Probing modifications of General Relativity using current cosmological observations

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We test General Relativity (GR) using current cosmological data: the cosmic microwave background (CMB) from WMAP5 (Komatsu et al. 2009), the integrated Sachs-Wolfe (ISW) effect from the cross-correlation of the CMB with six galaxy catalogs (Giannantonio et al. 2008), a compilation of supernovae Type Ia (SNe) including the latest SDSS SNe (Kessler et al. 2009), and part of the weak lensing (WL) data from CFHTLS (Fu et al. 2008, Kilbinger et al. 2009) that probe linear and mildly non-linear scales. We first test a model where the effective Newton's constant, mu, and the ratio of the two gravitational potentials, eta, transit from the GR value to another constant at late times; in this case, we find that standard GR is fully consistent with the combined data. The strongest constraint comes from the ISW effect which would arise from this gravitational transition; the observed ISW signal imposes a tight constraint on a combination of mu and eta that characterizes the lensing potential. Next, we consider four pixels in time and space for each function mu and eta, and perform a Principal Component Analysis (PCA) finding that seven of the resulting eight eigenmodes are consistent with GR within the errors. Only one eigenmode shows a 2-sigma deviation from the GR prediction, which is likely to be due to a systematic effect. However, the detection of such a deviation demonstrates the power of our time- and scale-dependent PCA methodology when combining observations of structure formation and expansion history to test GR.

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