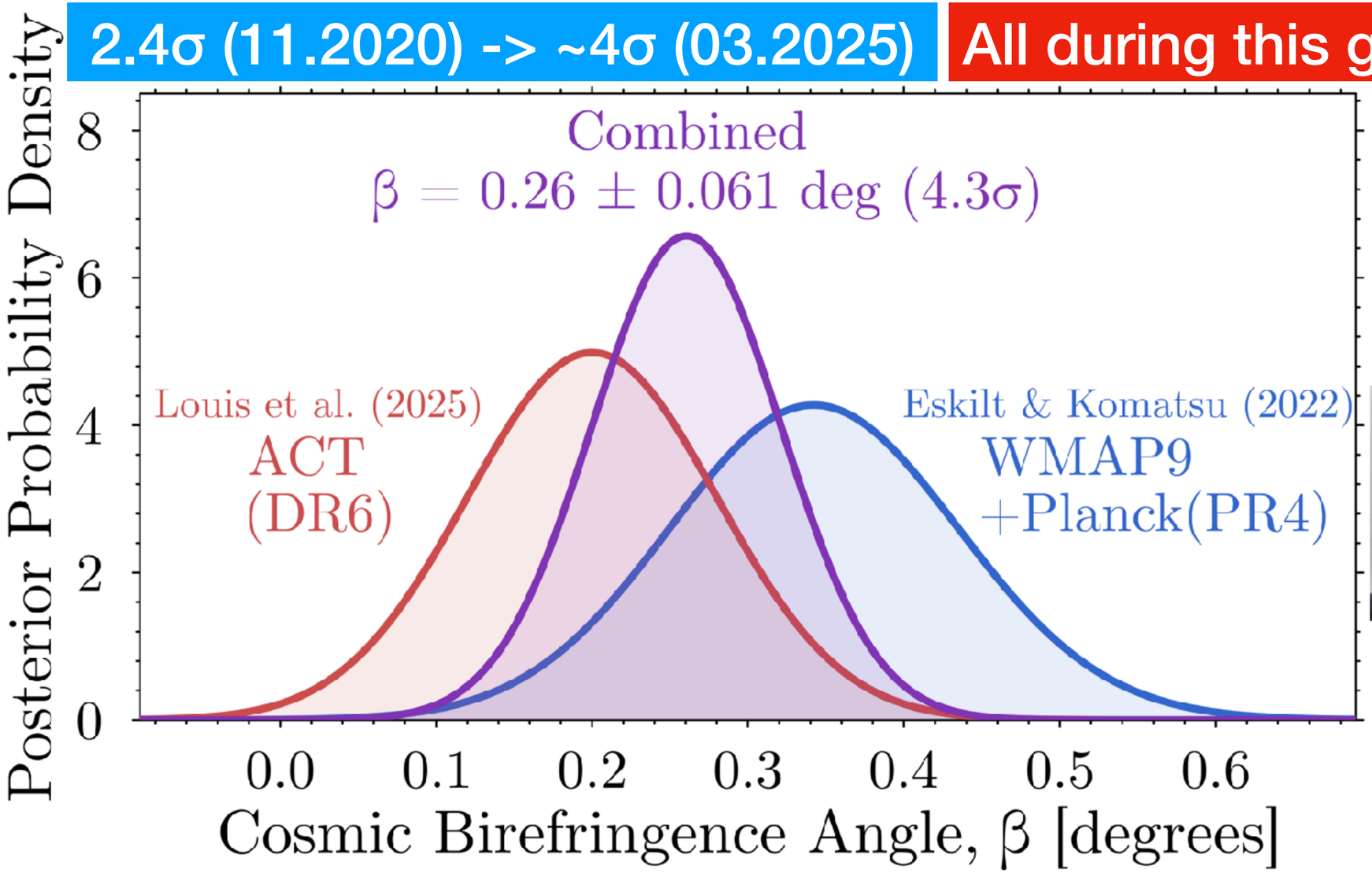
Cosmic birefringence: Highlights

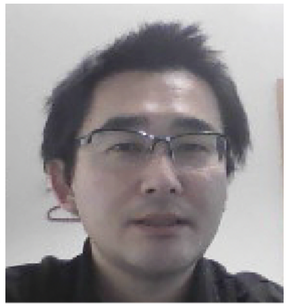
First hints from Planck HFI, confirmed by Planck LFT, and now by ACT



2.4σ (11.2020) -> ~4σ (03.2025)

All during this grant period





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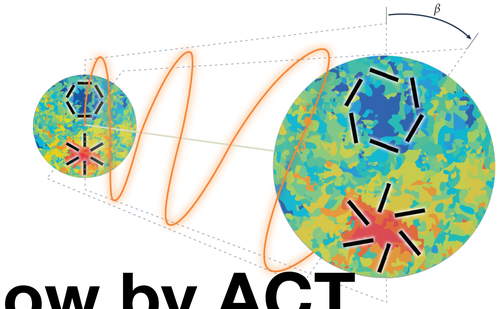

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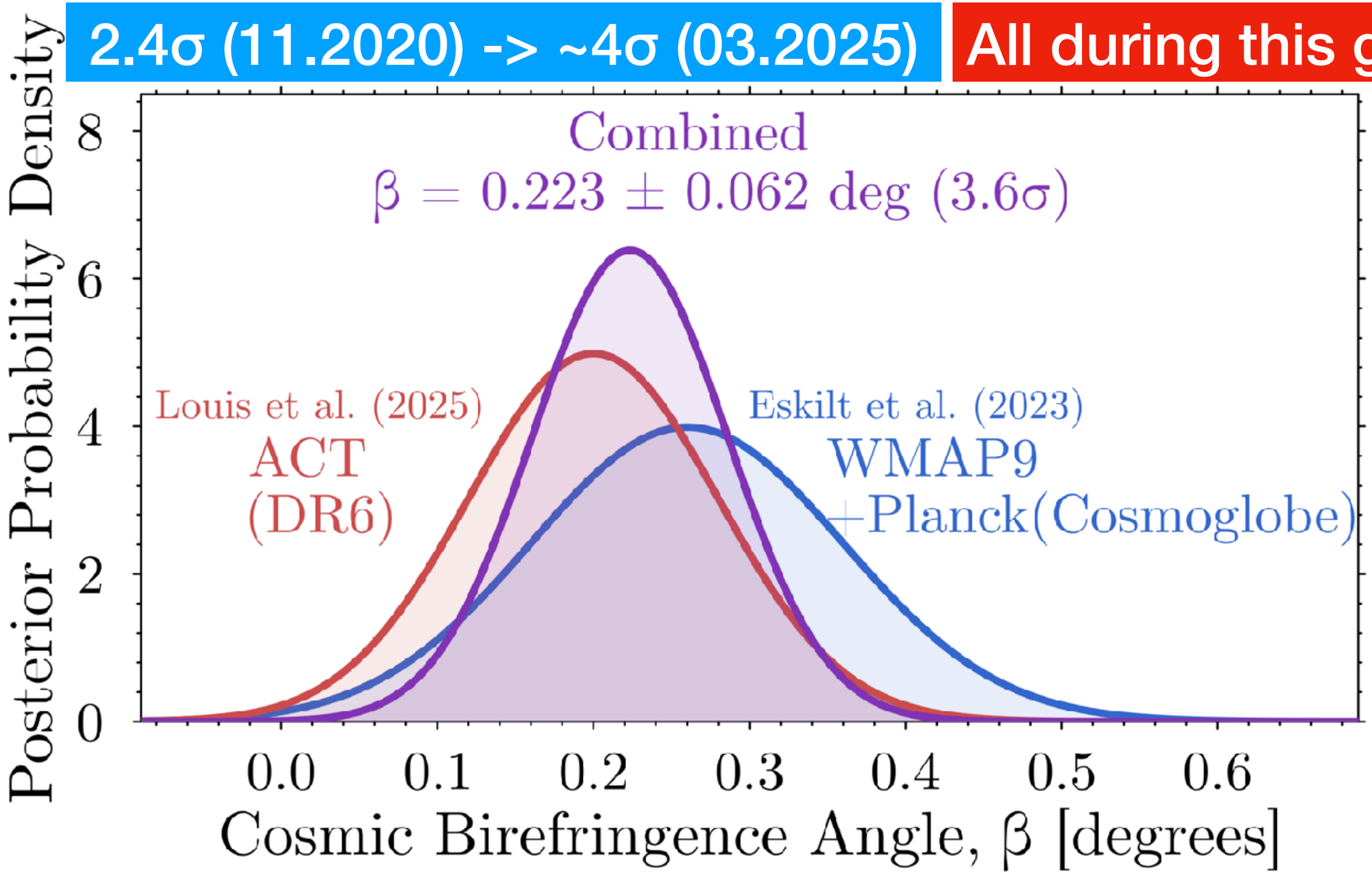

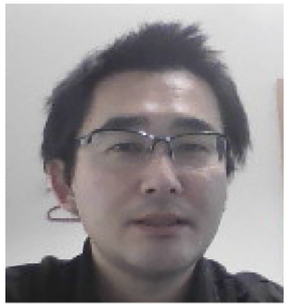

Cosmic birefringence: Highlights

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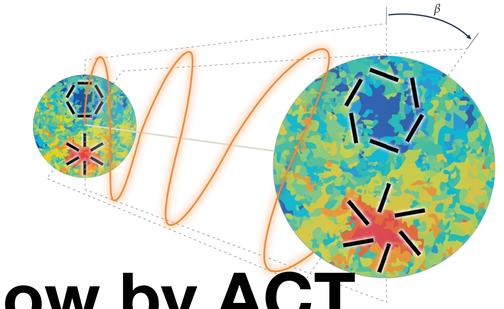

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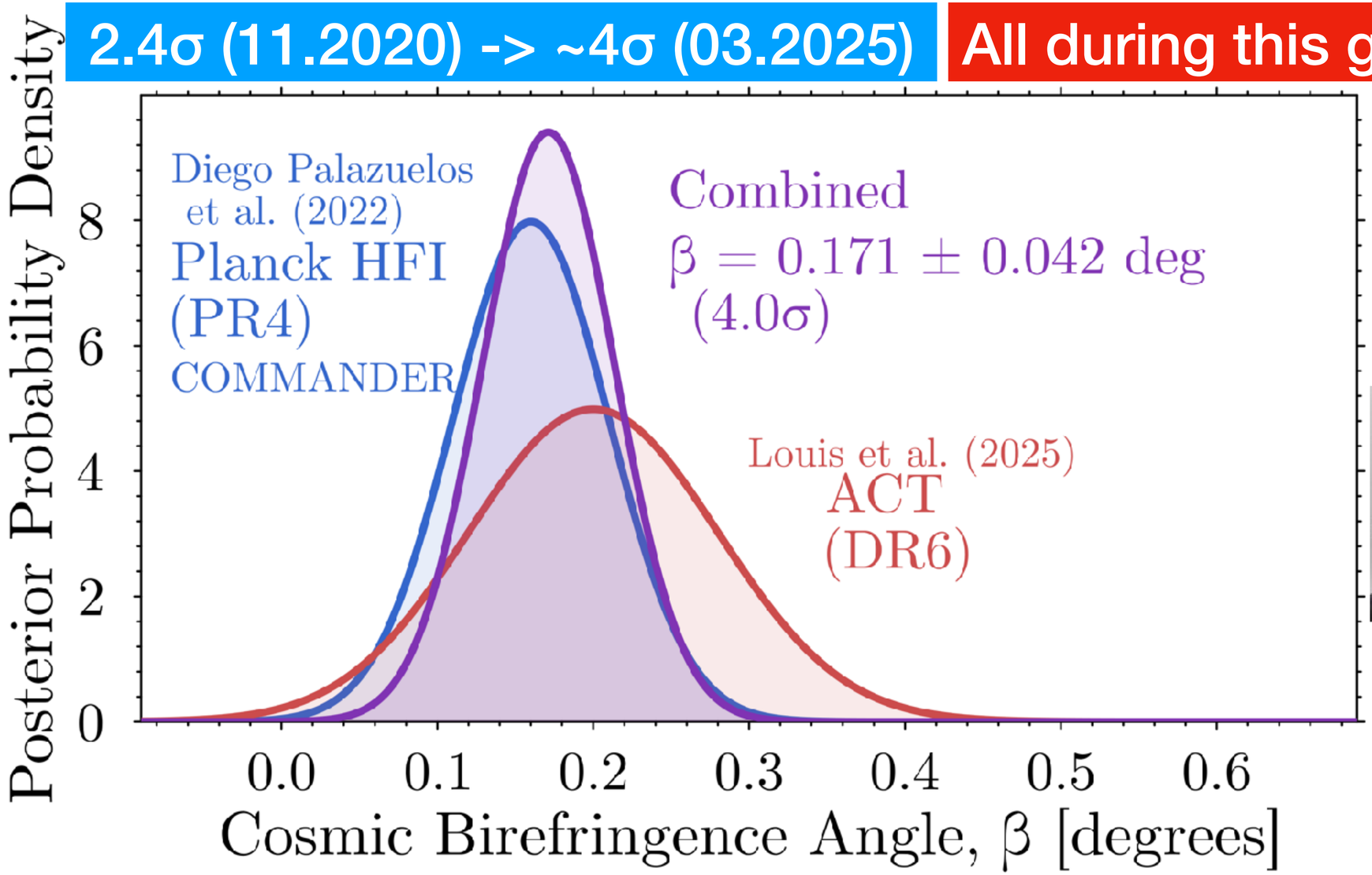
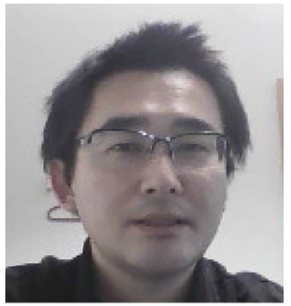
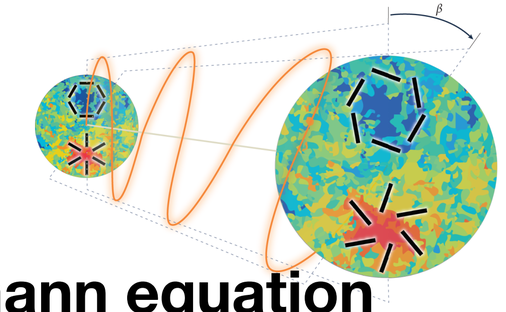
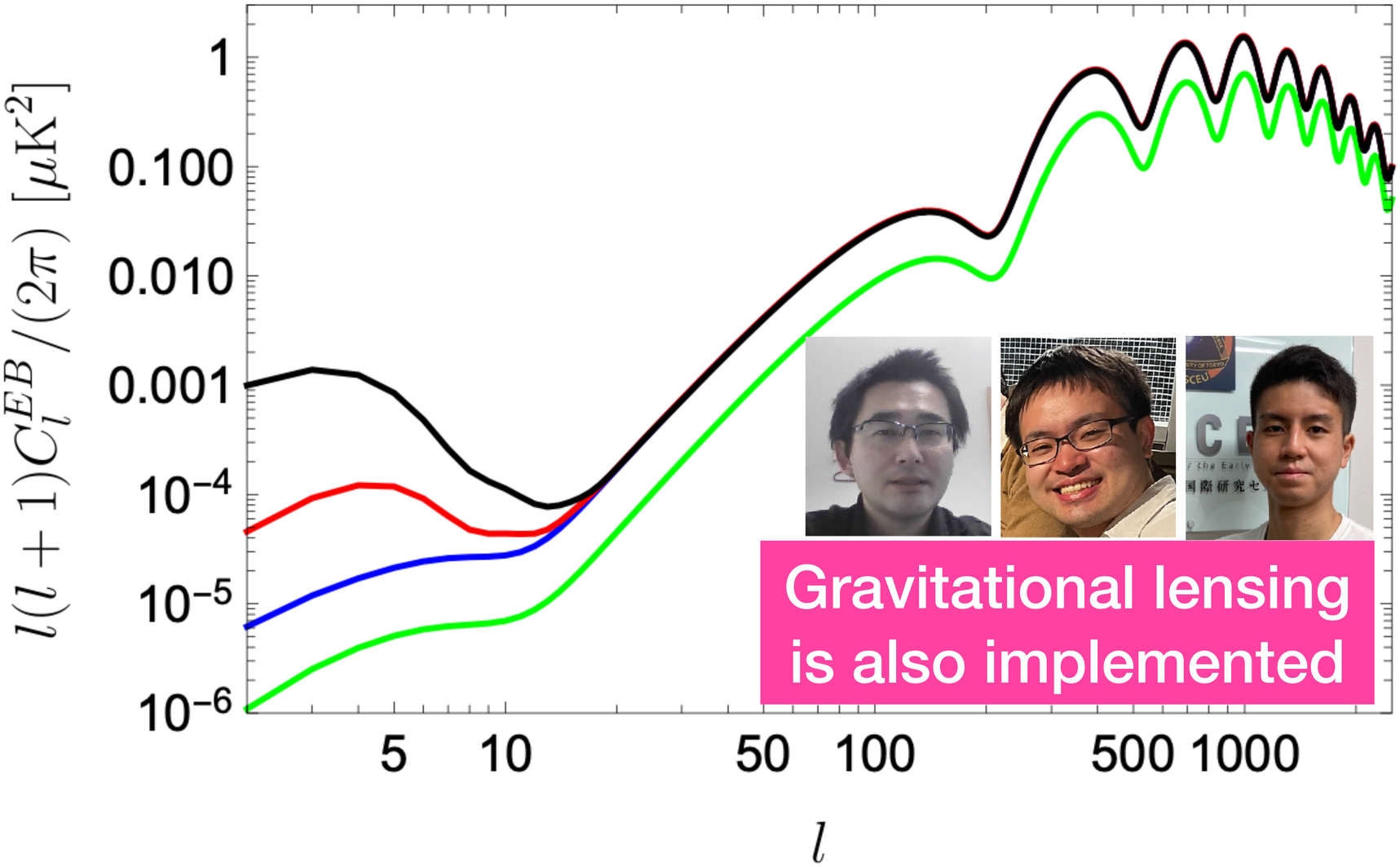




Cosmic birefringence: Highlights

Most precise calculation of the EB power spectrum from the Boltzmann equation





Gravitational lensing is also implemented

m_ϕ

$10^{-28.0}$ eV

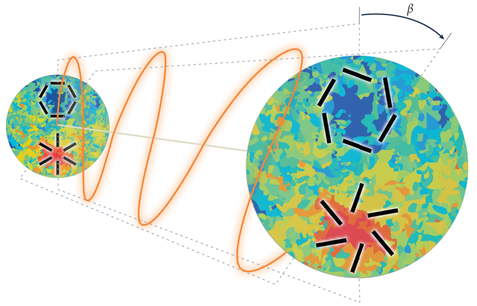
$10^{-30.3}$ eV

$10^{-31.2}$ eV

$10^{-32.3}$ eV

Cosmic birefringence: Highlights

We need new physics!



Can we explain cosmic birefringence without a new light field beyond Standard Model?

Cross-area paper: C01xB06

Yuichiro Nakai,[a,b] Ryo Namba,[c] Ippei Obata,[d,e] Yu-Cheng Qiu[a,b] and Ryo Saito[e,f]

The answer is no.