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Bayesian analysis of Starobinsky and Higgs inflation models with reheating in light of ACT and DESI data releases

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In the recent sixth data release (DR6) of the Atacama Cosmology Telescope (ACT) collaboration, the value of $n_{\rm s} = 0.9743 \pm 0.0034$ for the scalar spectral index is reported, which excludes the Starobinsky and Higgs inflationary models at 2σ level. In this paper, we perform a Bayesian inference of the parameters of the Starobinsky or Higgs inflationary model with non-instantaneous reheating using the Markov chain Monte Carlo method. For the analysis, we use observational data on the cosmic microwave background collected by the Planck and ACT collaborations and on baryonic acoustic oscillations from the Dark Energy Spectroscopic Instrument (DESI) collaboration. The reheating stage is modelled by a single parameter $R_{\rm reh}$, which contains a combination of the reheating temperature $T_{\rm reh}$ and the effective equation of state of matter during reheating $\bar{\omega}_{\rm reh}$. Using the modified Boltzmann code CLASS and the cobaya software with the GetDist package, we perform a direct inference of the model parameter space and obtain their posterior distributions. Using the Kullback–Leibler divergence, we estimate the information about the amplitude of the inflaton potential and 2.52 bits of information about the reheating parameter.

Inclusion of the ACT DR6 data provides 75% more information about the reheating stage compared to analysis without ACT data. In addition, we draw constraints on the reheating temperature and the average equation of state. While the former can vary within 10 orders of magnitude, values in the 95% credible interval indicate a sufficiently low reheating temperature; for the latter there is a clear preference for values greater than 0.5, which means that the conventional equations of state for dust $\omega = 0$ and relativistic matter $\omega = 1/3$ are excluded with more than 2σ level of significance. Nevertheless, there still is a big part of parameter space where Starobinsky and Higgs inflationary models exhibit a high degree of consistency with the latest observational data, particularly from ACT DR6. Therefore, it is premature to reject these models.

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