Observational signatures of Non-comoving Cosmology

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Abstract

One of the fundamental assumptions of the standard ΛCDM cosmology is that, on large scales, all the matter-energy components of the Universe share a common rest frame. This seems natural for the visible sector, that has been in thermal contact and tightly coupled in the primeval Universe. The dark sector, on the other hand, does not have any non-gravitational interaction known to date and therefore, there is no *a priori* reason to impose that it is comoving with ordinary matter. In this work we explore the consequences of relaxing this assumption and study the cosmology of non-comoving fluids. We show that it is possible to construct a homogeneous and isotropic cosmology with a collection of fluids moving with non-relativistic velocities. Our model extends ΛCDM with the addition of a single free parameter β_0, the initial velocity of the visible sector with respect to the frame that observes a homogeneous and isotropic universe. This modification gives rise to a rich phenomenology, while being consistent with current observations for $\beta_0 < 1.6 \times 10^{-3}$ (95% CL). This work establishes the general framework to describe a non-comoving cosmology and extracts its first observational consequences for large-scale structure. Among the observable effects, we find sizeable modifications in the density-velocity and density-lensing potential cross-correlation spectra. These corrections arise as dipolar modulations, giving rise to deviations from statistical isotropy. The relative motion between the different fluids also couples the vector and scalar modes, the latter acting as sources for metric vector modes and vorticity for all the species.

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