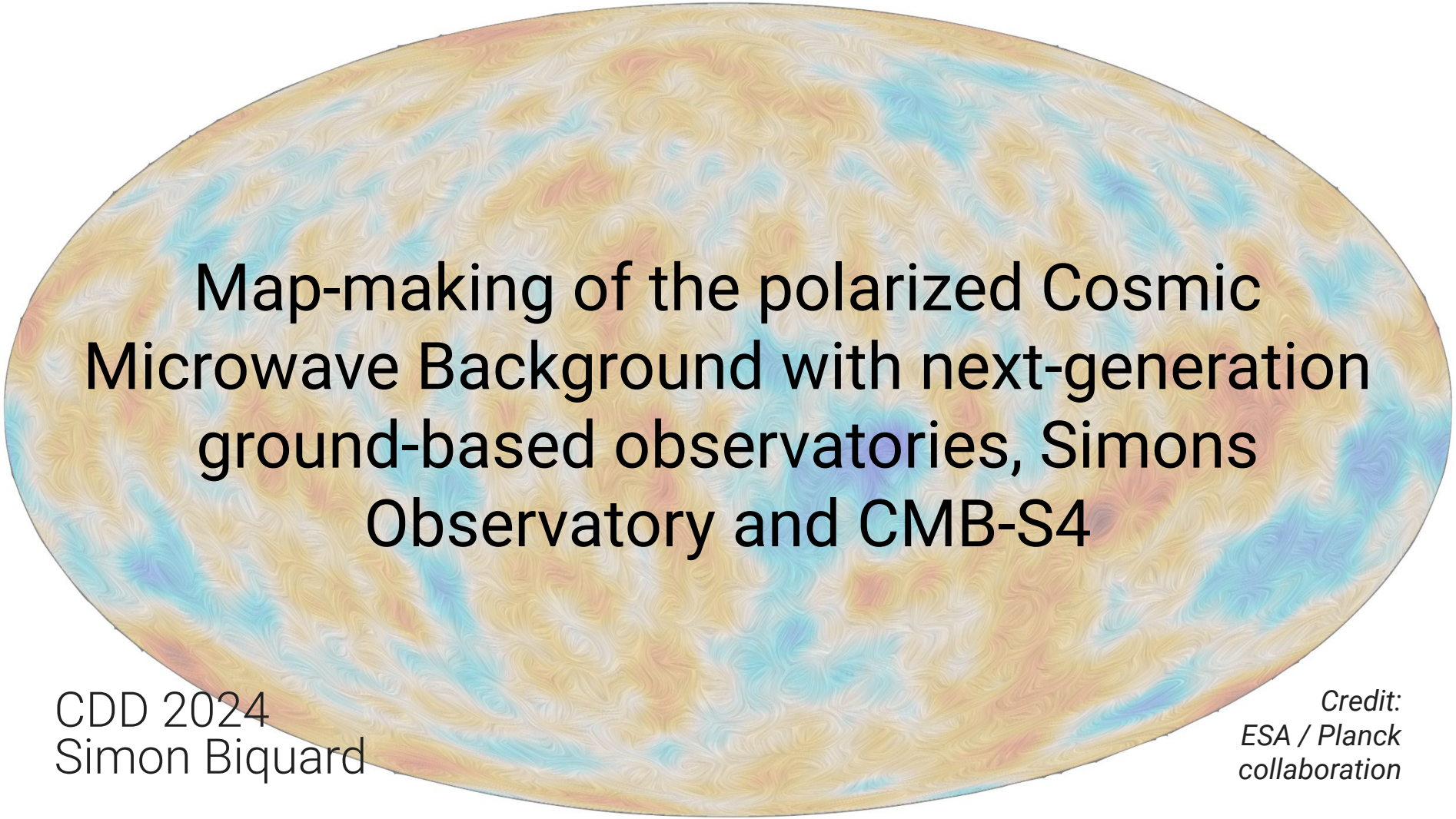
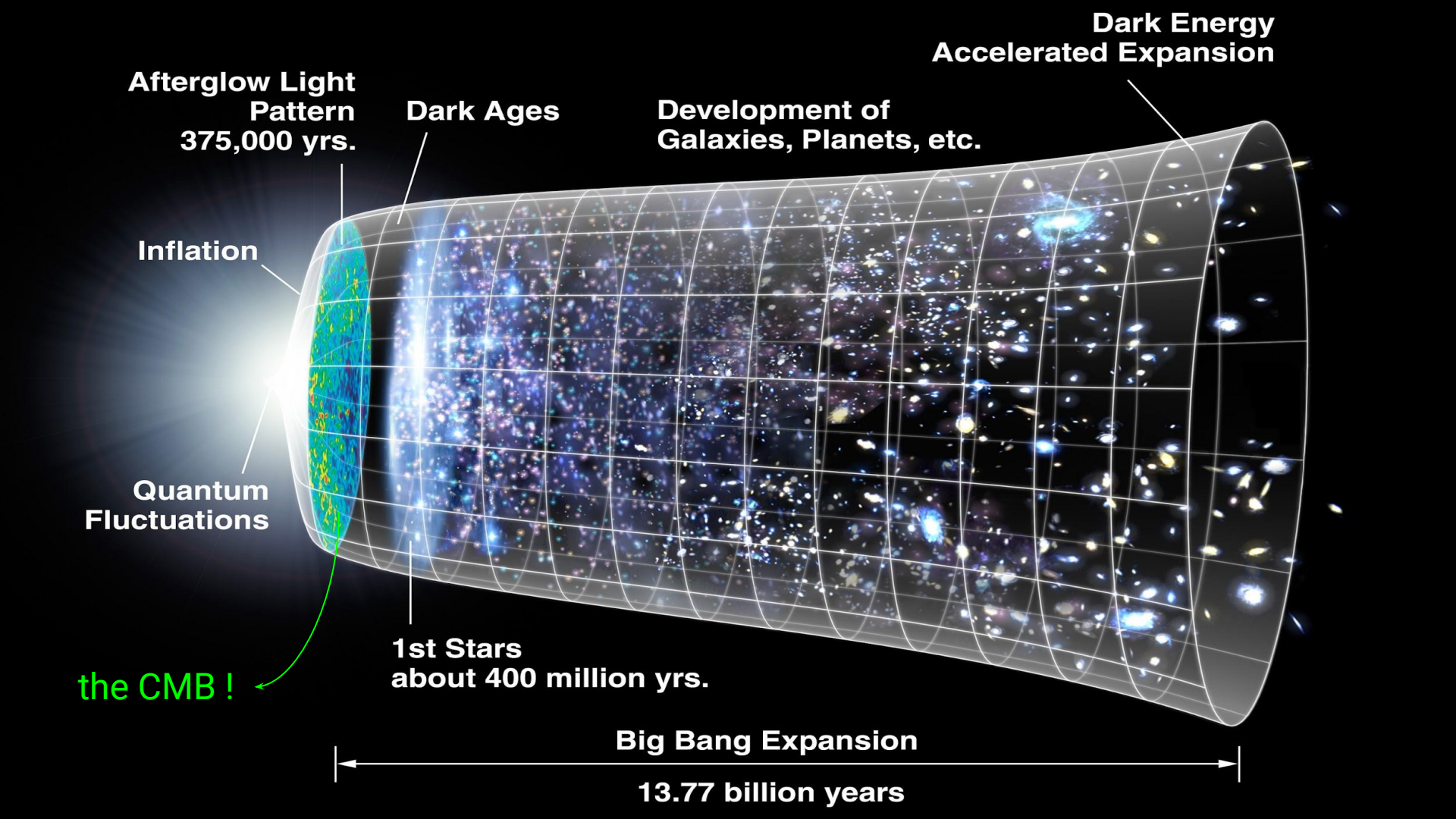


Map-making of the polarized Cosmic Microwave Background with next-generation ground-based observatories, Simons Observatory and CMB-S4

CDD 2024
Simon Biquard

Credit: ESA / Planck collaboration

Cosmic


Dark Energy
Accelerated Expansion
Afterglow Light
Pattern
375,000 yrs.
Dark Ages
Development of
Galaxies, Planets, etc.
Inflation
Quantum
Fluctuations
the CMB !
1st Stars
about 400 million yrs.
Big Bang Expansion
13.77 billion years

Expansion

E. Hubble (1929) but also Slipher, Friedmann, Lundmark, Lemaître, …

Correlation between *distance* to galaxy and receding (redshift) *velocity*

Universe is expanding !

Earlier : very small, dense and hot U.

Hot “Big Bang” model

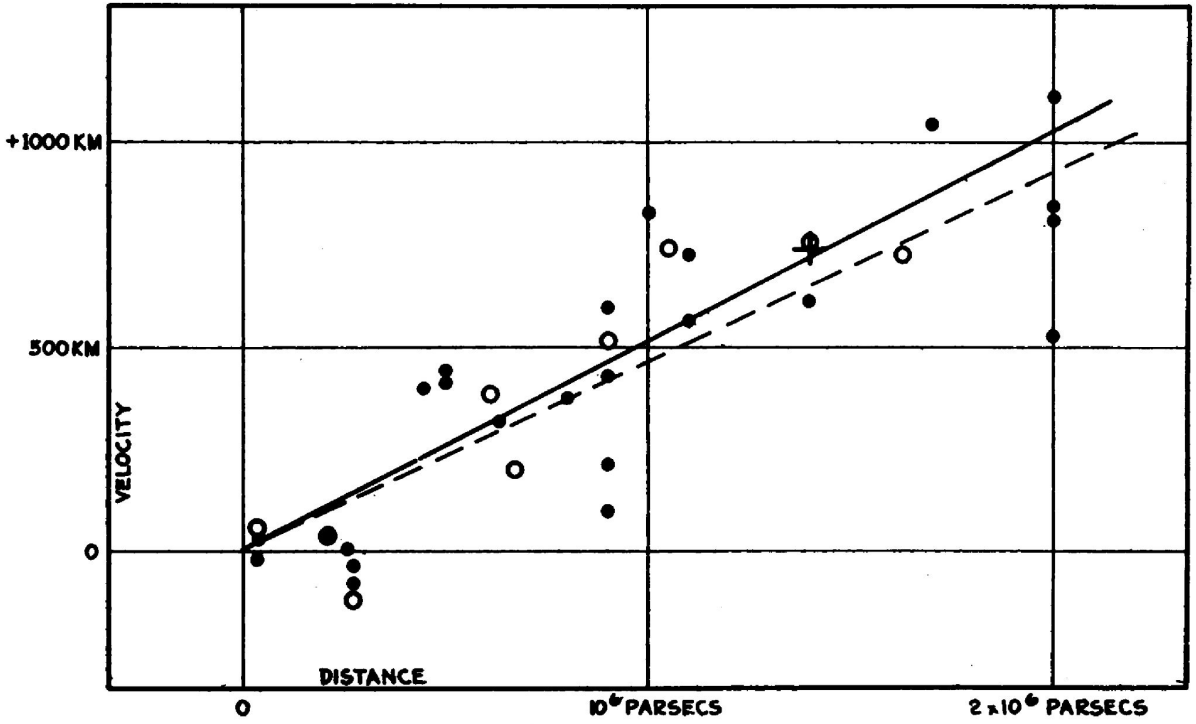


FIGURE 1

Velocity-Distance Relation among Extra-Galactic Nebulae.

Background (+ microwave)

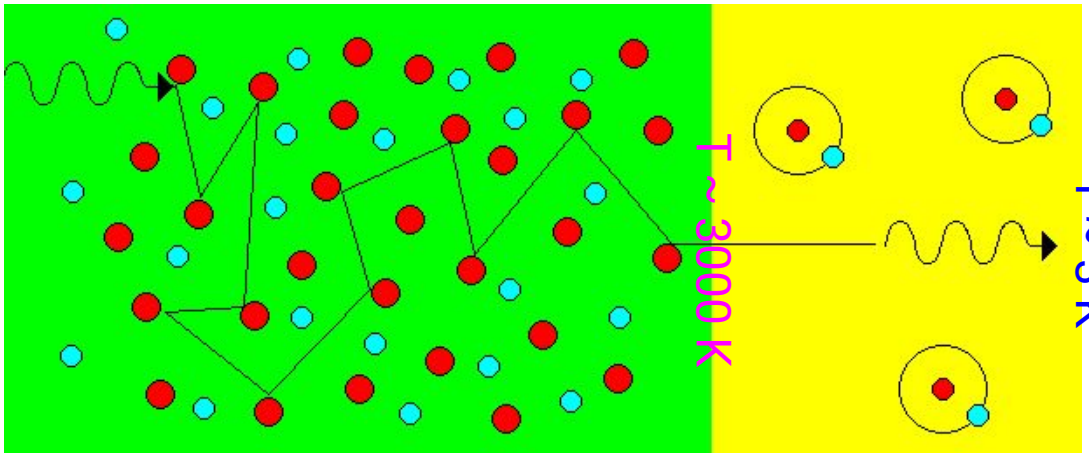
Origin of the CMB

1940s : prediction (Alpher, Herman)
1964 : detection (Penzias, Wilson)
1978 : Nobel prize

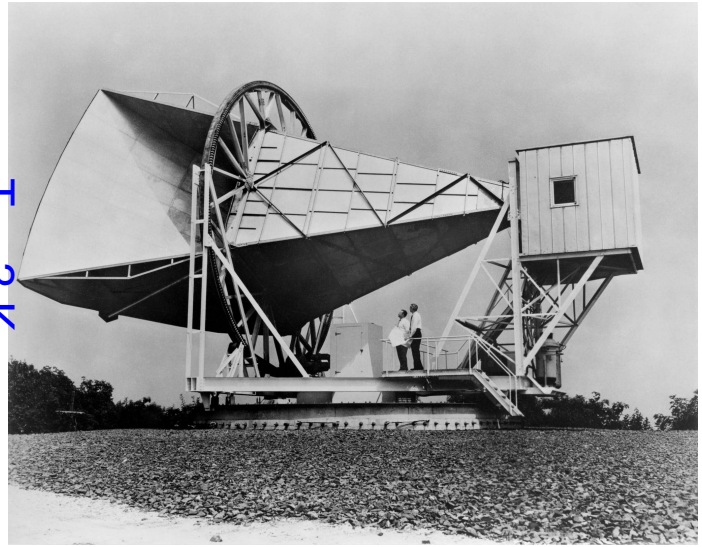
hot
opaque

recombination

colder
transparent



credit: J. Schombert (website)

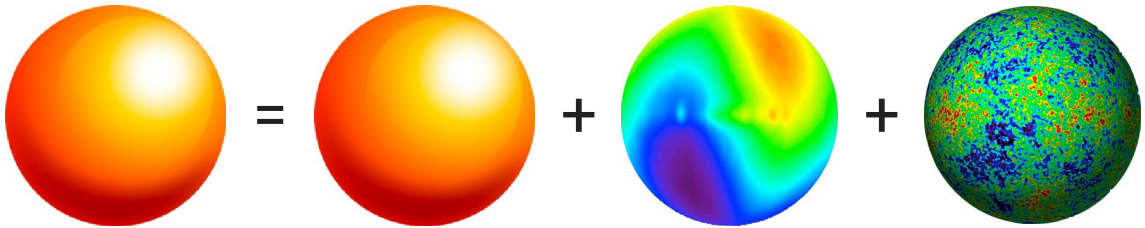


CMB anisotropies

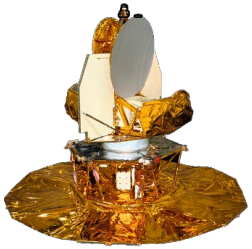
Universe is **not homogeneous** on small scales (galaxies, clusters, …)

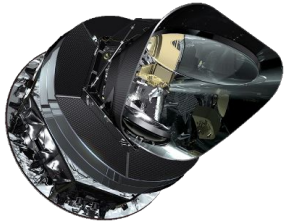
Today’s inhomogeneities result from tiny fluctuations in the very early U.

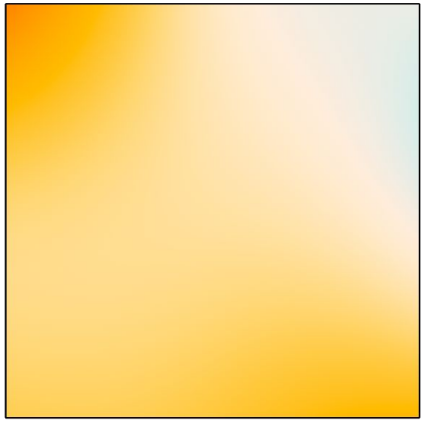
These fluctuations are visible on the CMB surface!

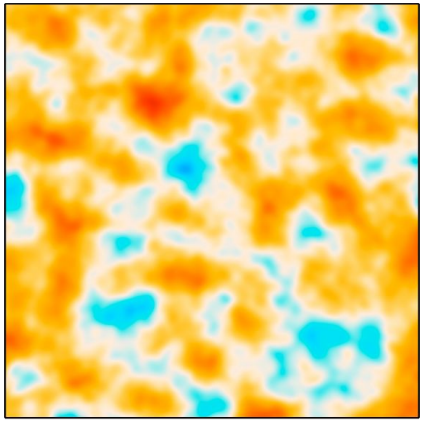


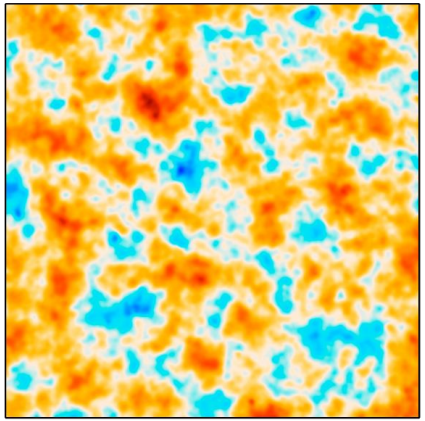
Credits: Josquin Errard











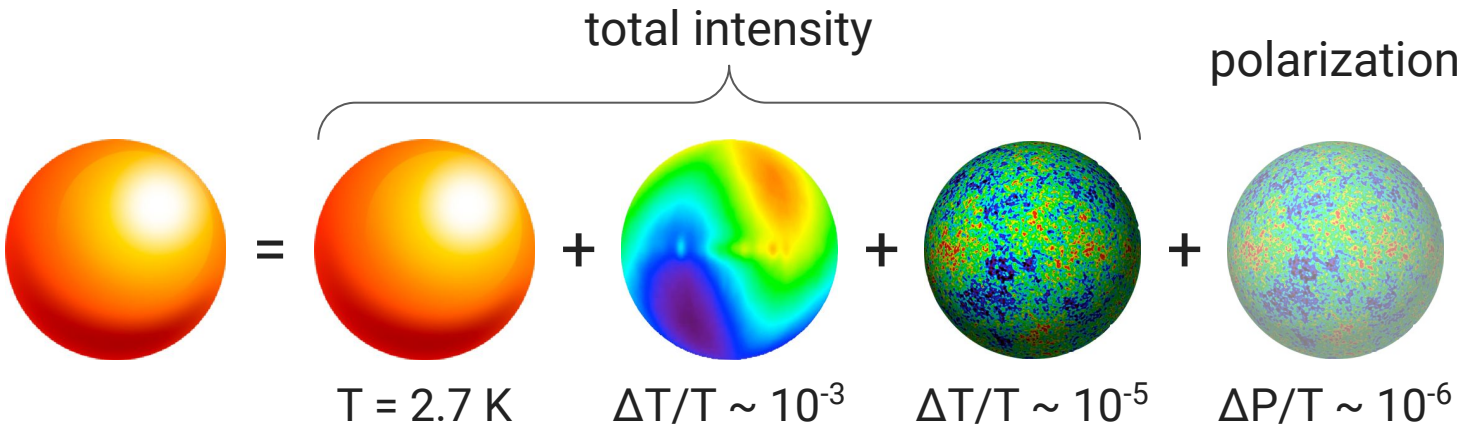
COBE WMAP Planck

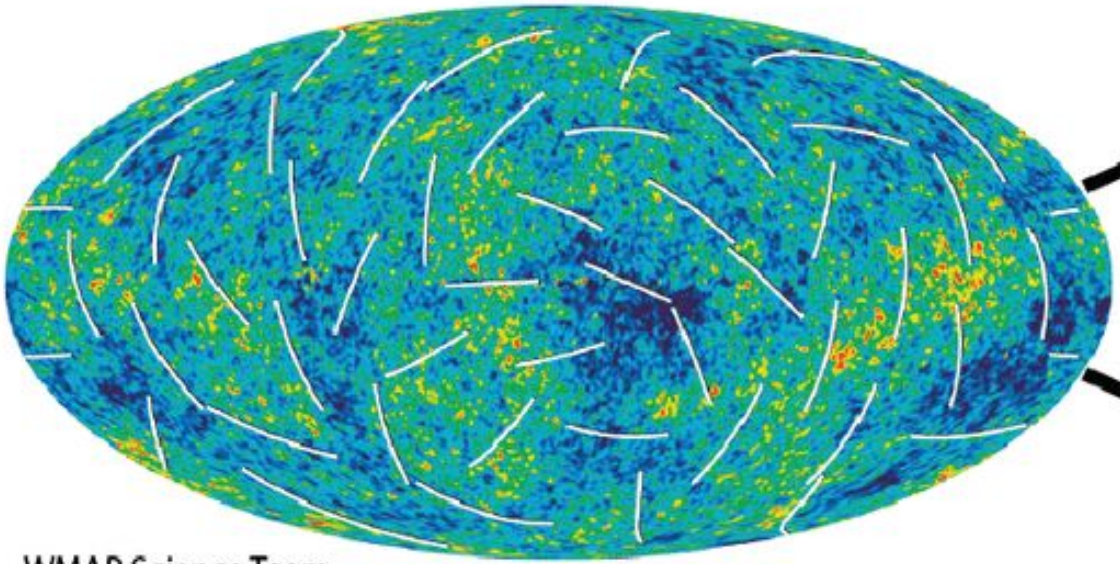
Increased angular resolution with successive generations of instruments – Credit: NASA/JPL-Caltech/ESA

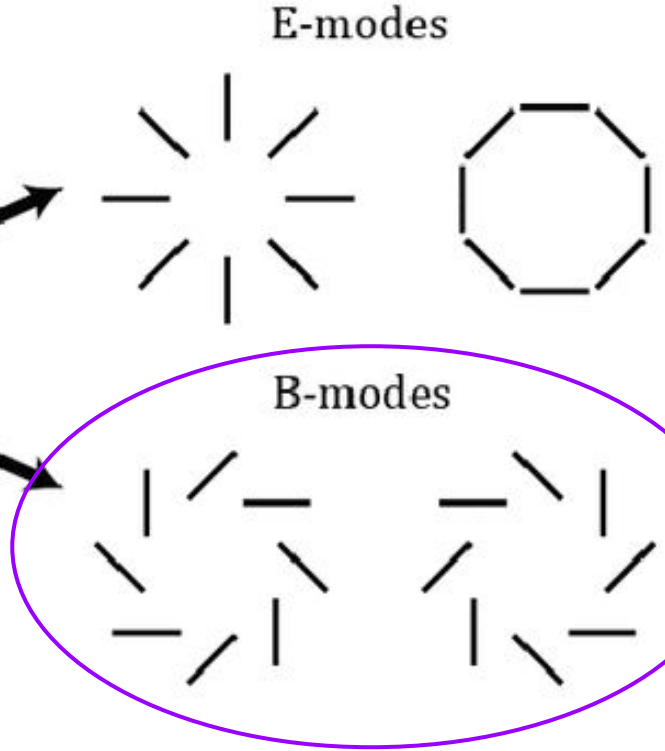
Polarization

What about polarization?

Thomson scattering + inhomogeneities = CMB photons are polarized



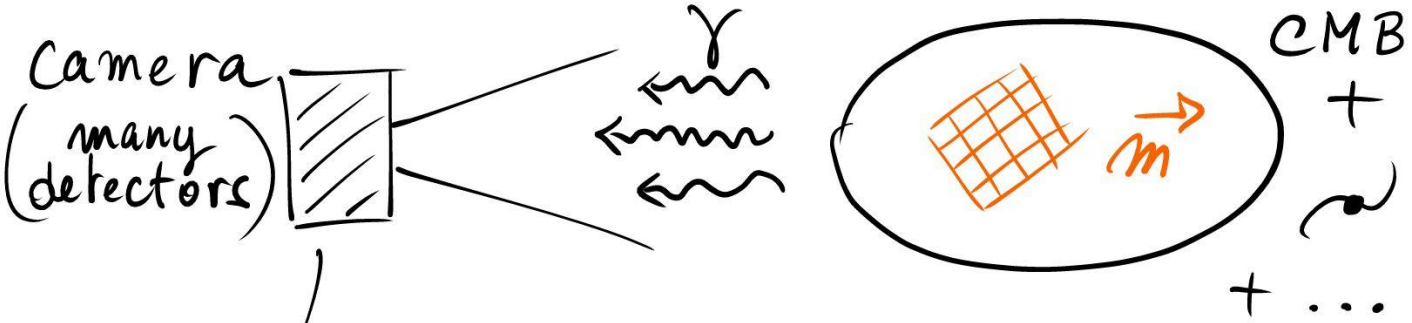


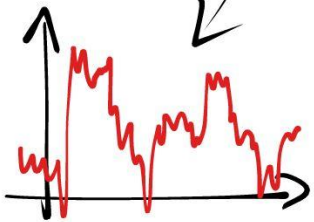


E- and B-mode patterns on the CMB polarization map
Credit: WMAP collaboration

Potential trace of *primordial gravitational waves* !

Map-making





time-ordered data (> petabyte !)

$\vec{d} = P\vec{m} + \vec{n}$

↳ reconstruct observed sky

$\hat{\vec{m}} = ??? \times \vec{d}$

+ characterize statistical properties

Next-generation observatories

Simons Observatory

Atacama desert (Chile)

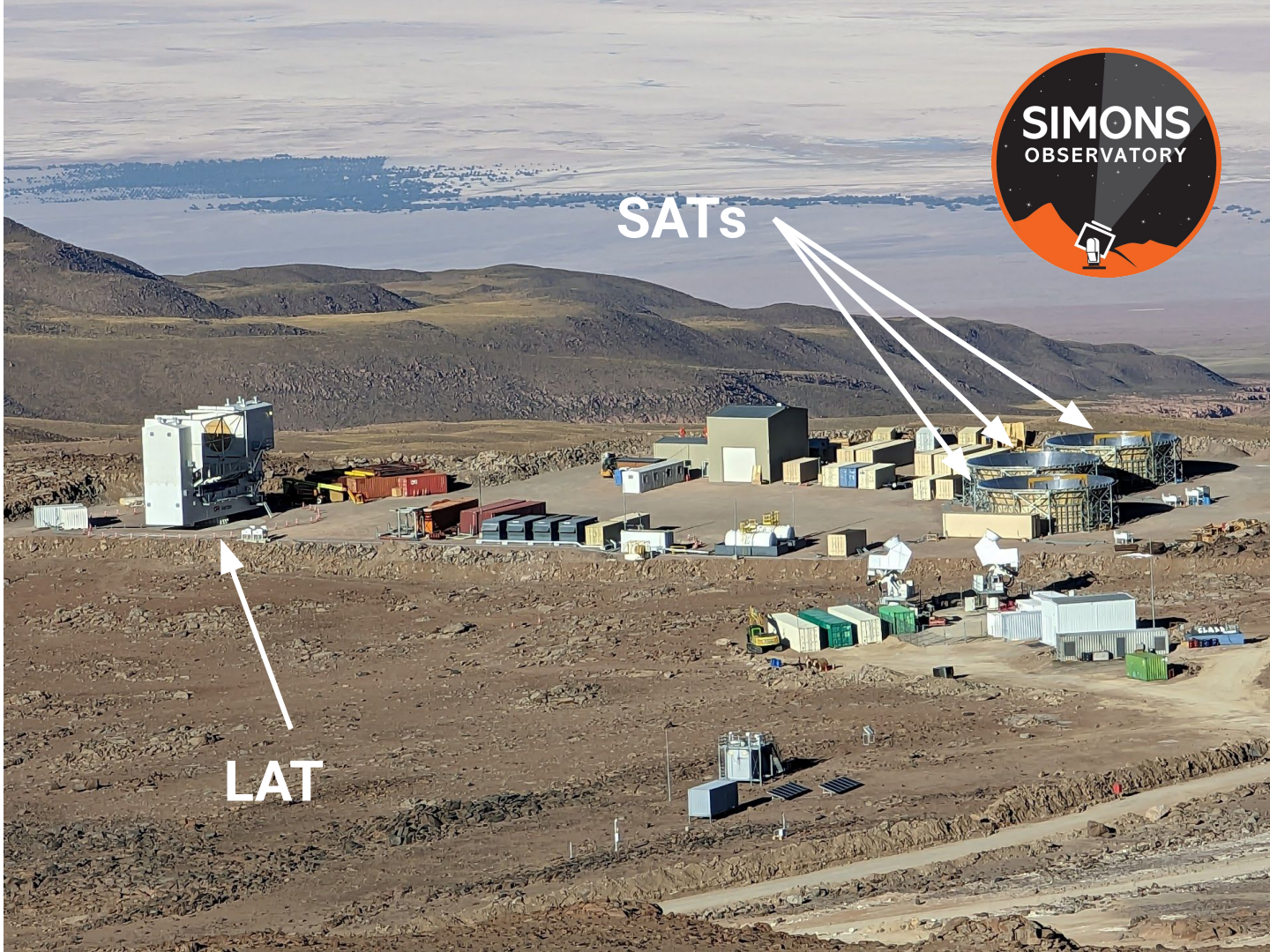
5200 m above sea level

3 small (0.4 m) telescopes

1 large (6 m) telescope

60,000 TES detectors

Many science cases !



Questions ?