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Title:

Dark Energy versus Modified Gravity: A Figure of Merit Analysis of Current Constraints on Detecting Deviations from General Relativity using the Latest Cosmological Data Sets

Abstract:

In this work we pursue the effort to develop a framework with which to distinguish whether the observed cosmic acceleration is caused by a modification of gravity physics rather than a dominant, as of yet unknown, "dark energy component of the universe. Dark energy currently the most widely accepted reason for the observed cosmic acceleration, but a modification to gravity physics on cosmological scales would also explain the cosmic acceleration. The growth of structure is coupled to the expansion history through the field equations so the two observables must be consistent. A modified gravity (MG) theory will change the growth equations and parameterizing this change will allow us to detect modifications to gravity physics on cosmological scales. To this end we use three different parameterizations of MG parameters that enter the perturbed field equations. In order to allow for variations of the parameters with the redshift and scale, the first two parameterizations use recently suggested functional forms while the third is based on binning methods. Next, employing the latest cosmological data sets including the recently refined HST-COSMOS weak lensing tomography data, the ISW-galaxy cross correlations from 2MASS and SDSS LRG galaxy surveys, the matter-power spectrum from SDSS-DR7 (MPK), the WMAP7 temperature and polarization spectra, the BAO from 2DF and SDSS-DR7, the Union2 compilation of type Ia supernovae, and other bounds from Hubble parameter measurements and Big Bang Nucleosynthesis, we place constraints on these parameters. A Figure of Merit approach is then used to study and compare the constraining power of various combinations of data sets on the MG parameters. Using the first parameterization, we find that the CMB+ISW+WL combination provides the strongest constraints on the MG parameters. The second parameterization and the binning methods, on the other hand, have CMB+MPK+ISW consistently providing some of the strongest constraints, showing that the constraints are parameterization dependent. We find that adding up current data sets does not consistently improve the uncertainties on MG parameters due to tensions between the best-fit MG parameters preferred by different data sets. Furthermore, some functional forms imposed by the parameterizations can lead to an exacerbation of these tensions. Finally, for all the parameterizations and binning methods used, we find that the values corresponding to general relativity are within the 95% confidence level contours for all data set combinations, keeping for now dark energy as the plausible explanation for cosmic acceleration.