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BBN and CMB combined and separate constraints on new physics: measuring Neff and probing its evolution

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Big Bang nucleosynthesis (BBN) and the cosmic microwave background (CMB) both probe the physics of the early universe. BBN accounts for the cosmic origin of the lightest chemical elements, such as helium-4 and deuterium. Having precisely measured nuclear data and the neutron lifetime as inputs, BBN abundance predictions depend on two cosmological parameters: the cosmic baryon-to-photon ratio $\eta = \mathrm{n_b}/\mathrm{n_\gamma}$ (equivalent to the baryon density $\Omega_\mathrm{b} h^2$) and the effective number of standard neutrino species $\mathrm{N_{eff}}$. BBN analysis has long used observed primordial abundances from astronomical observations to infer η and $\mathrm{N_{eff}}$. Crucially, both parameters are also measured independently from the CMB. Thus, the concordance between BBN and CMB determinations of these two parameters not only provides a critical test to the hot Big Bang model but also can reveal new physics.

The joint BBN+CMB constraint on $\mathrm{N_{eff}}$ is one of the key concerns in the quest for physics beyond the Standard Model (BSM). Any deviation in $\mathrm{N_{eff}}$ from the Standard Model prediction would point to nonstandard cosmology and likely new physics, as a complementary cosmological approach to terrestrial particle experiments. Moreover, the BBN+CMB constraining power on new physics improves whenever new observations with unprecedented high precision are available. Latest developments of relevant BBN+CMB analyses will be discussed. Furthermore, we can search for any changes in η and/or $\mathrm{N_{eff}}$ between BBN and the CMB. This is a new probe: only recently BBN and the CMB independently reach levels of precision that can meaningfully reveal such changes. We will present likelihoods of ($\Delta\eta$, $\Delta\mathrm{N_{eff}}$) that constrain a broad variety of BSM models, including extra entropy and/or radiation injection between BBN and the CMB.

Reference to paper (DOI or arXiv)

Your gender (free text)

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