

# ***COSMOLOGY WITH THE COSMIC MICROWAVE BACKGROUND: CURRENT STATUS AND FUTURE GOALS***

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Overwhelming evidence indicates that our complicated present-day universe (full of galaxies and stars and planets and at least some lifeforms) is evolving from a simple beginning as a dense cloud of hot plasma. The leftover, cooled-off radiation from the primordial plasma still permeates the universe, and is called the Cosmic Microwave Background (CMB). The spectral shape of the CMB matches Planck's curve to spectacular accuracy, confirming its genesis in a hot plasma. The CMB is a blackbody of temperature 2.725~K (Fixsen & Mather, 2002, ApJ 581, 817.) However, tiny anisotropies in the CMB temperature (or equivalently, its intensity) trace inhomogeneities already present when the universe was only a few hundred thousand years old. Measurements of the angular power spectrum of these spatial temperature fluctuations reveal evidence of dark-matter driven oscillations of the primordial plasma. Precise measurements of the power spectrum from a series of experiments culminating in the WMAP satellite data allow disentanglement of various cosmological parameters governing the progress and extent of those oscillations.

Three early-universe effects -- inflation, reionization, and those primordial oscillations -- polarize the CMB slightly. Inflation refers to an epoch in the very early universe in which the fabric of spacetime (or, more formally, points at fixed coordinates in the expanding metric of the universe) is postulated to have stretched apart at speeds in excess of the speed of light. This rapid expansion does not violate any edict of Einstein's, but does lead to several surprising results, including 1) that parts of the primordial plasma which were in causal contact before inflation began, and thus were in thermal equilibrium, get separated by distances greater than  $ct$ , where  $t$  is the age of the universe; and 2) the inevitable production of a stochastic spectrum of gravity waves. Reionization of the cooled primordial plasma is caused by UV emission from the first stars; we know it took place because the universe is no longer full of neutral hydrogen. Several experiments, lead by the DASI effort, have recently detected small polarization anisotropies in the CMB. The first (linearly) polarized fluctuations measured are at the level of parts per million of the CMB blackbody intensity: antenna temperature fluctuations of microKelvins. These polarization anisotropies are imprinted on the CMB radiation by the primordial oscillations. The measured data (as of February 2005) agree with extrapolations of what is expected, given the temperature anisotropy power spectrum. This agreement in itself is a victory and validation of the theory!

Further study of (and search for) the patterns of polarization anisotropy offers new bounty, in its potential to further our understanding of the epoch of reionization, and perhaps even to cast light on the epoch of inflation.