LSST Weak Lensing Cosmology

Impact of the scalar spectral index n_s

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Objectives & Research Question

One of the successes of previous Cosmic Microwave Background (CMB) experiments was the precise measurement of the scalar spectral index (n_s) different from 1 with high significance, ruling out the scale-invariant spectrum. Current weak lensing surveys such as DES are not sensitive to n_s [1]. However, future weak lensing measurements may make competitive constraints to this parameter. We forecast the sensitivity of LSST Y10 to the scalar spectral index, and the impact of its prior on cosmology.

Background

- The **matter power spectrum** describes the power of density fluctuations at various scales:

$$P(k) = A_s\left(\frac{k}{k_0}\right)^{n_s-1}$$

  - A_s is the amplitude, k_0 is an arbitrary pivot scale, and $\mathbf{n_s}$ is the **scalar spectral index**
- Most recent measurement from Planck 2018 [7]
  - $n_s = 0.9649 \pm 0.042$
- **Weak lensing** / **cosmic shear** measures the deformations of galaxy shapes due to the line-of-sight matter distribution, thus probing the matter power spectrum P(k)

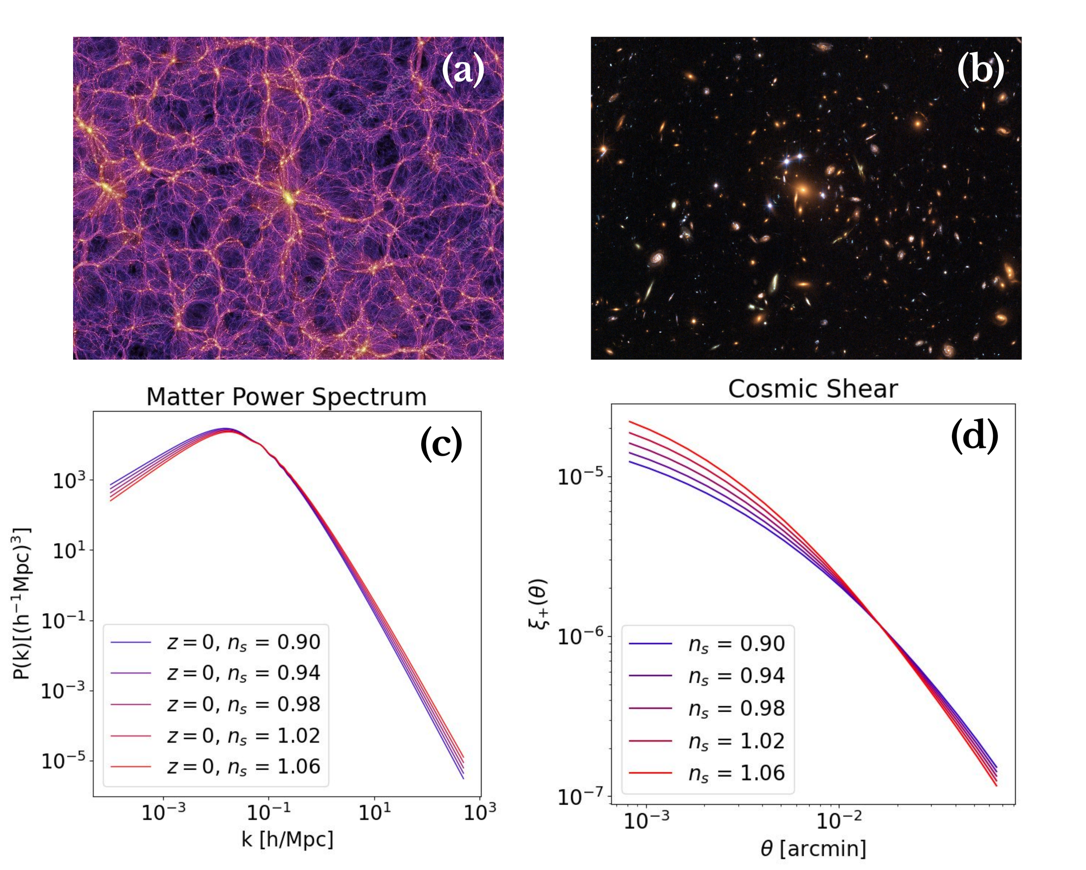

Figure 1. **(a)** Simulation of dark matter distribution [3]. **(b)** Hubble Space Telescope image of gravitational lens [4]. **(c)** Matter power spectrum P(k) and **(d)** shear two-point correlation function $\xi_+(\theta)$ (redshift bins 1 and 3) for different values of n_s using DES Y3 properties.

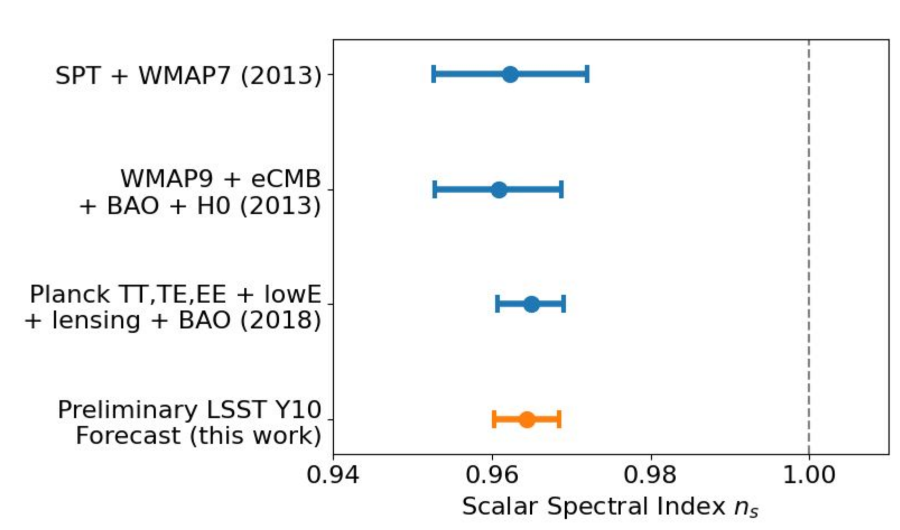

Figure 2. Scalar spectral index values from past CMB experiments [5,6,7]. The second value includes external CMB (eCMB) data from SPT and ACT. The last value is our preliminary LSST Y10 forecast. The dashed vertical line shows n_s = 1 (scale invariance).

Methodology

We forecast LSST Y10 data to simulate cosmic shear and galaxy clustering measurements. Using CosmoSIS and the Nautilus sampler, we constrain cosmological parameters to the simulated data using Bayesian parameter estimation. We test different priors for n_s including wide and narrow uniform priors and normal priors. We follow the analysis choices outlined in the Dark Energy Science Collaboration Science Requirements Document (DESC SRD) [2].

Preliminary Results

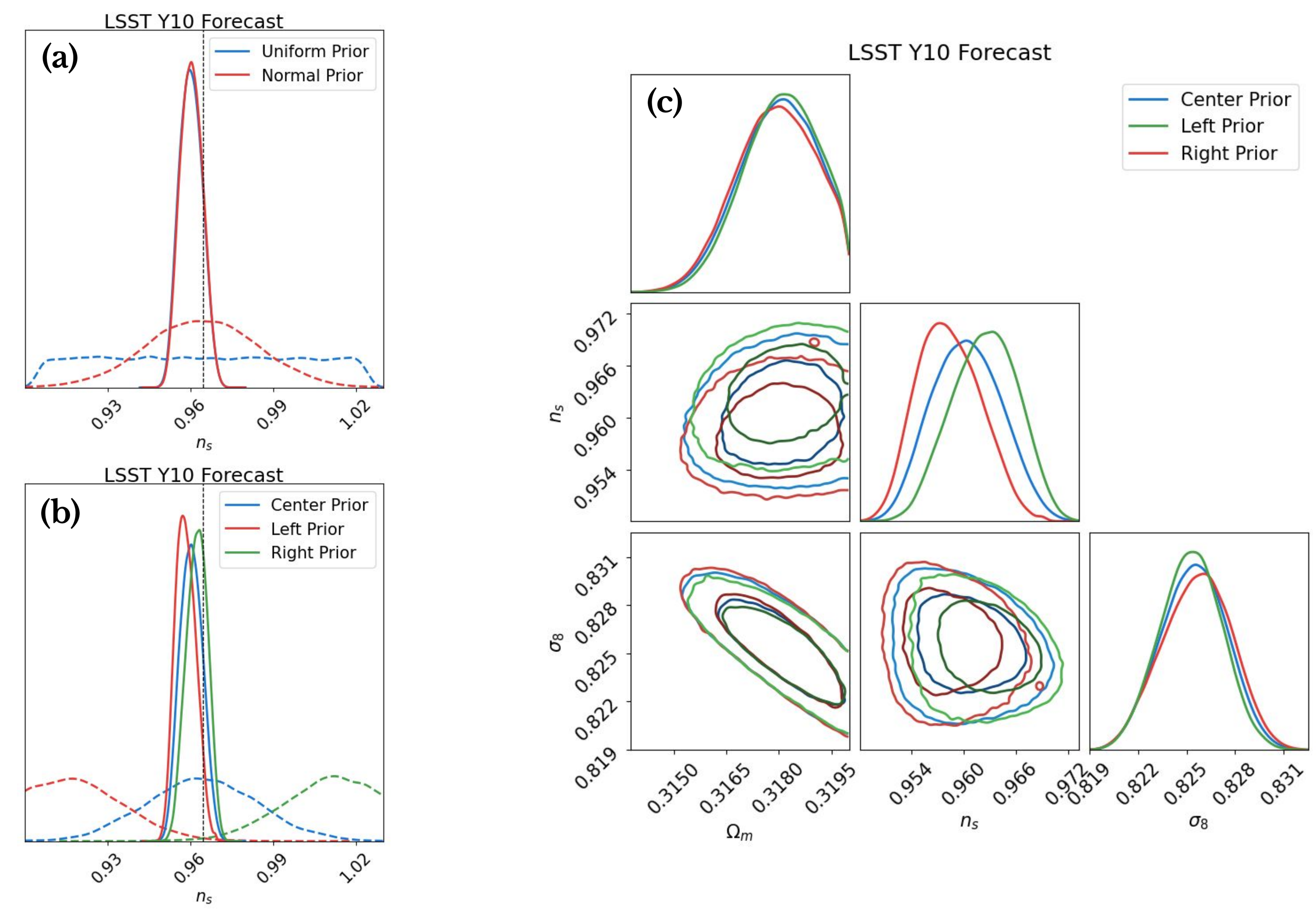

Figure 3. LSST Y10 forecast marginalized constraints on the scalar spectral index (n_s) using various priors: **(a)** Symmetric normal prior and uniform priors on n_s about the true value and **(b)** normal priors on n_s shifted from the true value. The priors are shown as dashed lines in the left plots. The black dashed line shows the true value (n_s=0.9645). **(c)** Marginalized constraints on the three parameters Ω_m, σ_8, and n_s using the shifted normal priors on n_s.

Discussion

- For LSST Y10 forecast, n_s is precisely measured, regardless of the prior on n_s. Figure 3a shows the same constraints for n_s for both informative normal priors and uninformative uniform priors. The choice of type of prior does not seem to impact weak lensing measurements.
- In Figure 3b, shifting the prior on n_s to the left and right of the true value also shifts the marginalized constraint on n_s. The shifted prior on n_s also slightly impact the parameters Ω_m and σ_8 as seen in Figure 3c.

Conclusions and Future Work

We find preliminary constraints on n_s using forecasted LSST Y10 data following the DESC SRD for various priors on n_s. Though the type of prior does not appear to impact n_s constraints, shifting the prior shifts the constraints of n_s and other parameters. The constraints from LSST Y10 seem competitive with current CMB measurements.

We plan to improve the accuracy of our findings by simulating LSST Y10 data with more realistic models for the forecast. This will allow us to determine whether n_s can be constrained with a more complex model.

References:
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