Observing the Birth of the Universe with the Cosmic Microwave Background

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Staring at the Night Sky

Milky Way
The Light Spectrum
The Sky at Microwave Frequencies

Milky Way

Cosmic Microwave Background
Discovery of the Cosmic Microwave Background in 1965

50 yrs birthday of the discovery

Nobel Prize in 1978

Microwave Receiver

Robert Wilson

Arno Penzias
A Cosmic Timeline

Cosmic Microwave Background

- Afterglow Light Pattern 380,000 yrs.
- Dark Ages
- Development of Galaxies, Planets, etc.
- Dark Energy Accelerated Expansion
- Inflation
- Quantum Fluctuations
- 1st Stars about 400 million yrs.
- Big Bang Expansion 13.7 billion years

Planck
Cosmic Microwave Background Fun Facts

- 400 photons (particle of light) per cubic cm today, anywhere.

1% of the snow-like noise actually comes from the CMB
The History of CMB observations

1965

Nobel Prize in 1978 to A. Penzias and R. Wilson

1992

COBE

Nobel Prize in 2006 to G. Smoot and J. Mather

2003

WMAP
Cosmology after Planck

- Cosmology:
  - The study of the evolution of the Universe and its nature on very large scales ($\gtrapprox 3$M light-years).

Planck Collaboration 2015
Cosmic Microwave Background and Cosmology

- Cosmic Microwave Background has been a formidable observational tool for cosmology over the last 50 years.
  - We can see a snapshot of the Universe when it was very young.

- Cosmology:
  - The study of the evolution of the Universe and its nature on very large scales (\(\approx 3\)M light-years).

- What is precision in cosmology?
  - As an example, the age of the Universe is measured to be 13.719 Gyr ± 0.5% using Planck (!!)
  - Other global properties such as the matter content of the Universe are measured at percent level.

- Thanks to the Cosmic Microwave Background and other tools, we are constantly improving our understanding of the evolution of the Universe.
  - Cosmology is an important and vibrant scientific endeavor.
FIN
Mollweide Projection