Prepared for submission to JCAP

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Abstract. In order to verify GR with the upcoming surveys we need to compare the cosmological quantities inferred by General Relativity (GR) assumptions with the ones with non-GR assumptions. In other words we need to compute the cosmological quantities (like $f\sigma_8$) consistently in each theory of gravity, including the specific background and perturbations. On the other hand, the effect of different dark energy models on linear and non-linear scales is still unknown and is not studied consistently. We are going to modify the relativistic N-body code "Gevolution" to implement the general effect of modified gravity models on scalar perturbations. To parametrize the possible deviations from GR, we use two parameters $\mu(k, z)$ and $\gamma(k, z)$ and we will discuss about the validity of GR by probing the parametric space of γ and μ...

Contents

1 Introduction

2 Idea

We start from the FRW metric in Poisson gauge,

$$ds^2 = a^2(\eta)\left[-e^{2\Psi}d\eta^2 - 2B_i dx^i dt + (e^{-2\Phi}\delta_{ij} + h_{ij})dx^i dx^j\right] \tag{2.1}$$

For the GR gravity the Einstein's equations including short wave correction reads,

$$(1+4\Phi)\nabla^2\Phi - 3\mathcal{H}\Phi' - 3\mathcal{H}^2\Psi + \frac{3}{2}\delta^{ij}\Phi_{,i}\Phi_{,j} = -4\pi G a^2\left(T^0_0 - \bar{T}^0_0\right) \tag{2.2}$$

$$\left(\delta^i_k\delta^j_l - \frac{1}{3}\delta^{ij}\delta_{kl}\right)\left[\frac{1}{2}h''_{ij} + \mathcal{H}h'_{ij} - \frac{1}{2}\nabla^2 h_{ij} + B'_{(ij)} + 2\mathcal{H}B_{(i,j)} + (\Phi-\Psi)_{,ij} - 2(\Phi-\Psi)\Phi_{,ij} + 2\Phi_{,i}\Phi_{,j} + 4\Phi\Phi_{,ij}\right]$$
$$= 8\pi G a^2\left(\delta_{ik}T^i_l - \frac{1}{3}\delta_{kl}T^i_i\right) \tag{2.3}$$

To parametrize the effect of modified gravity theories we modify the equation 2.2 in Fourier space by $G \to G_{\text{eff}} = \mu(k,z)G$, which modifies the Poisson equation. Moreover,

$$\frac{\Phi}{\Psi} = \gamma(k,z) \tag{2.4}$$

Like what is done in https://arxiv.org/pdf/1106.4543.pdf or http://aliojjati.github.io/MGCAMB/mgcamb.html.
We are going to do N-body simulation for some interesting functional form of G_{eff} and γ and statistically compare the observables in ΛCDM and modified gravity theory models.
Questions:

- why we are going to implement it in an N-body code?
  Since non-linearities are important and probably change the results.
- why in Gevolution?
  Since Newtonian N-body codes do not let us modify gravity by definition, so we need a relativistic code to be consistent.
- why G_{eff} and γ parametrization?
  - we don't know yet about the paramterziation, but I'm (FH) going to discuss with Lucas Lombriser arXiv:1608.00522v1 he is in our group and specialist in this field.

3 G_{eff} implementation in gevolution

For the moment we take $\gamma(k,z) = 1$ and implement G

4 Conclusions

Acknowledgements

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