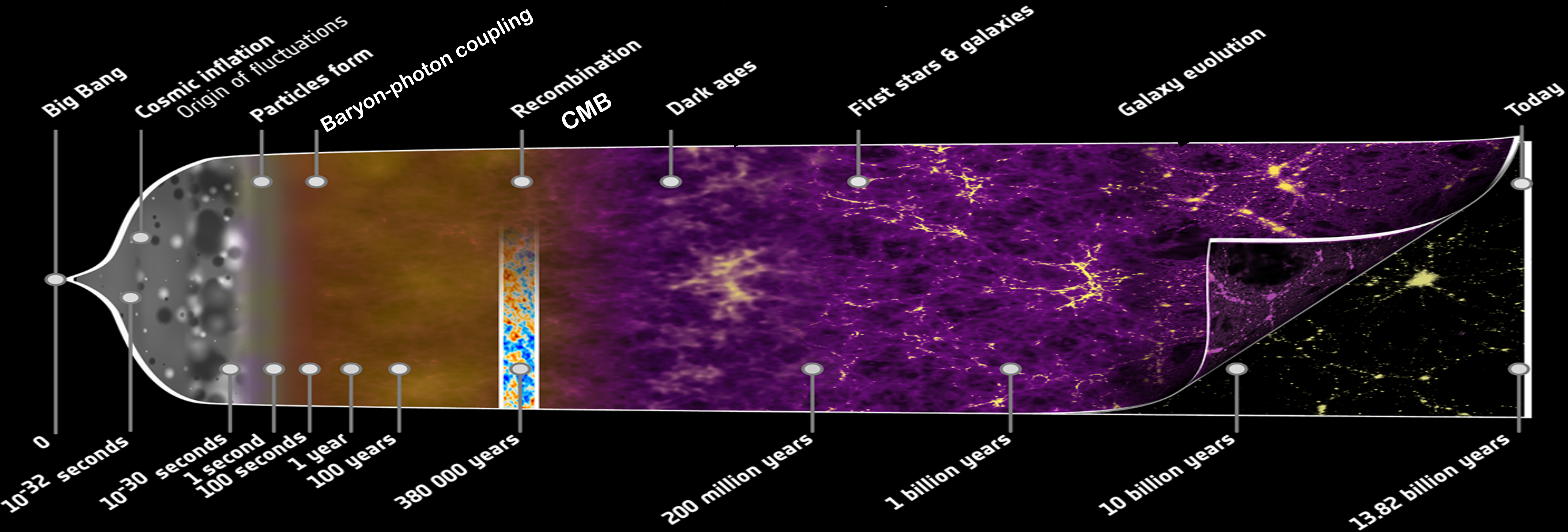


# Probing Parity Violation Physics with Cosmological probes

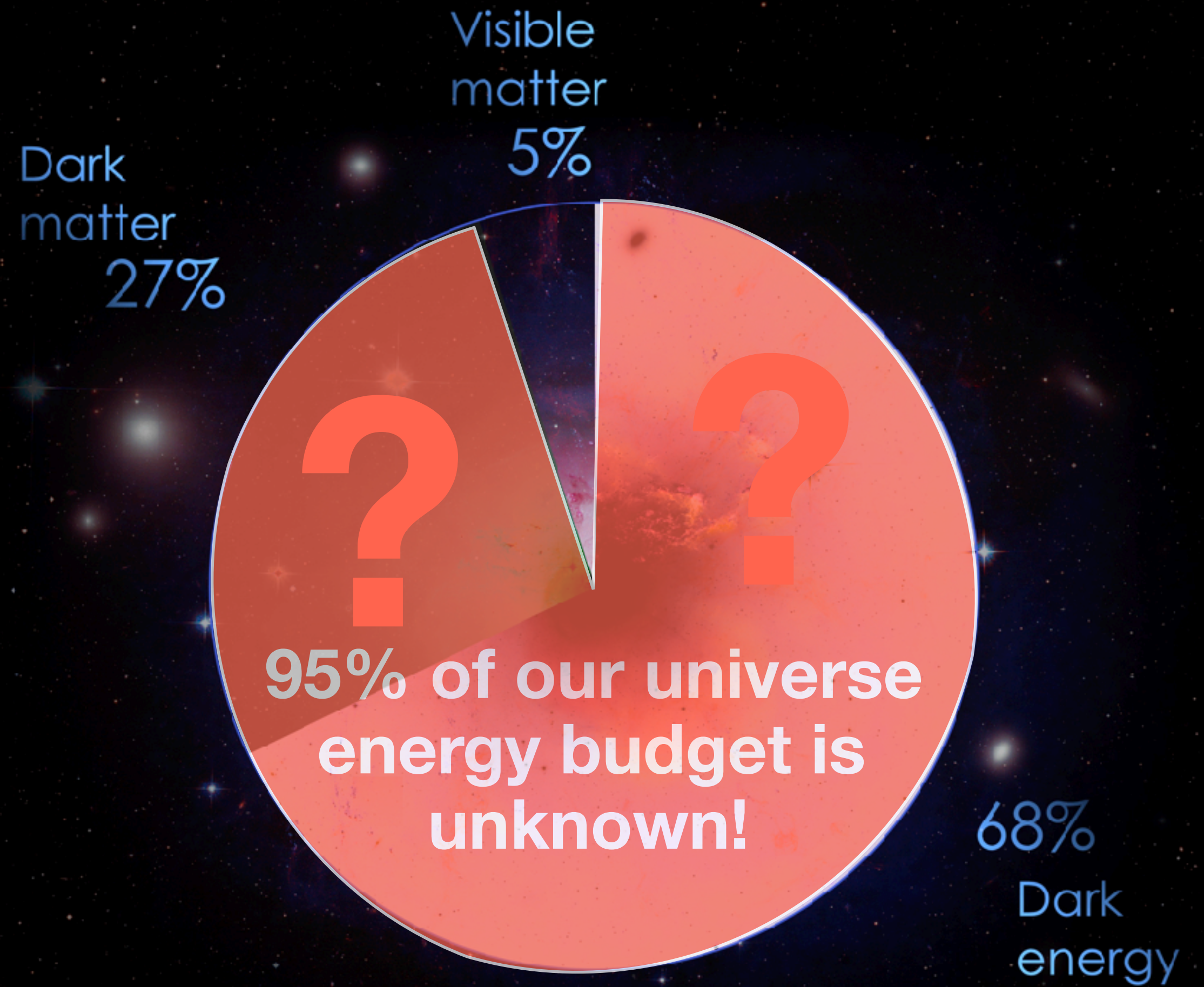
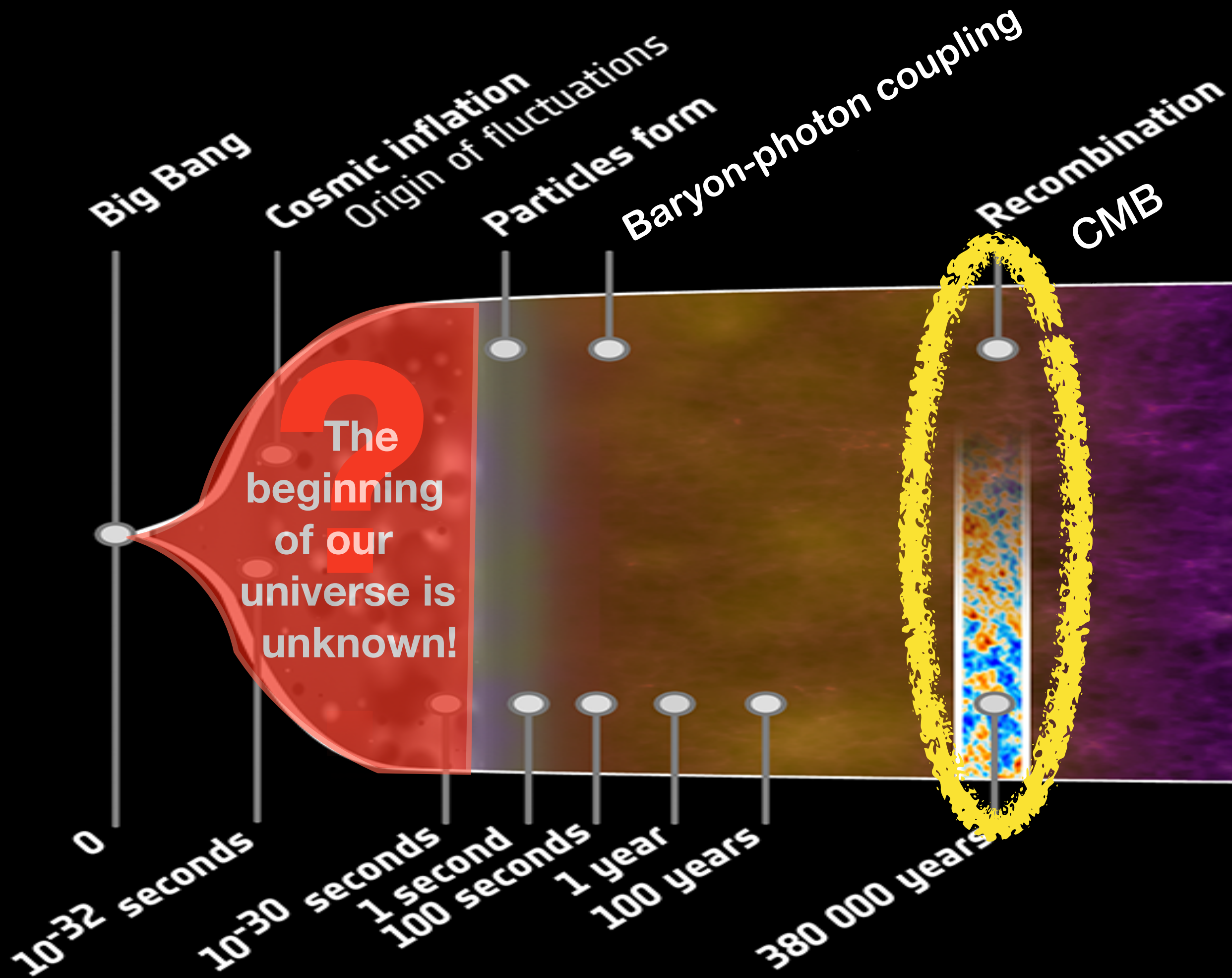
**Giuseppe Puglisi**  
**University of Catania**  
**30/11/2024**

# The Standard model of Cosmology: $\Lambda$ CDM



Credits: ESA & Planck Collaboration

# The Standard model of Cosmology: $\Lambda$ CDM



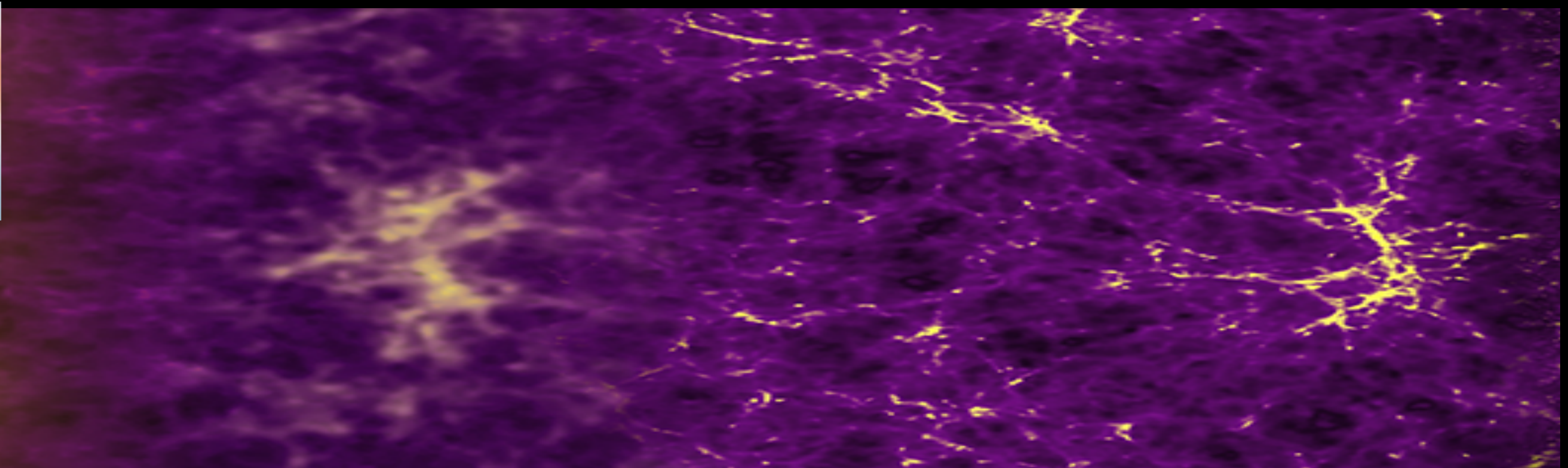
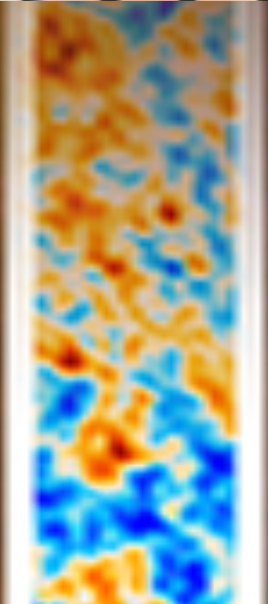
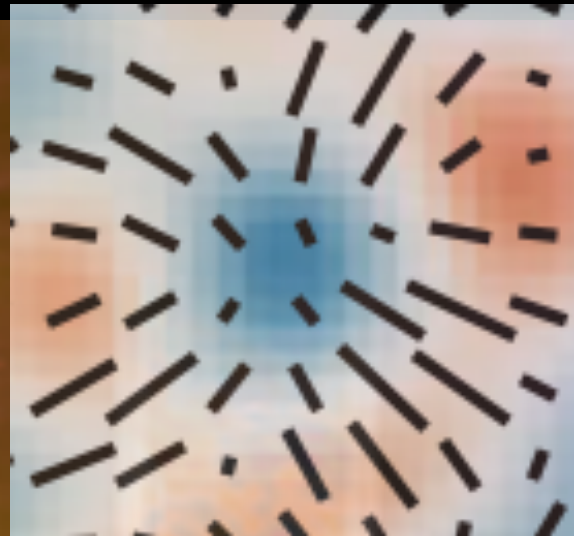
# Polarization Cosmic Microwave Background

## CMB in a nutshell:

- Black-body emission at  $T \sim 2.7$  K (Penzias & Wilson 1965)
- Emission peaks at 100 GHz (3mm)
- Anisotropies  $\delta T \sim 100 \mu K$  (COBE 1992)

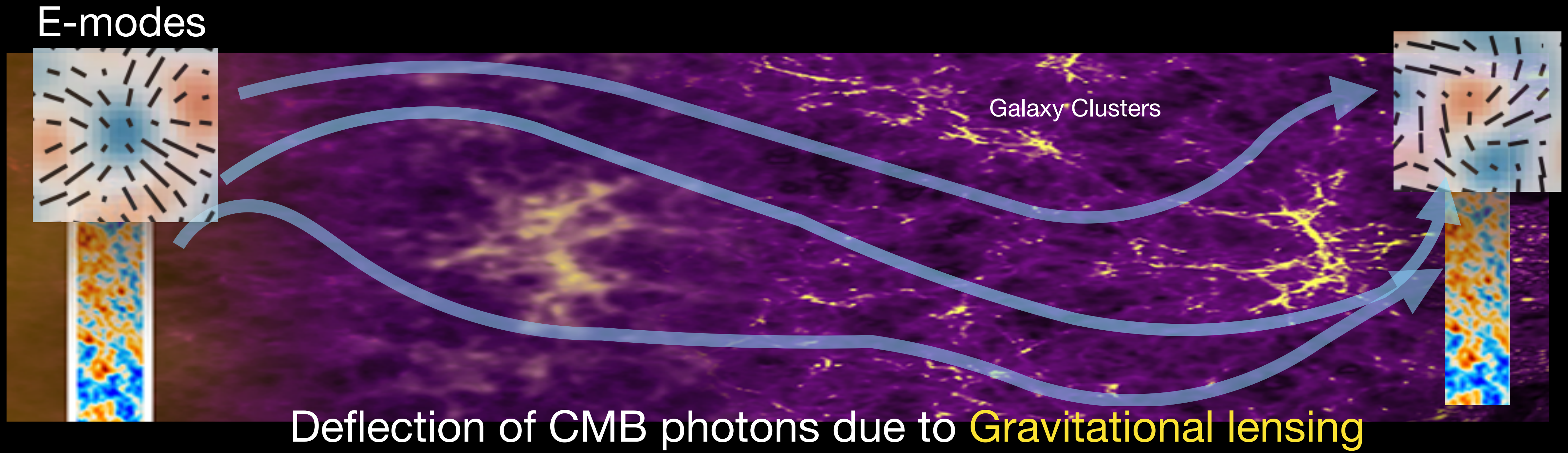
CMB Polarization  
firstly detected by  
DASI (Kovac et al. 2002)

E-modes



# Polarization Cosmic Microwave Background

Large scale structures (e.g. galaxy clusters) gravitationally distort the CMB anisotropies,  $\Rightarrow$  **lensing B-modes**



Lensing B-modes firstly detected by Polarbear Collaboration 2014

# What are Dark Matter and Dark Energy made of?

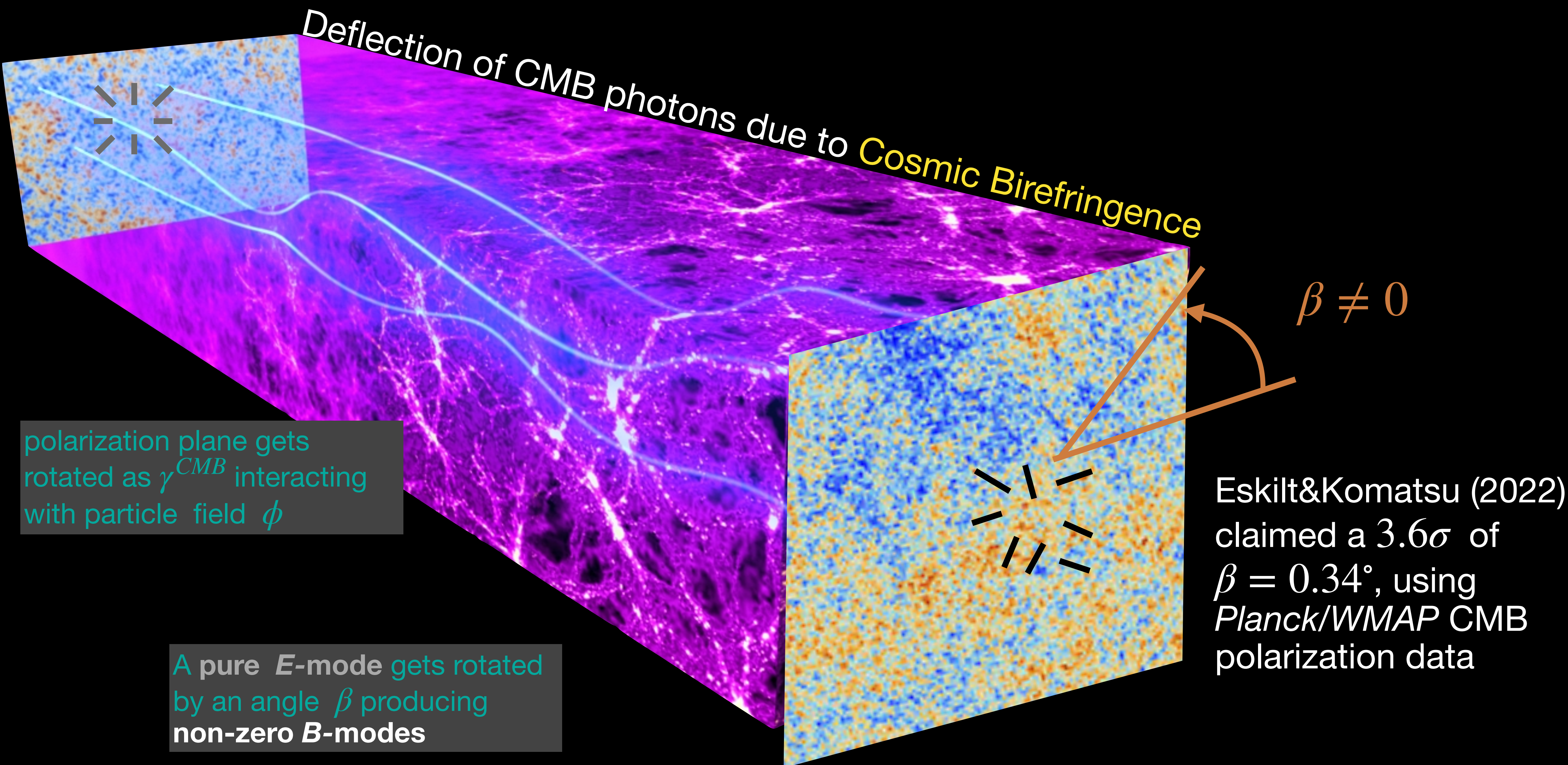
Deflection of CMB photons due to **Cosmic Birefringence**

$$\beta \neq 0$$

polarization plane gets rotated as  $\gamma^{CMB}$  interacting with particle field  $\phi$

A pure *E*-mode gets rotated by an angle  $\beta$  producing non-zero *B*-modes

Eskilt&Komatsu (2022) claimed a  $3.6\sigma$  of  $\beta = 0.34^\circ$ , using *Planck/WMAP* CMB polarization data



# What are Dark Matter and Dark Energy made of?

If confirmed, we could explain 95% of the energy-matter budget in the universe.

Deflection of CMB photons due to Cosmic Birefringence

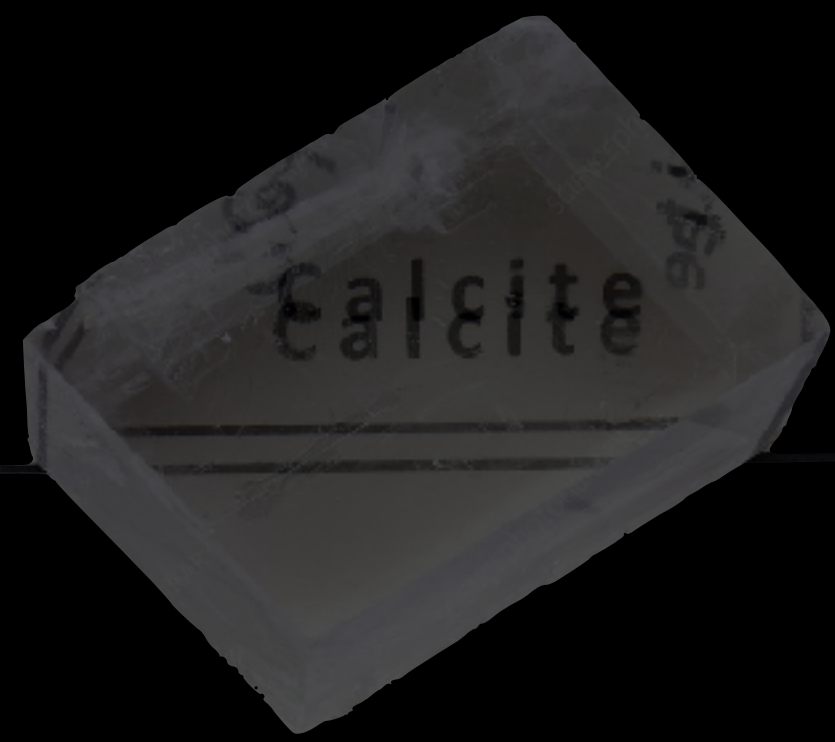
$\beta \neq 0$

polarization plane gets rotated as  $\gamma^{CMB}$  interact with a pseudo-scalar field  $\phi$

Eskilt&Komatsu (2022) claimed a  $3.6\sigma$  of  $\beta = 0.34^\circ$ , using *Planck*/*WMAP* CMB polarization data

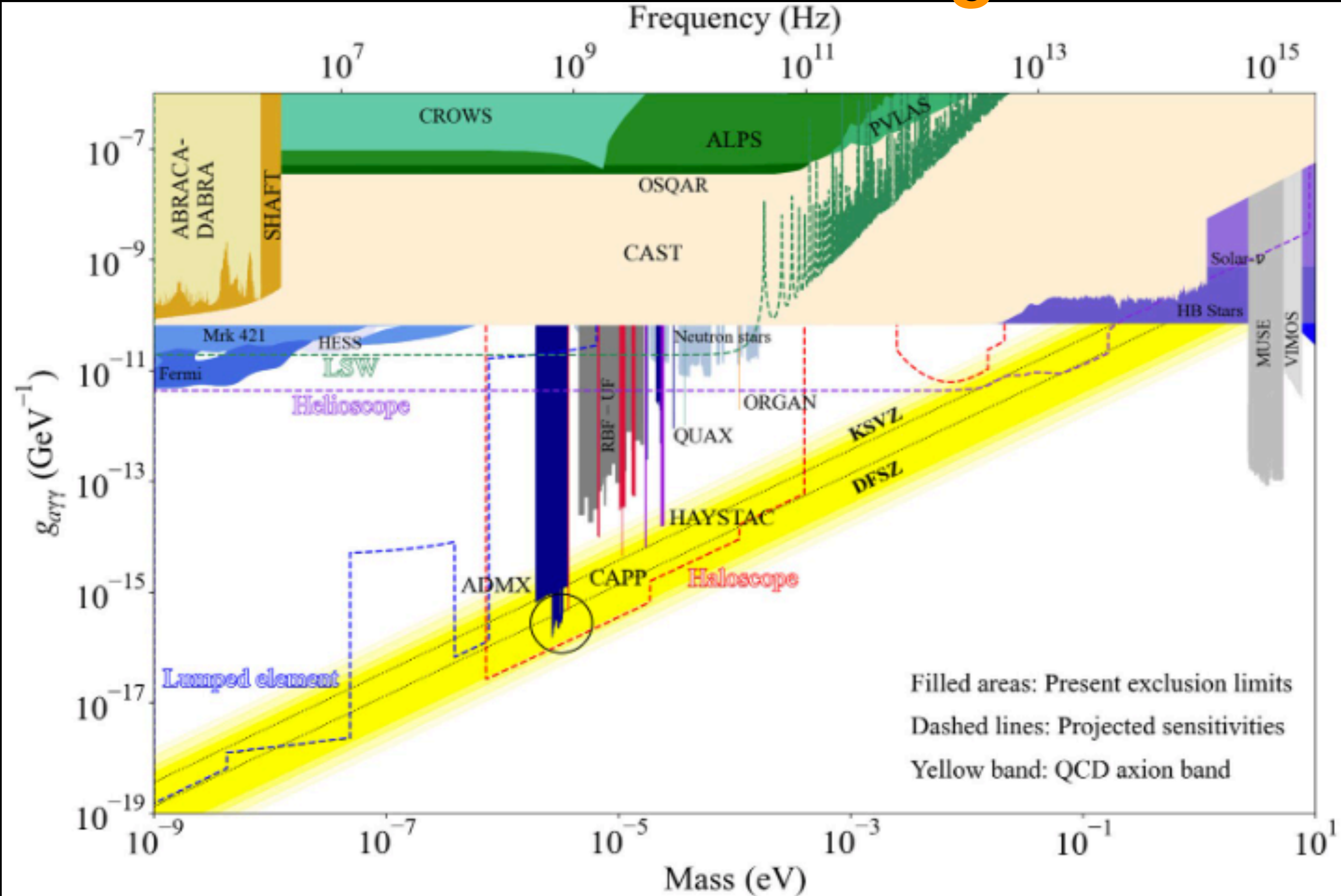
$$\implies m_\phi \sim 10^{-23} \text{ eV}$$

A pure *E*-mode gets rotated by an angle  $\beta$  producing non-zero *B*-modes and *EB* correlation



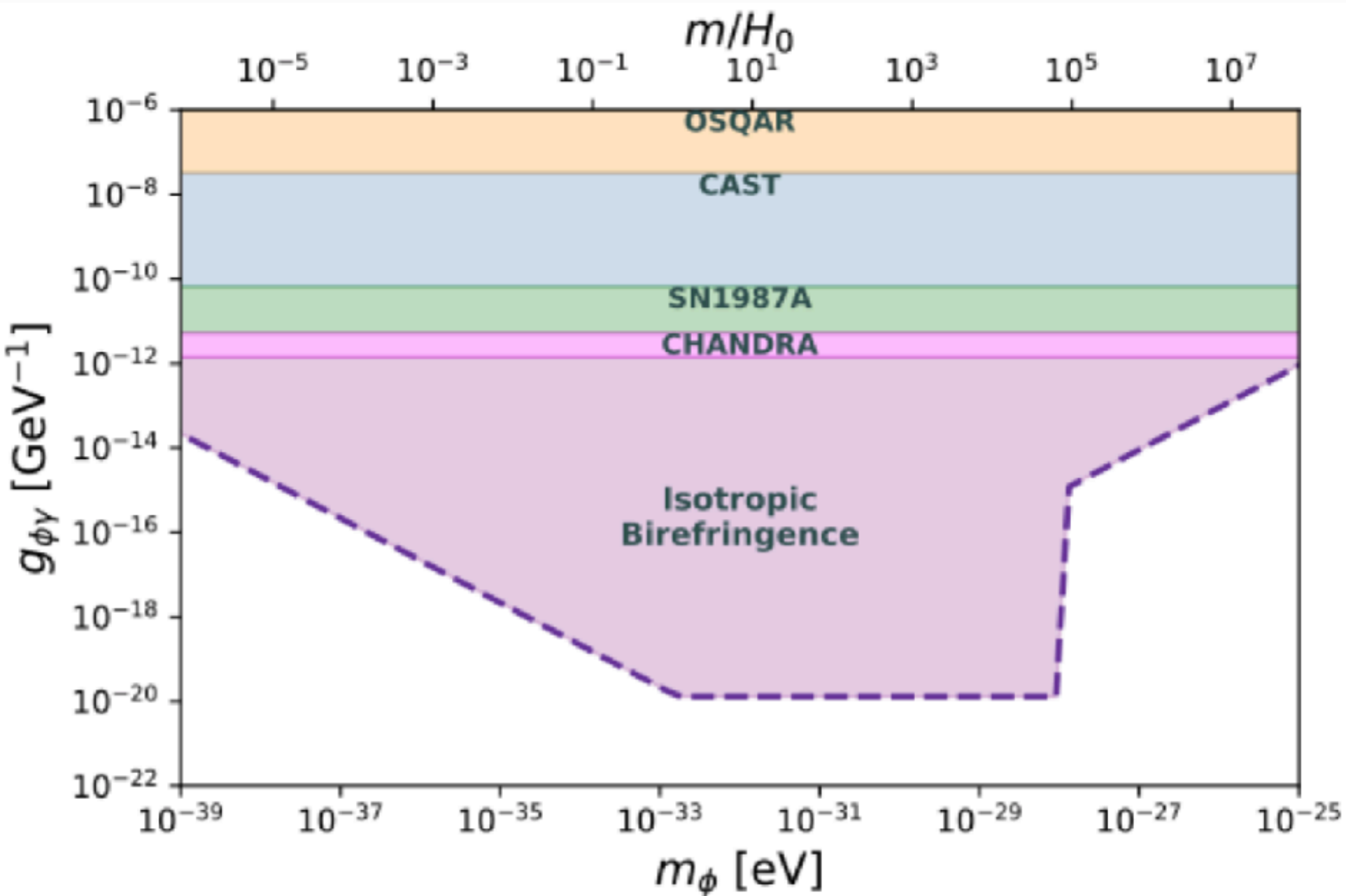
# Axion searches - 40 orders of magnitude!

Yi et al. 2023

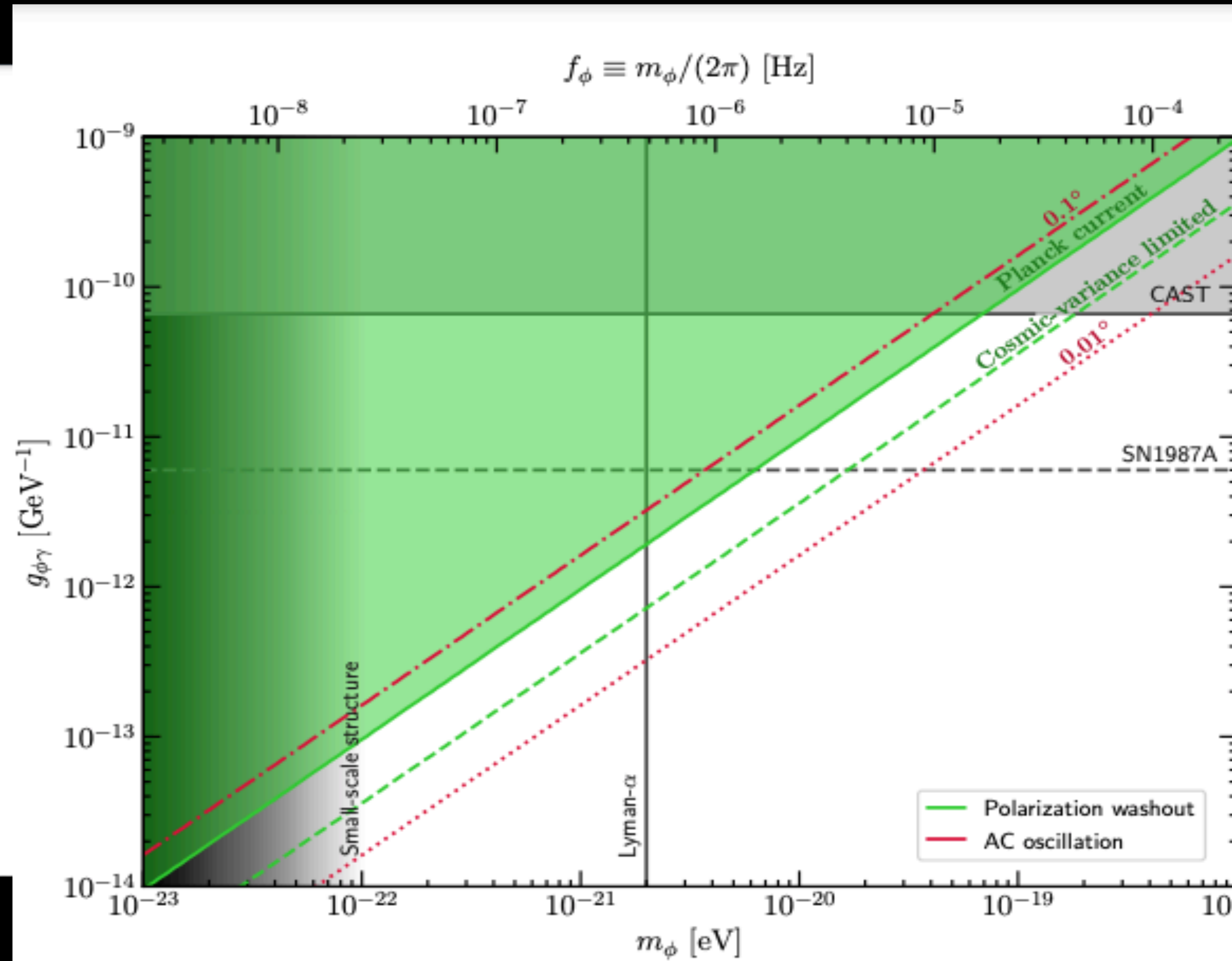




# Axion searches - 40 orders of magnitude!



Diego-Palazuelos 2023



Fedderke & Graham 2019

# Why now?

Observations with unprecedented sensitivity at 30-300 GHz from ACT and SO

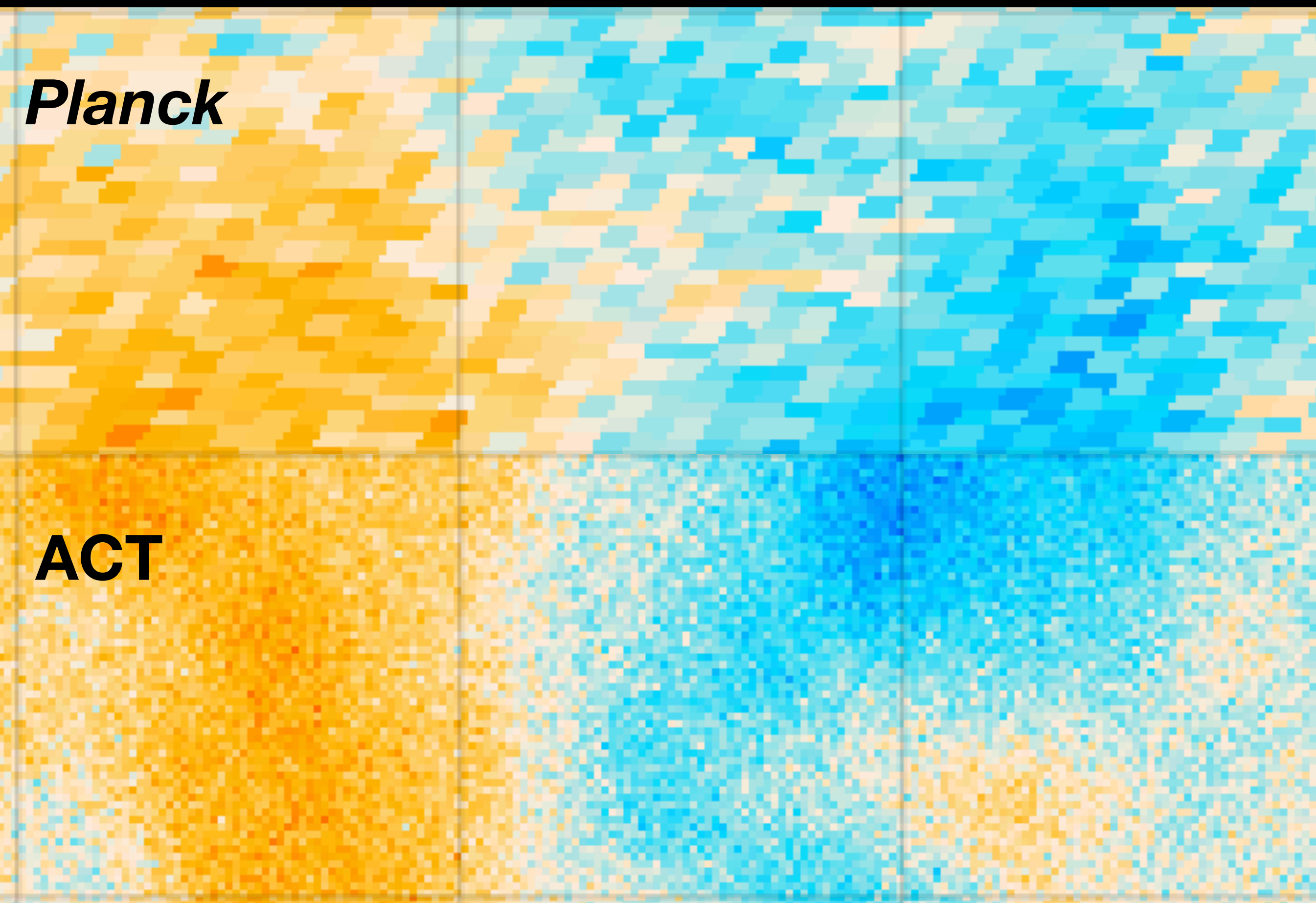
Observing since 2012 **ACT**

**SO-SATs**

Commissioning 2023

**SO-LAT**

Commissioning 2025



SO will be 10x more sensitive than ACT !

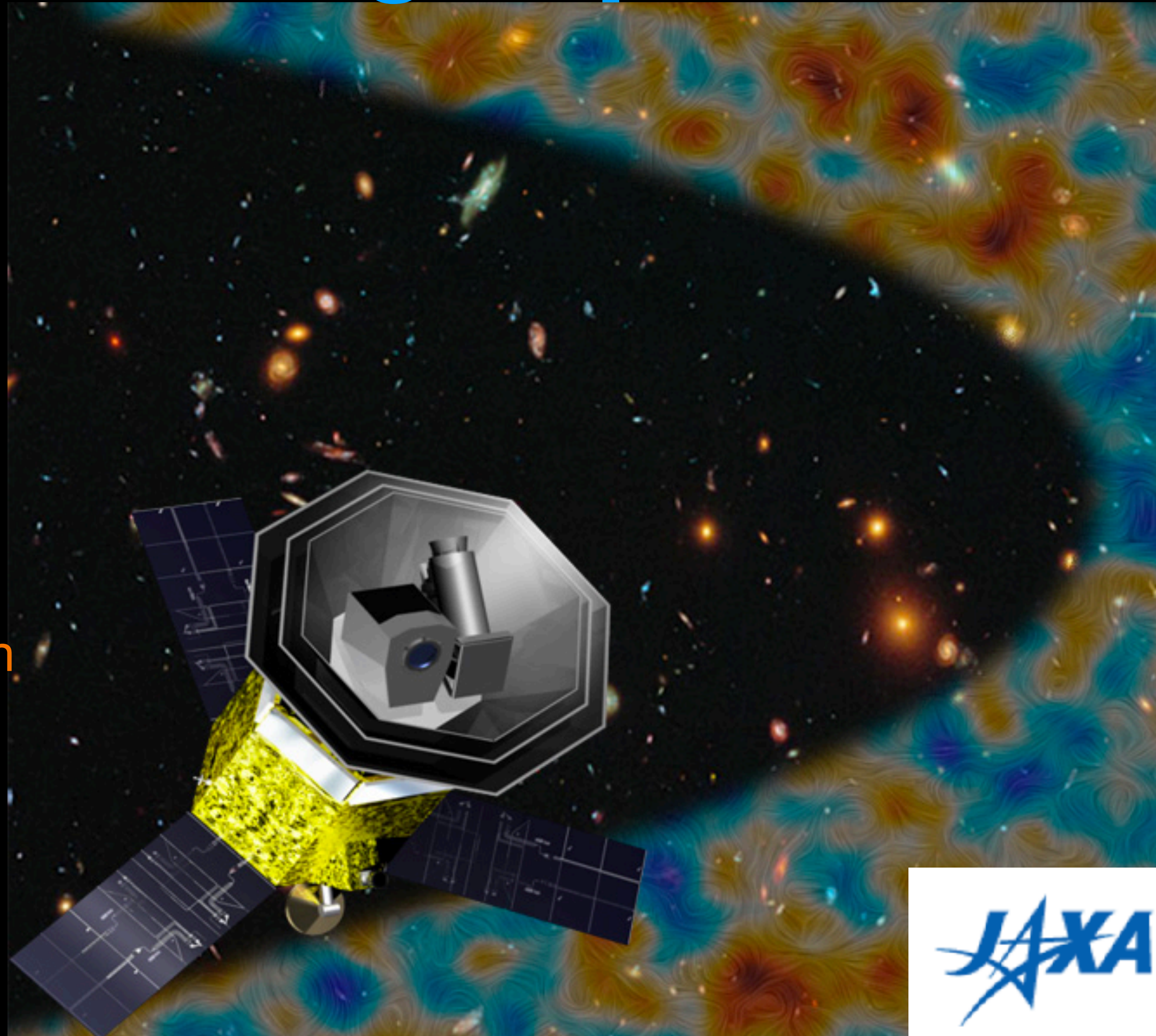
# CMB forthcoming experiments

Space-mission

## LiteBIRD

$r \sim 0.001$  at  $>5\sigma$  C.L.

- 22 frequency bands (40-400 GHz)
- 10-70 arcmin resolution
- ~4500 detectors



Japan Aerospace Exploration Agency

# Take home messages

Future cosmology surveys will enable breakthroughs in understanding our universe:

- $\rightarrow 5\sigma$  claim on Cosmic Birefringence, will open up to new observational windows on Dark matter (early dark energy) candidates
- Neutrino physics,  $\sum m_\nu < 20 \text{ meV}$ , enabling us to distinguish between <sup>$\nu$</sup> the neutrino hierarchies