

Cosmic Microwave Background Observations for Large-Scale Structure Studies
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The *Planck* mission and the current generation of ground-based cosmic microwave background (CMB) experiments (e.g., the Atacama Cosmology Telescope and the South Pole Telescope) have ushered in a new era of large-scale structure (LSS) studies. With arcminute resolution at frequencies around 100 GHz, CMB observatories probe the distribution of ionized gas in the circumgalactic medium (CGM) and the intergalactic medium (IGM) through the Sunyaev-Zeldovich (SZ) effects, the total mass distribution through gravitational lensing of the CMB and dust emission associated with star formation in active galaxies. These techniques, when combined with the large sky areas to be observed by proposed surveys, such as the Simons Observatory (SO) and CMB-S4, will open fresh new windows onto LSS and its evolution; the SZ effect, for instance, will be the most efficient way to finally unveil the state of the elusive CGM/IGM hosting at least 90% of all baryons (the so-called “missing baryons”), and CMB lensing is the only way to measure the mass distribution at redshifts much greater than unity, where gravitational shear measurements fail because of the lack of lensed background galaxies. By cross-correlating CMB lensing with galaxy tracers, we can reconstruct the evolution of the dark matter cosmic web over redshifts $z=1$ to 5, a unique capability that will yield critical cosmological constraints on dark energy, neutrino mass and modified gravity theories.

For these reasons, the application of CMB observations as a probe of LSS is a new and rapidly growing field with rich scientific opportunities. This thesis project focuses on research centered on cross-correlation of CMB observations with LSS tracers. One example is the cross-correlation of galaxies and clusters in the *Euclid* survey with CMB, SZ and CMB lensing maps. The thesis research includes analysis of LSS using available *Planck* and ground-based data, and theoretical development of these probes in preparation of the next generation surveys. The Ph.D. student will participate in SO and/or CMB-S4, contributing to efforts to construct data analysis methodology and pipelines.