[Introduction]Introductionch:introduction

One of the most remarkable achievements in physical sciences over the last few decades is the precision to which cosmologists have been able measure the initial conditions of our Universe. We know very well how it all began 13.8 billion years ago and what the starting ingredients were. From the panoply of planets, stars and galaxies we see around us today, we also have a good grasp on what those ingredients eventually became. The challenge facing Astronomy is to fill in the gaps in that long history and shed light upon the underlying physics which shaped the formation and evolution of these celestial objects.

The Early Universe What makes the measurements of the initial conditions in our Universe possible is the detailed observation of the cosmic microwave background (CMB). Famously discovered accidentally by Arno Penzias and Robert Wilson in 1964 Penzias:1965es but independently postulated several times in the preceding decades, the CMB represents the oldest light in the Universe. For the first $\sim 373,000$ years after the Big Bang all baryonic matter in the Universe – including free electrons, protons and neutrons – was coupled together in a hot, uniform, radiation-filled hydrogen plasma. As the Universe expanded and cooled, the electrons and protons eventually cooled enough to form neutral atoms ('recombination') shortly before cooling far enough to allow the radiation field to decouple from the baryons and the photons to stream freely through space ('decoupling'). It is those primordial photons that have been propagating through space and slowly cooling until this date to produce the cosmic microwave background we observe today.

Since the initial measurements of the CMB 50 years ago, a succession of ground-based, balloon-borne and space-based telescopes have measured the CMB with increasing precision. Despite initially appearing uniform in all directions, in 1992 data from the Cosmic Background Explorer (COBE) satellite indicated minute variations in the temperature of the CMB on small scalesRe-analysis of data from the Soviet RELIKT-1 anisotropy experiment did in fact lead to publication of anisotropy results several months before the COBE announcement (re-published in Strukov:1992ua Strukov:1992ua). However it was the COBE results for which the Nobel prize was later awarded. These anisotropies have since been measured to exquisite precision by the Wilkinson Microwave Anisotropy Probe (WMAP) and Planck experiments, leading to strong support for the currently favoured model of $\Lambda$-Cold Dark Matter () cosmology. Figure fig:cmb$_{c}omparisonillustratesjusthowmucheachnewgenerationofspace-basedCMBlaboratoryhasimprovedourpicturec$

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Planck CMB [The Cosmic Microwave Background anisotropy.]Top: Illustration of the increase in angular resolution offered by successive generation of CMB observatories, Credit – NASA/JPL-Caltech/ESA. Bottom: The all-sky map of the cosmic microwave background anisotropies as measured by the Planck satellite, Credit – ESA and the Planck Collaboration. fig:cmb$_{c}omparison$

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