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Distributions of Gas and Galaxies from Galaxy Clusters to Larger Scales

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We address the distributions of gas and galaxies on three scales: the outskirts of galaxy clusters, the clustering of galaxies on large scales, and the extremes of the galaxy distribution. In the outskirts of galaxy clusters, long-standing analytical models of structure formation and recent simulations predict the existence of density jumps in the gas and dark matter profiles. We use these features to derive models for the gas density profile, obtaining a simple fiducial model that is in agreement with both observations of cluster interiors and simulations of the outskirts. We next consider the galaxy density profiles of clusters; under the assumption that the galaxies in cluster outskirts follow similar collisionless dynamics as the dark matter, their distribution should show a steep jump as well. We examine the profiles of a low-redshift sample of clusters and groups, finding evidence for the jump in some of these clusters. Moving to larger scales where massive galaxies of different types are expected to trace the same large-scale structure, we present a test of this prediction by measuring the clustering of red and blue galaxies at $z \sim 0.6$, finding low stochasticity between the two populations. These results address a key source of systematic uncertainty – understanding how target populations of galaxies trace large-scale structure – in galaxy redshift surveys. Such surveys use baryon acoustic oscillations (BAO) as a cosmological probe, but are limited by the expense of obtaining sufficiently dense spectroscopy. With the intention of leveraging upcoming deep imaging data, we develop a new method of detecting the BAO in sparse spectroscopic samples via cross-correlation with a dense photometric catalog. This method will permit the extension of BAO measurements to higher redshifts than possible with the existing spectroscopy alone. Lastly, we connect galaxies near and far: the Local Group dwarfs and the high redshift galaxies observed by Hubble and Spitzer. We examine how the local dwarfs may have appeared in the past and compare their properties to the detection limits of the upcoming James Webb Space Telescope (JWST), finding that JWST should be able to detect galaxies similar to the progenitors of a few of the brightest of the local galaxies, revealing a hitherto unobserved population of galaxies at high redshifts.