Exploring Mirror Twin Higgs Cosmology with Present and Future Weak Lensing Surveys

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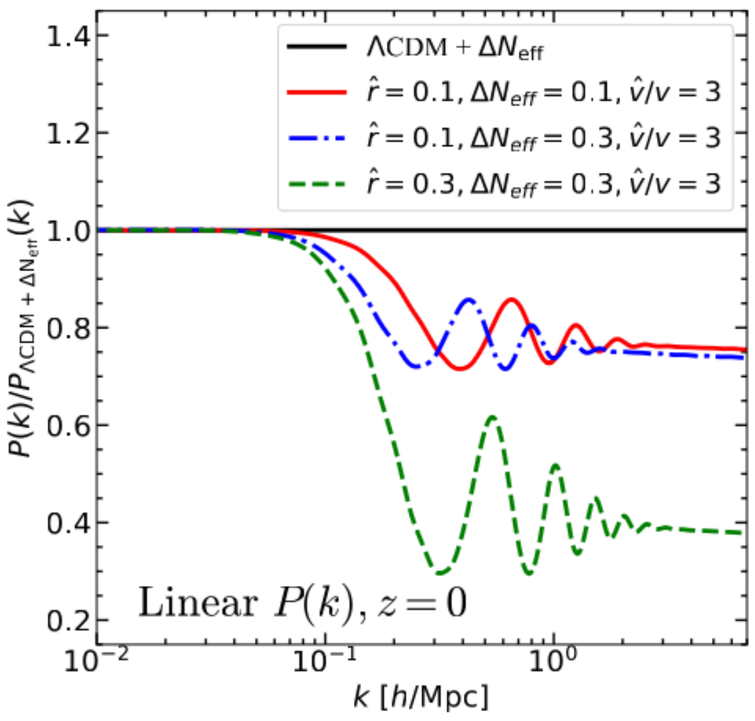
Abstract

We explore the potential of precision cosmological data to study non-minimal dark sectors by updating the cosmological constraint on the mirror twin Higgs model (MTH). The MTH model addresses the Higgs little hierarchy problem by introducing dark sector particles. In this work, we perform a Bayesian global analysis that includes the latest cosmic shear measurement from the DES three-year survey and the Planck CMB and BAO data. In the early Universe, the mirror baryon and mirror radiation behave as dark matter and dark radiation, and their presence modifies the Universe's expansion history. Additionally, the scattering between mirror baryon and photon generates the dark acoustic oscillation process, suppressing the matter power spectrum from the cosmic shear measurement. We demonstrate how current data constrain these corrections to the ΛCDM cosmology and find that for a viable solution to the little hierarchy problem, the proportion of MTH dark matter cannot exceed about $30\,\%$ of the total dark matter density, unless the temperature of twin photon is less than $30\,\%$ of that of the standard model photon. While the MTH model is presently not a superior solution to the observed H_0 tension compared to the $\Lambda CDM + \Delta N_{\rm eff}$ model, we demonstrate that it has the potential to alleviate both the H_0 and S_8 tensions, especially if the S_8 tension persists in the future and approaches the result reported by the Planck SZ (2013) analysis. In this case, the MTH model can relax the tensions while satisfying the DES power spectrum constraint up to $k \lesssim 10\ h{\rm Mpc}^{-1}$. If the MTH model is indeed accountable for the S_8 and H_0 tensions, we show that the future China Space Station Telescope (CSST) can determine the twin baryon abundance with a $10\,\%$ level precision.

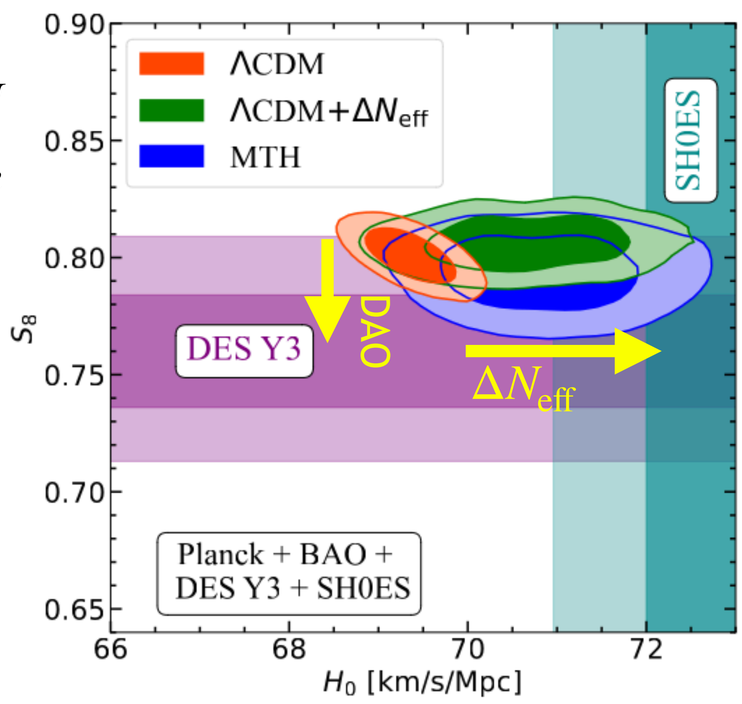
MTH cosmology

- *The linear matter power spectrum of MTH model was suppressed on small scale compared with Λ CDM model.*



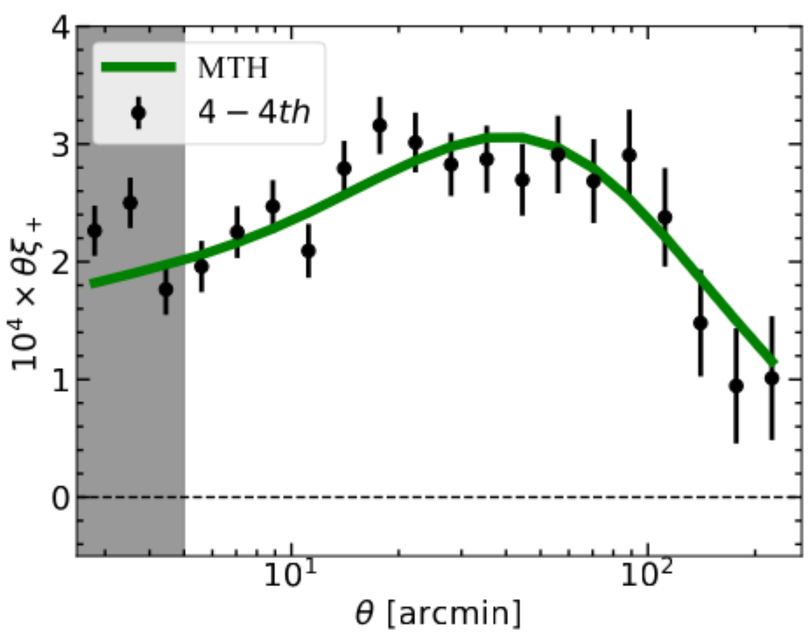
H_0 & S_8 tension

- *We demonstrate MTH can alleviate both the H_0 and S_8 tensions simultaneously.*



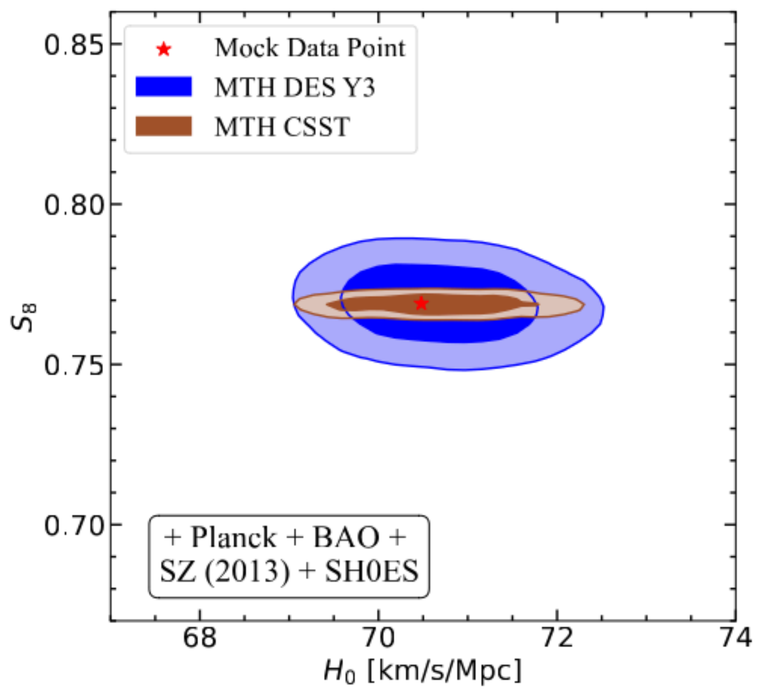
Weak lensing test

- *We use Dark Energy Survey 3 year weak lensing data to constrain the parameter space of MTH model.*



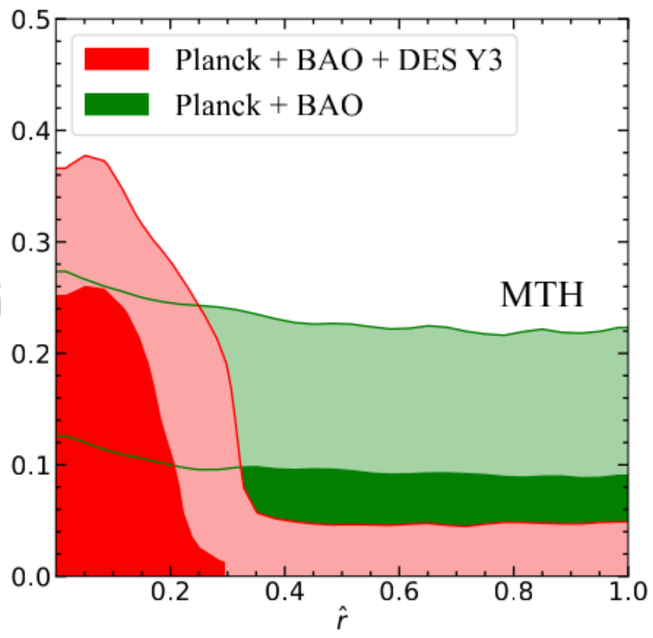
Prediction of CSST

- *We predict the power of CSST to constrain cosmological parameters.*
- *Especially for S_8, the error bar shrinks ~ 10 times.*



Proportion of MTH dark matter

- *We obtain an upper bound of proportion of MTH for the first time via weak lensing observations.*
- *This result is potentially universal for dark matter models that could also cause such suppression on matter power spectrum.*



Comments are welcome!

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