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Measuring the pairwise kinematic Sunyaev-Zel'dovich effect with the Atacama Cosmology Telescope

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We have made improved measurements of the kinematic Sunyaev-Zel'dovich (kSZ) effect using data from the Atacama Cosmology Telescope (ACT) and the Baryon Oscillation Spectroscopic Survey (BOSS). A map of the Cosmic Microwave Background (CMB) composed from two seasons of observations each by ACT and the Atacama Cosmology Telescope Polarimeter (ACTPol) receiver was used. The mean pairwise baryon momentum associated with the positions of 50,000 bright galaxies in the BOSS DR11 Large Scale Structure catalog was evaluated over the 600 square degrees of overlapping sky area. The kSZ signal arising from the large-scale motions of clusters was measured by fitting data to an analytical model, with the free parameter of the fit determining the optical depth to microwave photon scattering for the cluster sample. Our most conservative simulation-based uncertainty estimates for the mean pairwise momenta as a function of galaxy separation gave signal-to-noise values between 3.6 and 4.1 for various luminosity cuts. A novel approach to estimating cluster optical depths from the average thermal Sunyaev-Zel'dovich (tSZ) signal at the cluster positions was explored, and our results are broadly consistent with those obtained from the kSZ signal. In the future, the tSZ signal may provide a valuable source of cluster optical depths, enabling the extraction of velocities from the kSZ sourced mean pairwise momenta. The mean pairwise velocity of clusters is sensitive to the growth of structure and the Universe's expansion history, making it an excellent probe for gravity on large scales and a means for neutrino mass sum constraints. New CMB maps from multi-frequency ACTPol observations promise to improve statistics and systematics for SZ measurements. With these and other upcoming data, such as measurements from DESI, CCAT-prime, and Simons Observatory, the pairwise kSZ signal is poised to become a powerful new cosmological tool, able to test models of modified gravity and dark energy and constrain neutrino physics.

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