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Probing the First Instants and the Rest of the Universe with Polarized Signatures in the Cosmic Microwave Background

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The cosmic microwave background (CMB) radiation reports the initial conditions in the universe for the formation of large scale structures (galaxies and their dark matter halos, clusters of galaxies). The rich angular power spectrum of the CMB's intensity traces the primordial power spectrum of density fluctuations, but also encodes details of the CMB's interactions with the rest of the universe in its 13-billion-year flight. The CMB is slightly polarized by Thomson scattering whenever there is any local quadrupolar anisotropy in the distribution of the scattering electron population. Acoustic oscillations in the primordial plasma lead to finite local quadrupoles, but the ensuing polarization from this process exhibits an even parity symmetry. We refer to the angular power spectrum of this even-parity polarization as the E-mode spectrum, and name the odd-parity patterns B-modes. A tantalizing fact is that the gravitational wave background left after inflation also produces local quadrupoles, yet the ensuing CMB polarization is not constrained in its parity. Inflation is the only primordial source of B-modes yet proposed, and CMB B-modes are the only proposed avenue for measurement of the energy scale of inflation! Moreover, the inflationary signature in the B-modes is confined to large angular scales. The vanishing of the primordial B-mode spectrum at fine angular scales sets up excellent initial conditions for tracing the subsequent evolution of large scale structure in the universe, since that structure's mass deflects the CMB photons, re-arranging some of the E-mode patterns into B-modes. I will elaborate on the present state of CMB polarization measurements at both large and small angles in the context of their potential discovery space.