

Cosmic Microwave Background: Our key to unravel the mysteries of the Universe

Elena de la Hoz

December 14, 2020

Cosmology Group, Instituto de Física de Cantabria

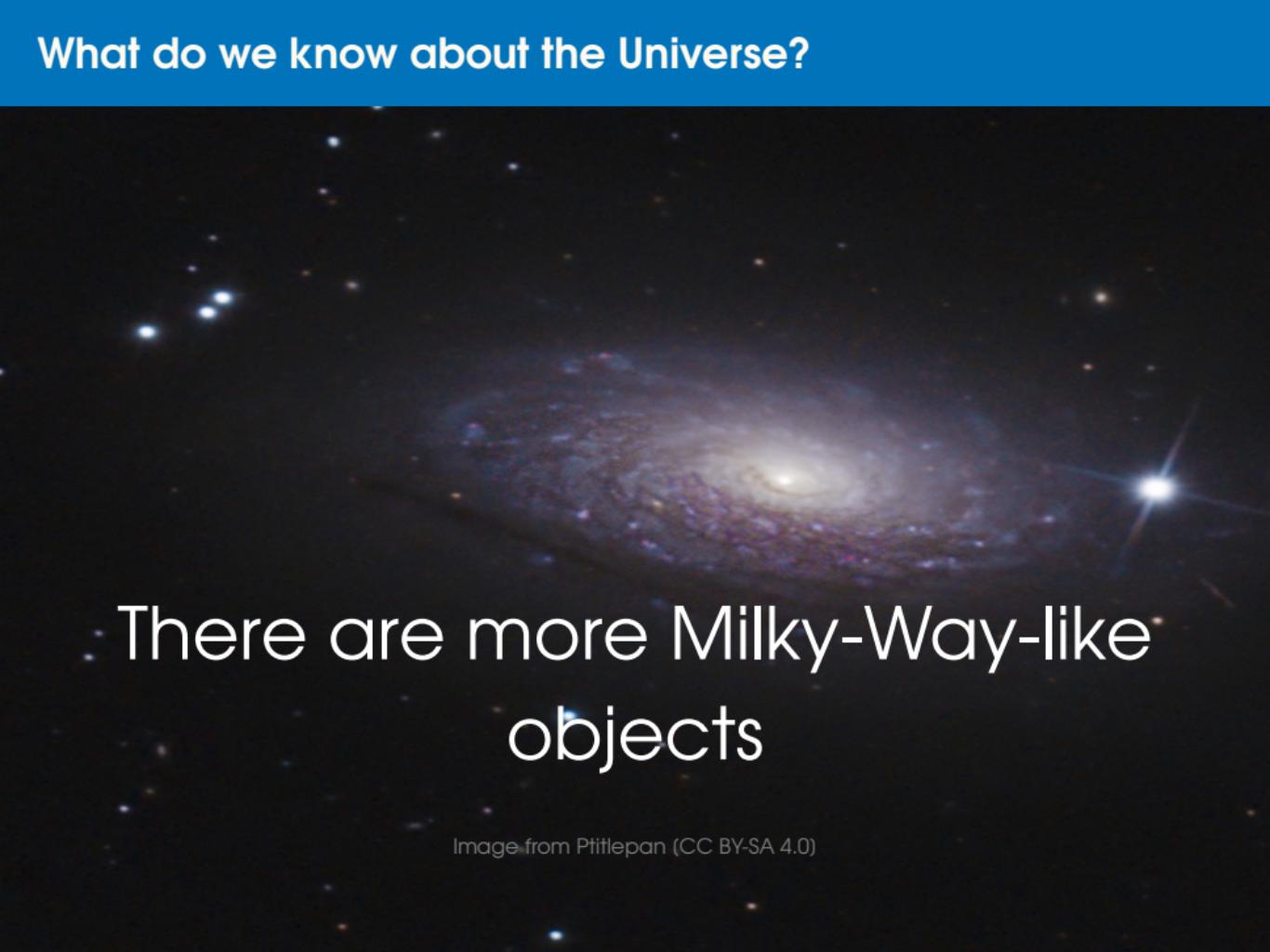


Outline

- 1 Modern Cosmology Milestones
- 2 Cosmic Microwave Background
- 3 Future Prospects: CMB Polarization

Modern Cosmology Milestones

What do we know about the Universe?

A photograph of a spiral galaxy, likely the Milky Way, showing its characteristic spiral arms and central bright nucleus. The galaxy is set against a dark, star-filled background.

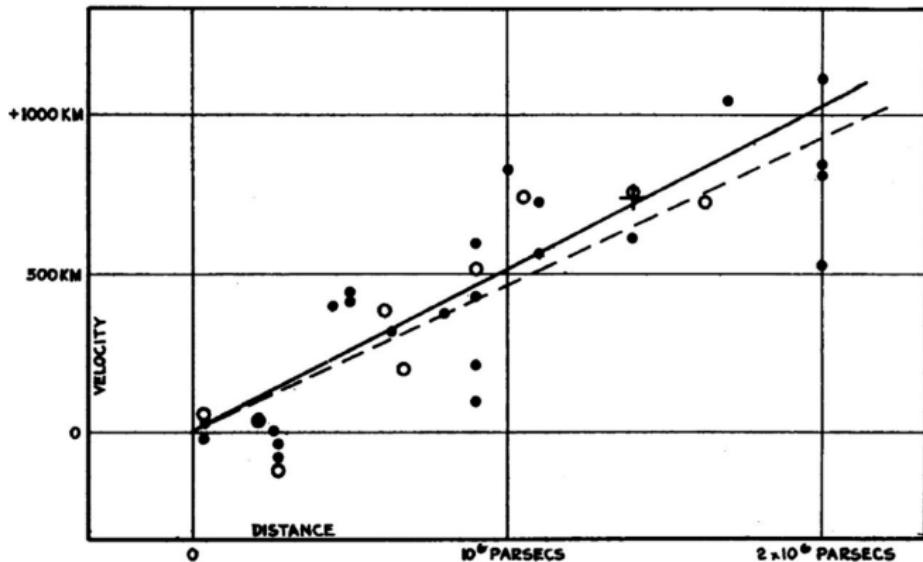
: There are more Milky-Way-like objects

Image from Ptitlepan (CC BY-SA 4.0)

What do we know about the Universe?

Hubble's law

Velocity-Distance Relation among Extra-Galactic Nebulae.



Hubble, Proceedings of the National Academy of Sciences, 1929, 15, 168

What do we know about the Universe?

Large Scale Structure

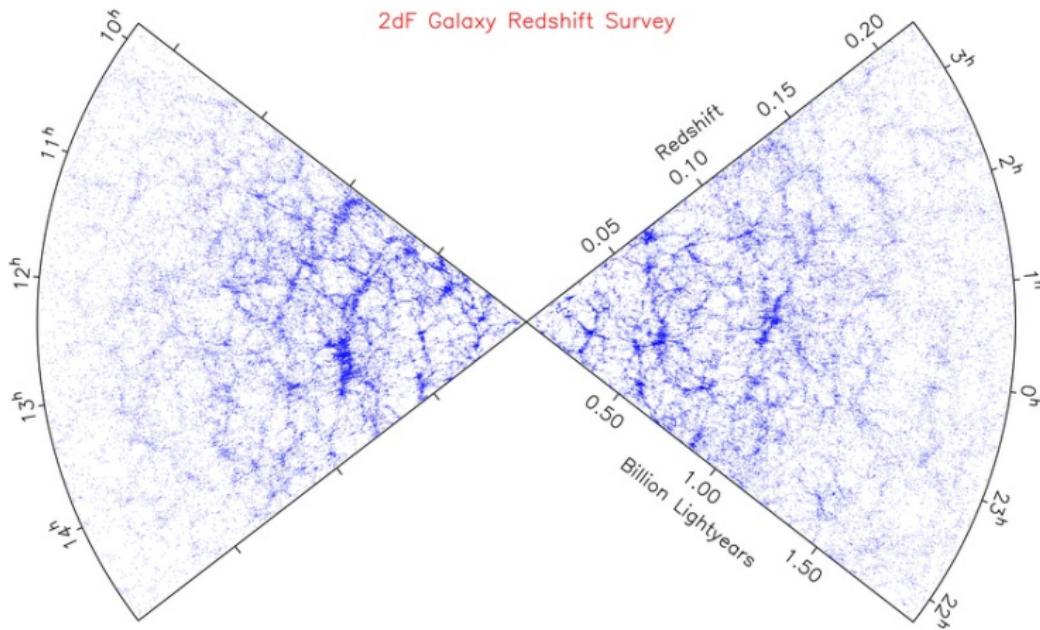
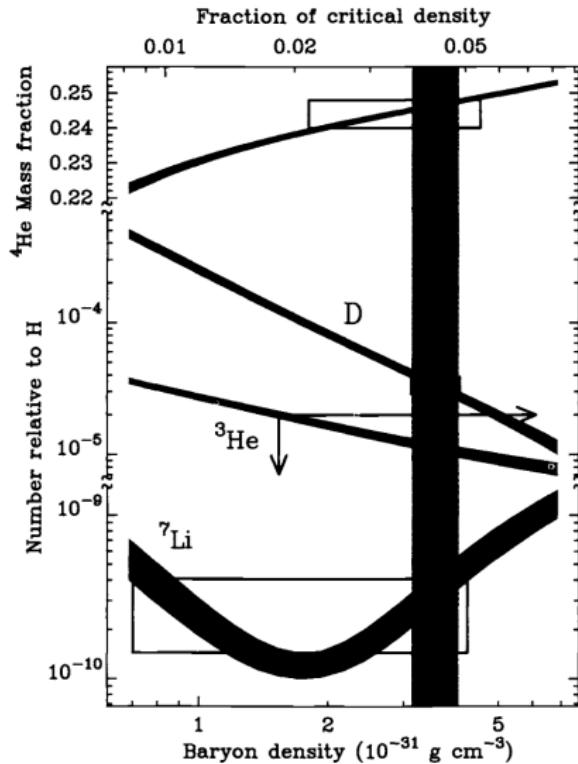


Image from the 2dF Galaxy Redshift Survey: <http://www.2dfgrs.net/>

What do we know about the Universe?

Primordial Nuclide Abundances

Image from Dodelson, Scott. Modern cosmology. Elsevier, 2003.



What do we know about the Universe?

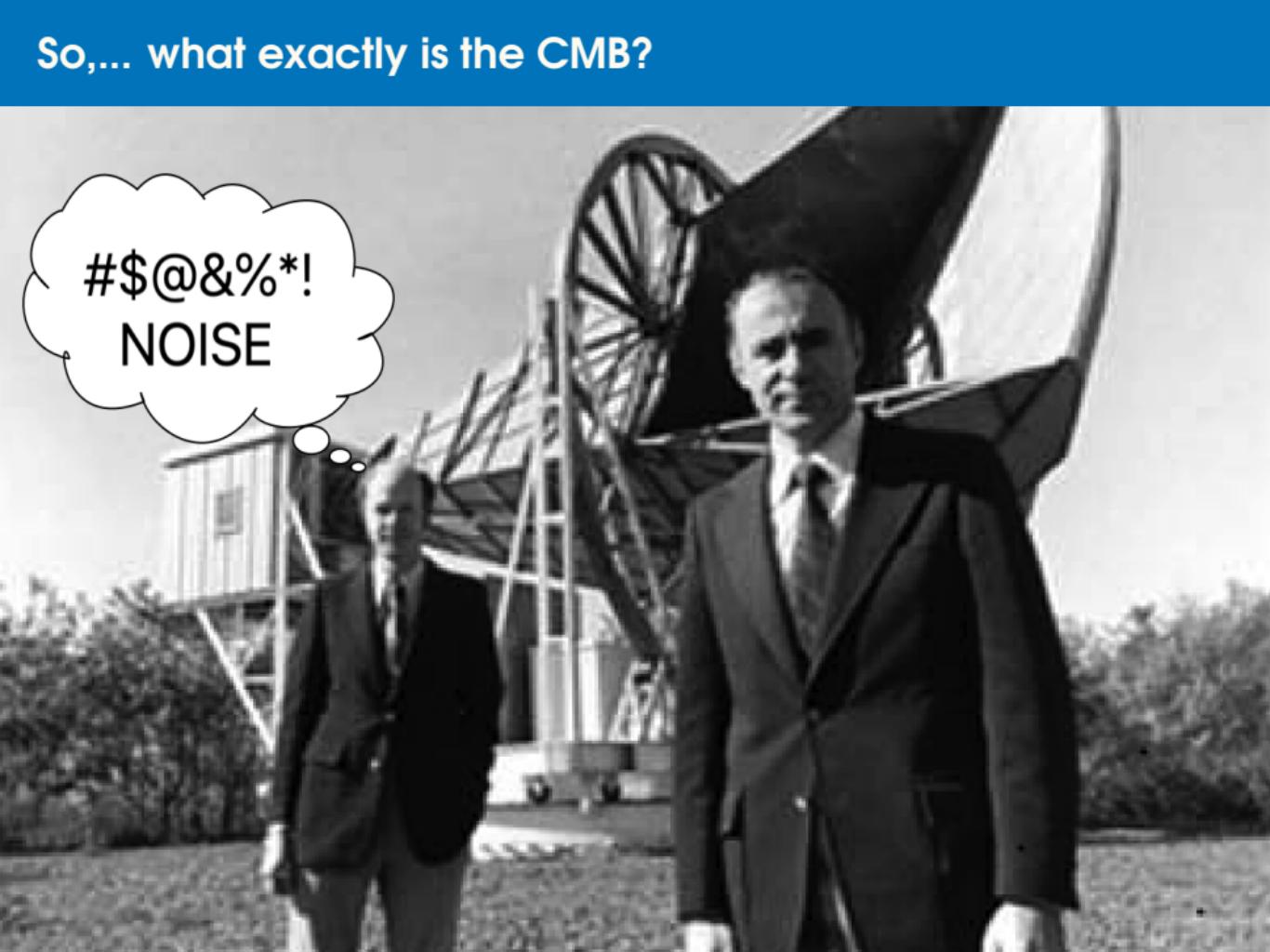
Detection of the Cosmic Microwave Background

Image courtesy of ESA and the Planck Collaboration.

<https://www.cosmos.esa.int/web/planck/picture-gallery>

Cosmic Microwave Background

So,... what exactly is the CMB?



#\$@&%*!
NOISE

So,... what exactly is the CMB?



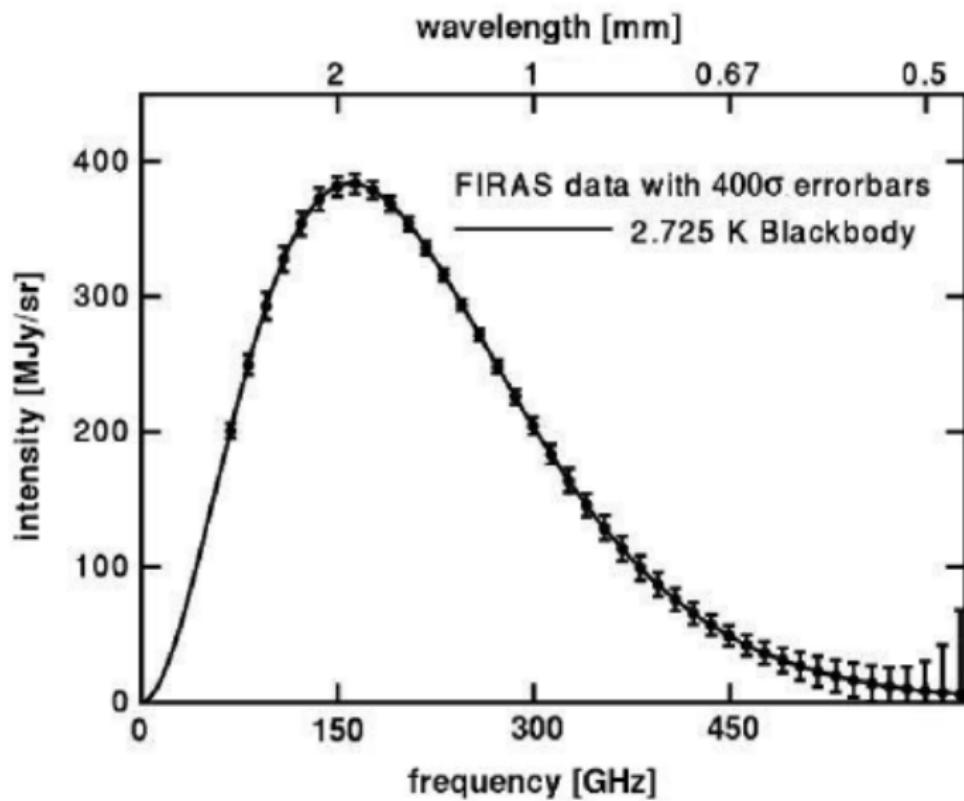
Robert H. Dicke. Photo by Bob Matthews,
Department of Physics, Princeton University



-THUG LIFE-



COBE. Black-body Spectrum



Mollweide Projection



Image from: <https://www.nasa.gov/topics/earth/overview/index.html>

Mollweide Projection

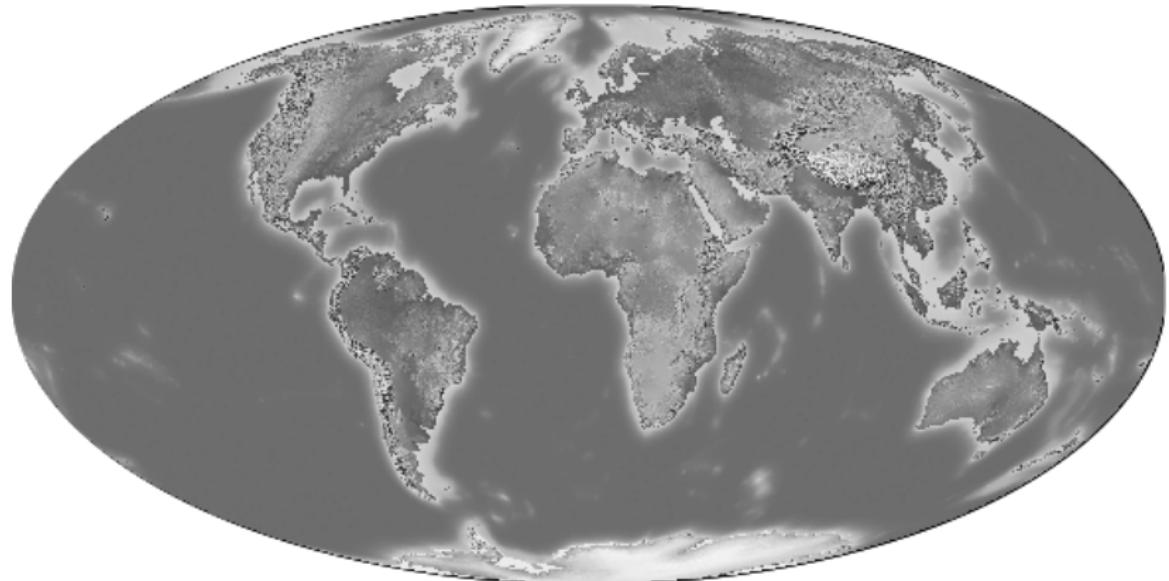


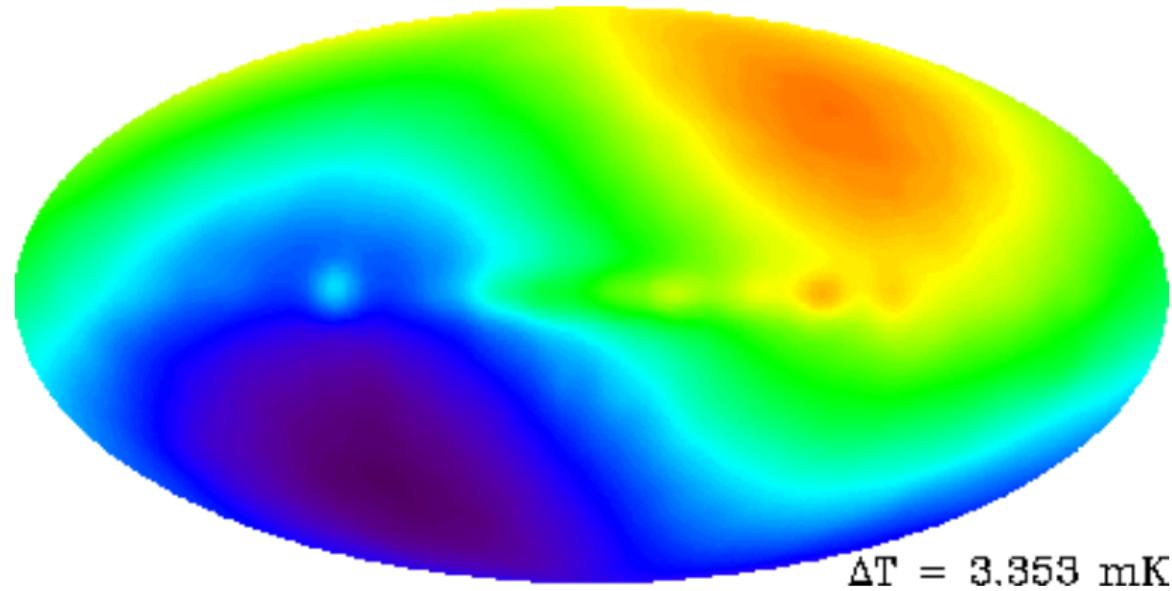
Image by Andrea Zonca retrieved from: <https://nbviewer.jupyter.org/gist/zonca/6187504>

COBE DMR. CMB map



Image from https://lambda.gsfc.nasa.gov/product/cobe/dmr_image.cfm

COBE DMR. CMB map



$\Delta T = 3.353 \text{ mK}$

Image from https://lambda.gsfc.nasa.gov/product/cobe/dmr_image.cfm

COBE DMR. CMB map

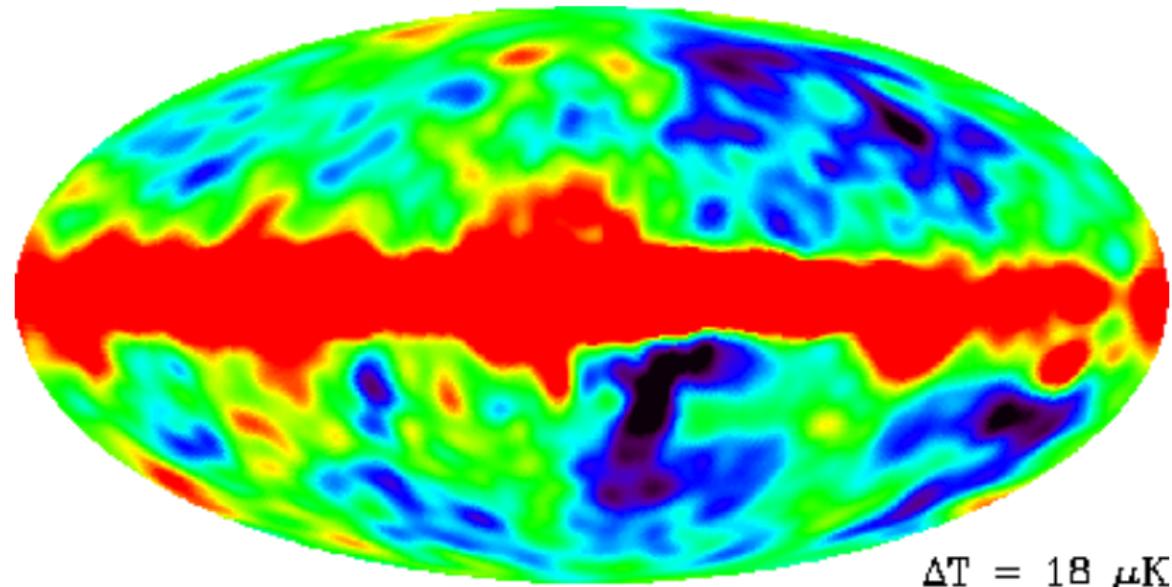


Image from https://lambda.gsfc.nasa.gov/product/cobe/dmr_image.cfm

Planck Temperature CMB anisotropies

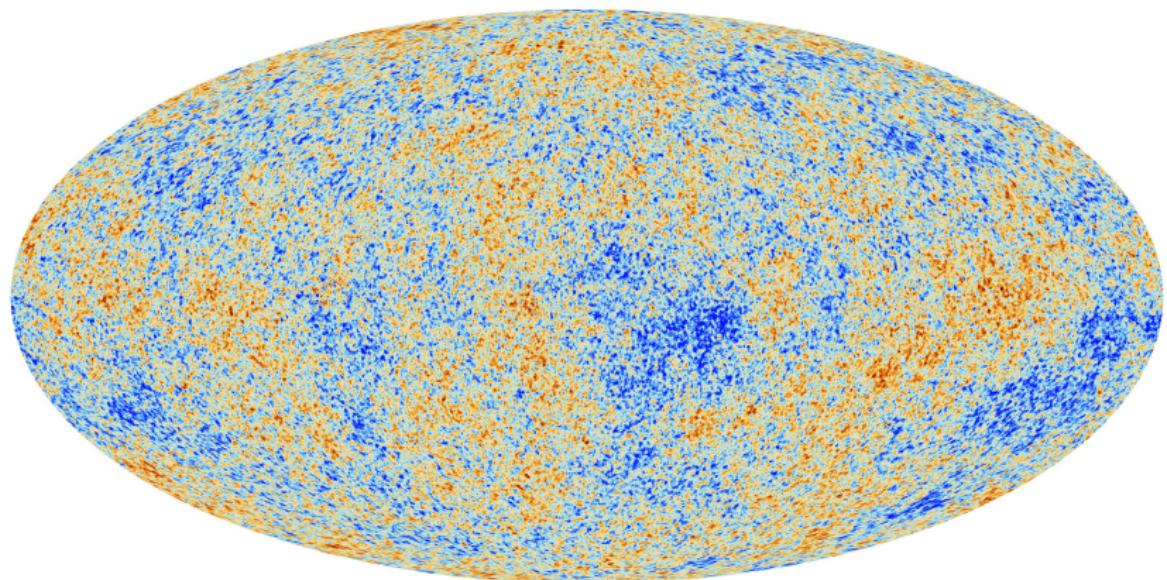
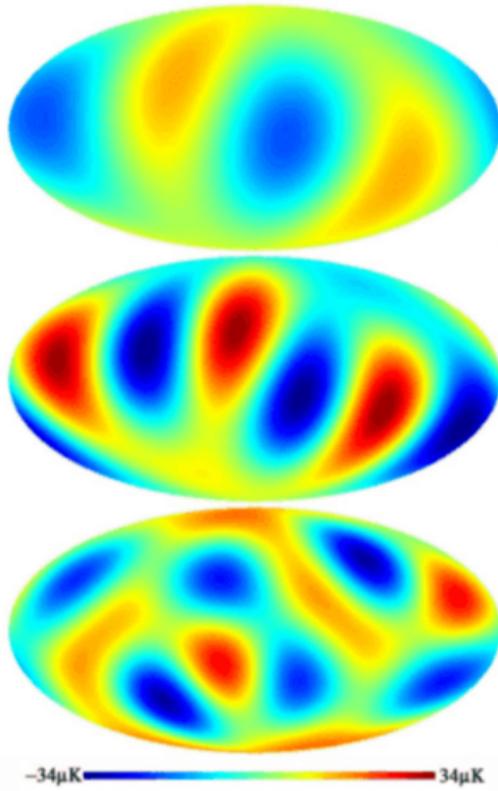


Image courtesy of ESA and the Planck Collaboration.

<https://www.cosmos.esa.int/web/planck/picture-gallery>

Sphere scales



Planck CMB Temperature Power Spectrum

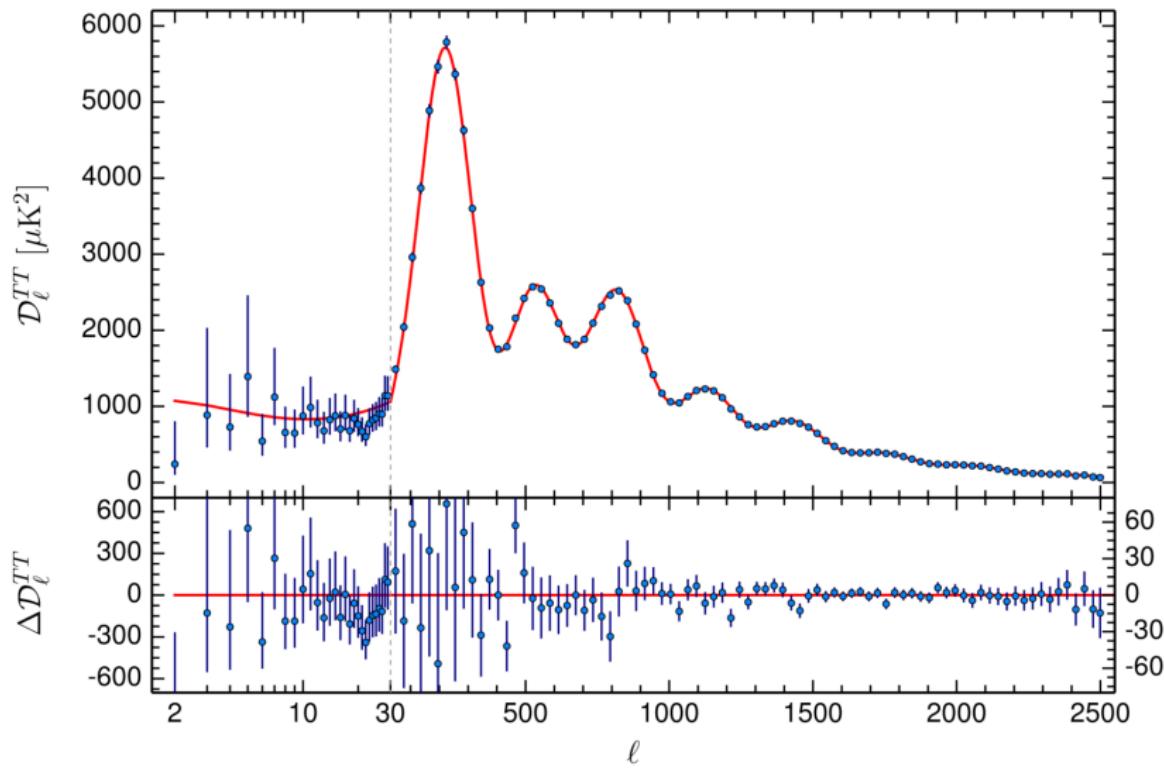


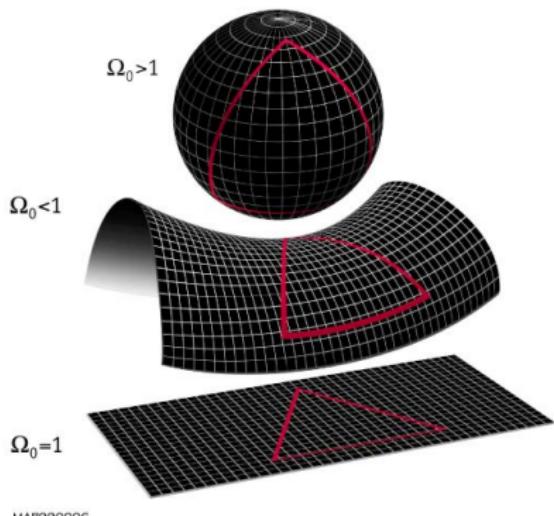
Image courtesy of ESA and the Planck Collaboration.

<https://www.cosmos.esa.int/web/planck/picture-gallery>

Future Prospects: CMB Polarization

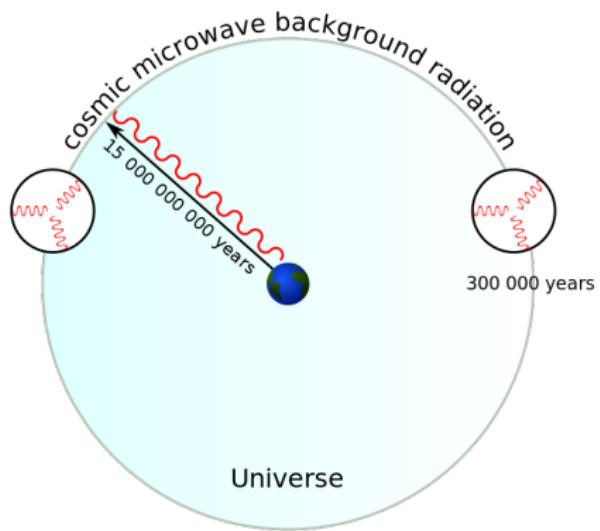
Problems of the Standard Big Bang Cosmology

- ▶ Flatness problem
- ▶ Horizon problem
- ▶ Monopole problem



Problems of the Standard Big Bang Cosmology

- ▶ Flatness problem
- ▶ Horizon problem
- ▶ Monopole problem



The original uploader was Theresa knott at English Wikipedia.derivative work: chris (CC BY-SA 3.0)

Problems of the Standard Big Bang Cosmology

- ▶ Flatness problem
- ▶ Horizon problem
- ▶ Monopole problem



k7290920 www.fotosearch.com

Inflation

- ▶ Flatness problem
- ▶ Horizon problem
- ▶ Monopole problem

Inflation

- ▶ Flatness problem
- ▶ Horizon problem
- ▶ Monopole problem

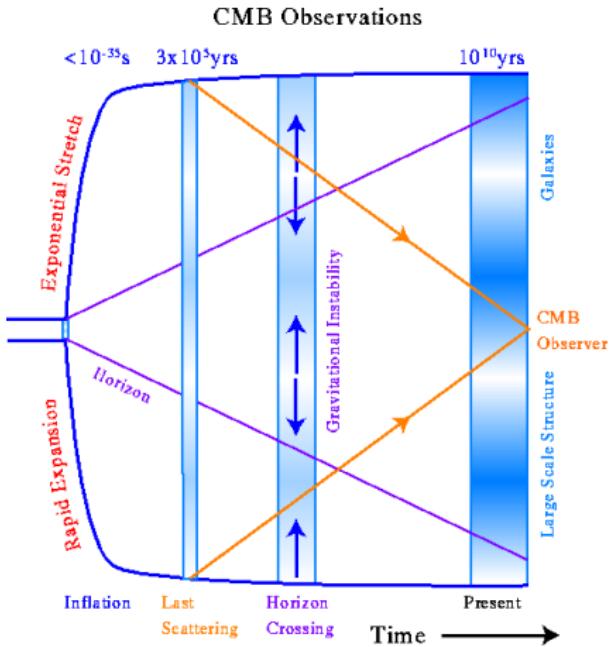
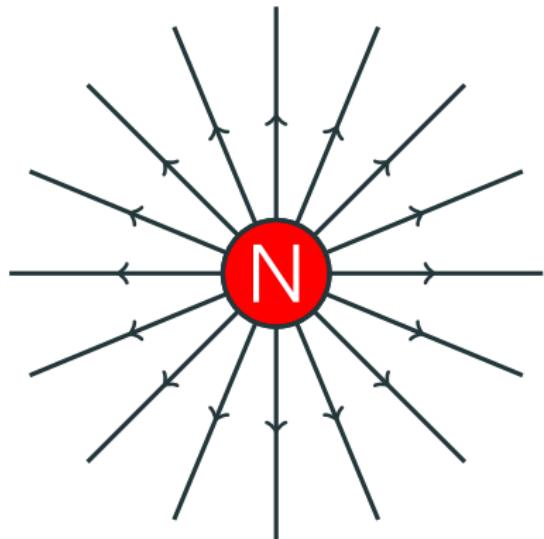


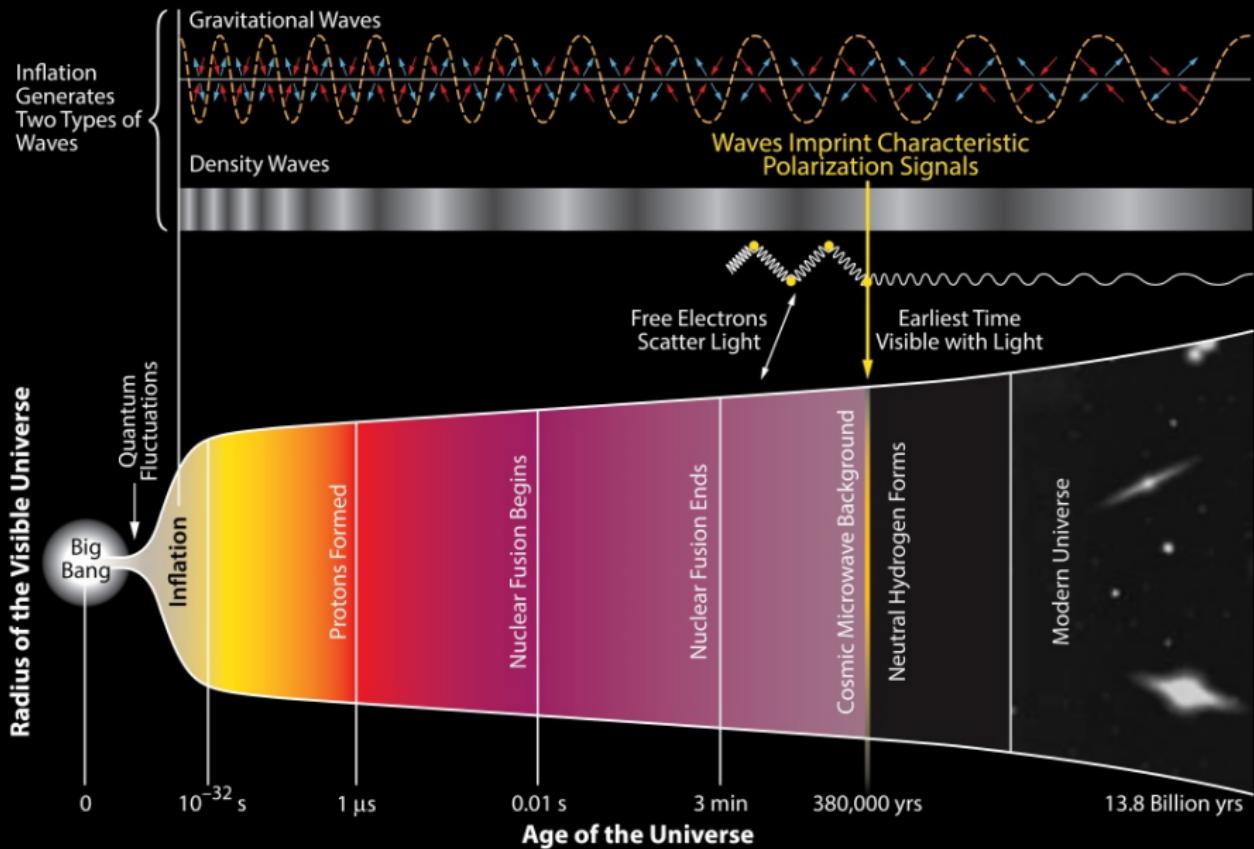
Image from <http://background.uchicago.edu/~whu/index.html>

Inflation

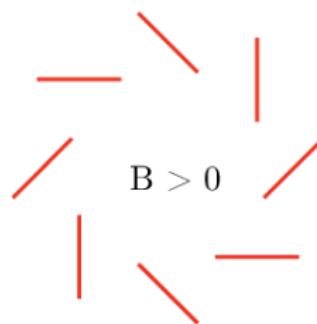
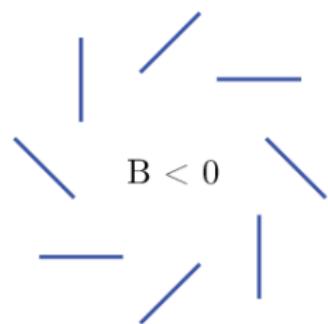
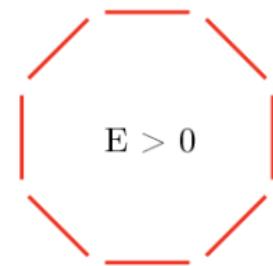
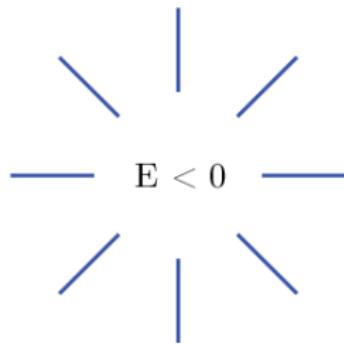
- ▶ Flatness problem
- ▶ Horizon problem
- ▶ Monopole problem



History of the Universe



E & B modes



E & B modes

