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Imprints of Ultra-light Axions in the Halo Bias

Ultra-light axions with masses $10^{-33} < m_\phi/\text{eV} < 10^{-22}$ are allowed to constitute only a small fraction of the observed dark matter abundance. Nevertheless, they may yet produce a visible impact on the cosmology due to their macroscopic quantum scale. Next generation galaxy survey data are poised to challenge this possibility, but in order to do so, all aspects of structure formation in this quasi-linear regime must be accounted for consistently and precisely. This includes modeling not only the effect of these axions on the background cosmology and matter fluctuations, but also on the halo bias that governs the tracers we observe, namely galaxies. In this work we discuss the effect of ultra-light axions on cosmological observables, and present a prescription for computing the growth-induced scale-dependent bias in their presence. We find that these axions introduce a step in the halo bias at their characteristic Jeans scale, representing - even at percent-level abundances - a sizable increase in the total scale-dependence of the bias, compared to the ΛCDM fiducial. We implement this prescription as a function of axion mass and relic abundance, in a public package which we dub {\tt RelAxiFast}, an extension of the extant {\tt RelicFast}.

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