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How dark matter, baryons, and radiation imprint scales on galaxy clustering today

The growth of structure around the time of matter-radiation equality, z˜3000, is determined by both the matter and radiation. Outside the sound horizon, inhomogeneities in the radiation contribute gravitationally to the growth of perturbations, as do inhomogeneities in the matter. In contrast, inside the sound horizon, the radiation inhomogeneities contribute less and less. This difference most strongly affects the growth of perturbations entering the horizon around matter-radiation equality, and is typically cast as a wavenumber-dependent transfer function that evolves the primordial spectrum of perturbations. Previously, analytic solutions have been found for both the small-wavenumber (outside the horizon) and large-wavenumber (deep inside the horizon) limits, and a full transfer function derived by interpolation between the two. This approach offers but inexact treatment of modes entering the horizon around matter-radiation equality. Here we present an analytic derivation of the transfer function valid on all scales. In particular, it accurately treats modes entering the horizon at equality, and also includes the baryon acoustic oscillations (BAO). Essentially, we offer a unified, simple picture of the growth of perturbations on all scales, valid in the linear regime of structure formation (z>100). This picture illustrates how the interplay of dark matter, baryons, and radiation imprints the horizon at both matter-radiation equality and at decoupling on the clustering of galaxies today.

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