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Measuring the growth rate with multi-tracer technique

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Abstract

We generated a Log-Normal galaxy map for two different tracers and obtained from this map the monopole and quadrupole for each tracer. With these observables we performed an MCMC in order to measure the growth rate of density perturbations. Our main goal in the future is to study modified gravity, with the same technique, by measuring the growth rate.

Introduction

The matter power spectrum in redshift space is calculated in terms of the power spectrum, in linear theory, as:

$$P^s_m(k,z) = [b(z) + f(z)\mu^2]^2 P_m(k)$$

where $f(z) = \frac{d\ ln(D(z))}{d\ ln(a)}$ is the growth rate of linear density perturbations, b is the linear bias and μ is the cosine of the angle between the k mode and the line of sight. It can be expanded in a multipole expansion with monopole and quadrupole given, respectively, by $P_0(k) = (b^2 + \frac{2}{3}bf + \frac{1}{5}f^2)P_m(k)$ and $P_2(k) = (\frac{4}{3}bf + \frac{4}{7}f^2)P_m(k)$. These observables will play a central role in this work.

Multi-tracer technique

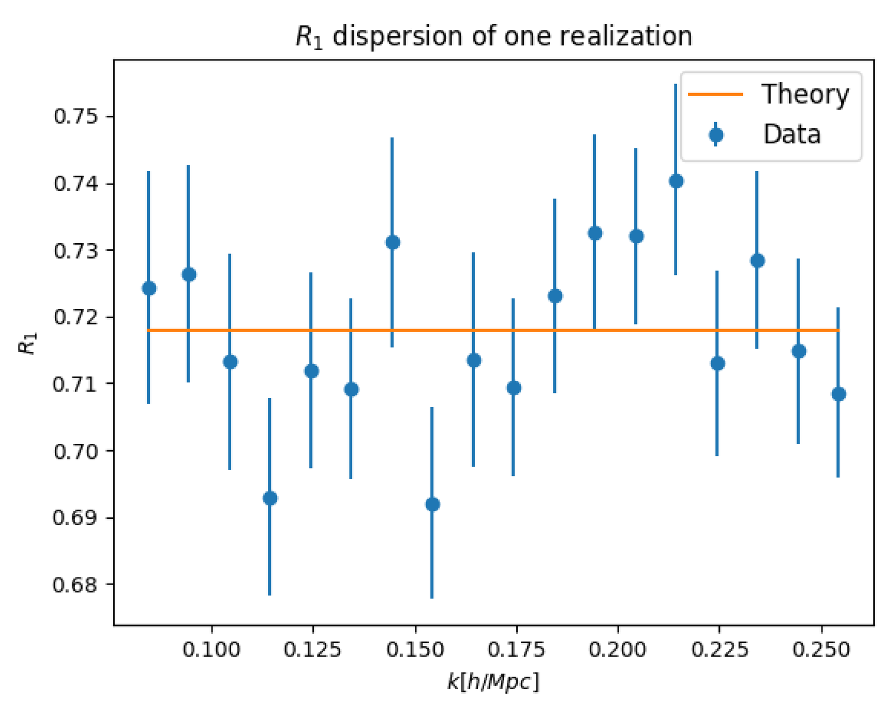
Galaxy surveys are expected to perform high-accuracy tests for models of modified gravity through redshift space distortions [2]. Cosmic variance can be circumvented for some cosmological parameters by comparing the clusterings between different types of tracers. Then, we should be able to measure these parameters with a precision that is not limited by cosmic variance[1]. In this work we measure the growth rate of density perturbations using the multi-tracer technique.

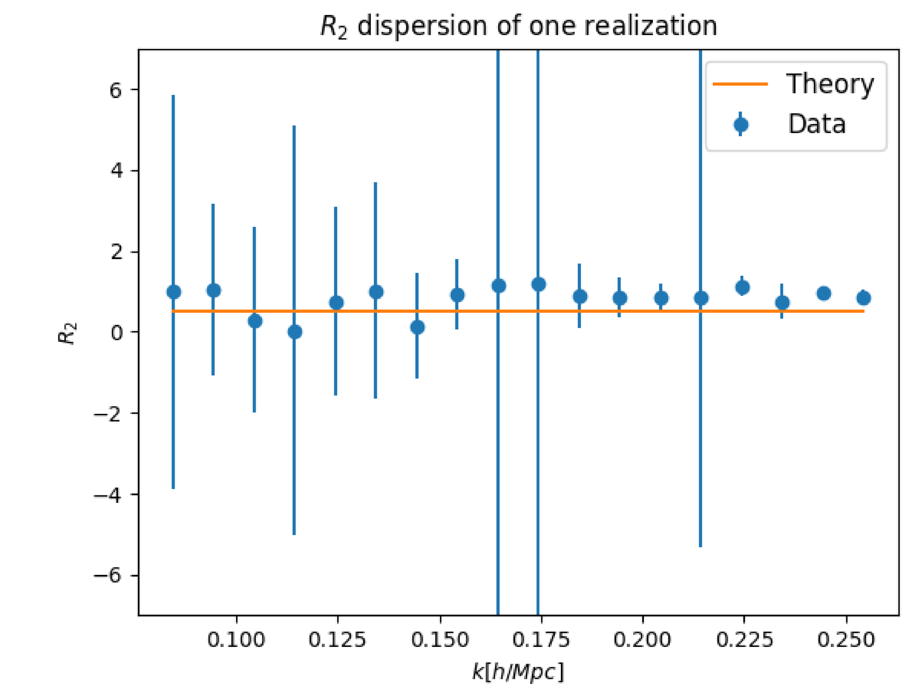
The observables

We used a Log-Normal mock galaxy map as data and measured P_0 and P_2. Then, we created the ratios $R_1 = \frac{P_0^1}{P_0^2}$ and $R_2 = \frac{P_2^1}{P_2^2}$ where the upper index refers to different tracers, with different biases.

Results

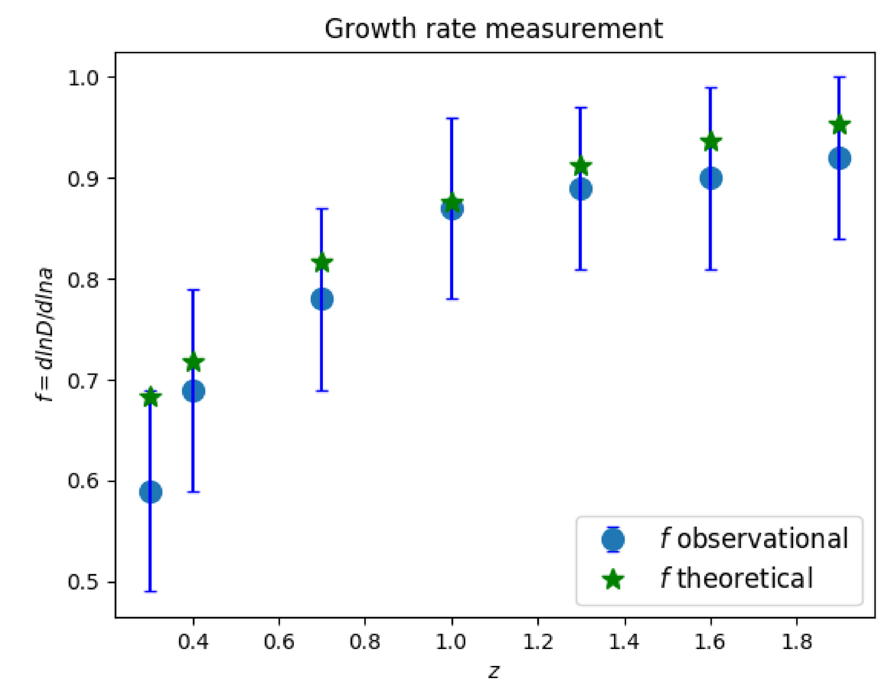
We generated 250 log-normal galaxy maps with 2 tracers of biases $b_1 = 1.4$ and $b_2 = 1.7$. With MCMC (Markov Chain Monte Carlo Method) we fitted the R_1 and R_2 ratios. The following figures shows the theoretical ratio for redshift $z = 0.4$, for a given map that we choose randomly from the 250 maps.





Compared with the theoretical values, the mean R_1 and R_2 from data have a bias with dependence in k. This bias was taken in to account in order to perform the MCMC.

We obtained the following measurements for the growth rate:



Next steps

This work is under development, so, there are some further steps to be taken now:

- Generate the log-normal maps with $n > 2$ tracers
- Create other observables than the ratios, like some combination of the monopoles and quadrupoles. These observables should improve the measurement.
- Besides just varying f in MCMC, also vary the cosmology
- Finally, generate the log-normal maps for a modified gravity model and then analyze if f is a good observable in order to constraint gravity.

References

[1] L Raul Abramo and Katie E Leonard. Why multitracer surveys beat cosmic variance. *Monthly Notices of the Royal Astronomical Society*, 432(1):318–326, 2013.

[2] Eric V Linder. Cosmic growth history and expansion history. *Physical Review D*, 72(4):043529, 2005.