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Constraints on Dynamical Dark Energy Models from the Abundance of Massive Galaxies at High Redshifts

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We compare the maximal abundance of massive systems predicted in different dynamical dark energy (DDE) models at high redshifts $z \approx 4-7$ with the measured abundance of the most massive galaxies observed to be already in place at such redshifts. The aim is to derive constraints for the evolution of the dark energy equation of state parameter w which are complementary to existing probes. We adopt the standard parametrization for the DDE evolution in terms of the local value w_0 and of the look-back time derivative w_a of the equation of state.
We derive robust constraints on combinations of (w_0, w_a) in the different DDE models by using three different and independent probes: (i) First, we compare the observed stellar mass function of massive objects at $z \geq 6$ derived from the CANDELS survey with the halo mass function predicted in the different DDE models. (ii) Second, we consider the estimated volume density of massive halos derived from the observation of massive, star-forming galaxies detected in the submillimeter range at $z \approx 4$, and compare it with the predicted halo abundance at the same redshift in the different DDE models. (iii) We consider the most massive system (estimated gas mass exceeding $3 \cdot 10^{11} M_{\odot}$) observed to be in place at $z \approx 7$, a far-infrared-luminous object recently detected in the South Pole Telescope (SPT) survey. We derive the probability for such an object to be detected in the area covered by SPT for different DDE models, and we compute the corresponding exclusion plots in the $(w_0 - w_a)$ plane. Finally, we show that the combination of our results from the three above probes {\it excludes a sizable fraction} of the DDE parameter space $w_a > -3/4 - (w_0 + 3/2)$ presently allowed (or even favored) by existing probes.

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