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Decoding Holographic Dark Energy in the structure formation

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We implemented in the popular Boltzmann solver **CLASS** a holographic dark energy **(HDE)** model with two infrared (IR) cut-offs: the Ricci scalar curvature **(RDE)** and its more general version the Granda-Oliveros **(GO)**. For the background, we show that the HDE density using the GO cut-off can exhibit radiation, matter, or DE behavior depending on the component that dominates the energy budget, while the RDE density can only be matter-like or DE-like. We also study the impact of HDE on linear order perturbations, for which we assumed DE is associated to a fluid with constant sound speed squared $\hat{c}_{\mathrm{s}}^2$ in the rest-frame and vanishing anisotropic stress. We found analytical approximate solutions for matter and DE perturbations in the matter dominance epoch. Our findings show that matter perturbations behave slightly differently with respect to the standard cosmological model and the HDE clusters proportional to matter perturbations. Since our Equation of state might cross the phantom divide, we use the Parameterized Post-Friedmann **(PPF)** formalism for the evolution of perturbations, so that cosmological constraints could be computed. We consider the latest cosmological data, including supernovae, BAO, and CMB. Our investigation found that $\hat{c}_{\mathrm{s}}^2 = 1$ is excluded at 3σ, which indicates that might not be an appropriate assumption about DE. Finally, we also found that RDE constraints show a preference for higher H_0 values in agreement with local model-independent measurements, and lower values of σ_8 than in the ΛCDM model in good agreement with DES results, therefore our results seem to simultaneously relieve the current tensions.

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