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A nearly complete census of intergalactic gas using the kinematic Sunyaev-Zel'dovich effect

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A complete census of baryons in the late universe is a long-standing challenge due to the intermediate temperature and rarefied character of the majority of cosmic gas. To gain insight into this problem, we extract measurements of the kinematic Sunyaev-Zel'dovich (kSZ) effect from the cross-correlation of angular redshift fluctuations, a novel probe that contains precise information about the cosmic density and velocity fields, and CMB maps high-pass filtered using aperture photometry. Remarkably, we detect significant cross-correlation for a wide range of redshifts and apertures using 6dF galaxies, BOSS galaxies, and SDSS quasars as tracers, yielding an 11 sigma detection of the kSZ effect. We then leverage these measurements to set constraints on the location, density, and abundance of gas inducing the kSZ effect, finding that this gas resides outside dark matter haloes, presents densities ranging from 10 to 250 times the cosmic average, and comprises half of all baryons predicted by early-universe studies. Taken together, these findings suggest that our technique provides a nearly complete census of intergalactic gas from $z = 0$ to 5.

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