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Cosmological forecasts from photometric measurements of the angular correlation function for the Legacy Survey of Space and Time

Diogo H. F. de Souza[1,2] **and Basílio X. Santiago**[1,2]

[1]Instituto de Física, UFRGS, Caixa Postal 15051, Porto Alegre, RS - 91501-970, Brazil
[2]Laboratório Interinstitucional de e-Astronomia - LIneA, Rua Gal. José Cristino 77, Rio de Janeiro, RJ - 20921-400, Brazil
emails: diogo.henrique@ufrgs.br, basilio.santiago@ufrgs.br

Abstract. We aim to do forecasts for the Legacy Survey of Space and Time (LSST) with a theoretical modeling of the two point angular correlation function. The Fisher matrix is the starting point. This is a square matrix over the cosmological parameters, whose diagonal contains direct informations on the parameters expected uncertainties.

Keywords. Cosmology, large-scale structure of universe, cosmological parameters, LSST

1. Introduction

The LSST is located on the Cerro Pachón ridge in north-central Chile (Abell *et al.* (2009)). The LSST is expected to begin the operation in 2022. So one natural question is, can we extract information even before the release of the data? We aim to answer this question with a general formalism. We use the angular correlation function (ACF) to study forecasts for the errors of cosmological parameters obtained with LSST, the next future large-scale photometric survey. We intend to apply this study to the dark energy equation parameter w, cold dark matter density Ω_{cdm}, dark energy density Ω_w, baryonic matter density Ω_b, and the fluctuation amplitude at scale of $8h^{-1}$Mpc, σ_8.

2. Theoretical framework

The theoretical framework described here, in general, is the same for all photometric surveys, so the approach that we follows is very close to that described in Sobreira *et al.* (2011) that did forecasts for the Dark Energy Suvery (DES).

The starting point is the Fisher matrix $F_{\alpha\beta}$ described by

$$F_{\alpha\beta} = \frac{\partial w^i(\theta^n, p)}{\partial p_\alpha} \left[C^{-1}\right]^{ij}_{nm} \frac{\partial w^j(\theta^m, p)}{\partial p_\beta} + \frac{1}{2}\mathrm{Tr}\left[C^{-1}\frac{\partial C}{\partial p_\alpha}C^{-1}\frac{\partial C^{-1}}{\partial p_\beta}\right]. \tag{2.1}$$

In Eq. (2.1), $w^i(\theta^n, p)$ is the ACF evaluated at the i-th bin of redshift and in n-th angular bin, θ^n, and for a given particular set of cosmological parameters $\{p\}$. In general, the ACF is described by Eq. (2.2)

$$w(\theta) = \int_0^\infty dz_1 f(z_1) \int_0^\infty dz_2 f(z_2) \xi^s(r(z_1, z_2, \theta)), \tag{2.2}$$

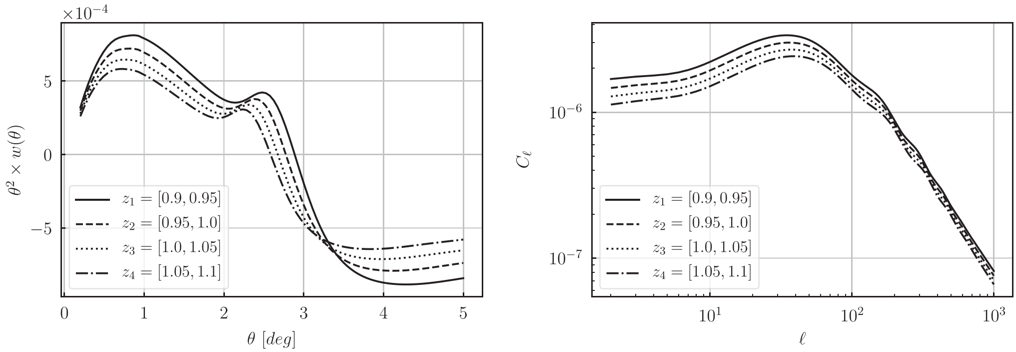

Figure 1. Analysis of ACF and APS, for the LSST, with redshift z ranging in the interval $[0.9, 1.1]$ with bin width $\Delta z = 0.05$, therefore $z = \cup_{i=1}^{4} z_i$.

where $f(z) = \phi(z)b(z)D(z)$ is a function of the photometric selection function, $\phi(z)$, the bias, $b(z)$, between galaxies and Dark Matter, and the growth function, $D(z)$. Finally, ξ^s, is the correlation function in redshift space.

The $C := \frac{2}{(4\pi)^2 f_{sky}} \sum_\ell [(2\ell+1)\mathcal{P}_\ell(cos\theta_n)\mathcal{P}_\ell(cos\theta_m)(C_\ell^{ij} + \frac{\delta_{ij}}{n_i})^2]$ is the covariance matrix, where C_ℓ^{ij} is the angular power spectrum (APS) given by

$$C_\ell^{ij} = \frac{2}{\pi} \int dk\, k^2 P(k) \Psi_\ell^i(k) \Psi_\ell^j(k). \tag{2.3}$$

$P(k)$ is the matter power spectrum and $\Psi_\ell^i(k)$ are functions, computed in the i-th redshift bin, that encode information about the survey and cosmology.

The information about the survey ($\Psi_\ell(k)$) includes the photometric selection function, the photometric redshift error $\mathrm{P}(z_p; z)$ and the galaxy redshift distributions $n(z)$. These two latter are given by (2.4)

$$\mathrm{P}(z_p; z) \propto \exp\left[-\frac{(z_p - z - \delta_z)^2}{2\sigma_z^2}\right], \quad n(z) \propto z^\alpha \exp\left[-\left(\frac{z}{z^*}\right)^\beta\right]. \tag{2.4}$$

3. Modeling for LSST

To compute some of the equations presented here, we use specific existing code. The Code for Anisotropies in the Microwave Background (CAMB) is used to generate the $P(k)$ and other fundamental background functions, like Hubble parameter $H(z)$ and comoving distance χ. To generate ACF and APS, we use the Code Cosmology Library (CCL). Finally, we combine all these codes using the Python environment to automate the computations. Figure 1 shows the ACF and the APS for the LSST calculated for the $z = [0.9, 1.1]$. Currently we are applying this same method to obtain the complete covariance matrix, APS and ACF to the full redshift interval of interest that we are studying. This allows us to obtain the C^{-1} and the $\partial w/\partial p_\alpha$ to finally, by Eq (2.1), obtain the Fisher matrix.

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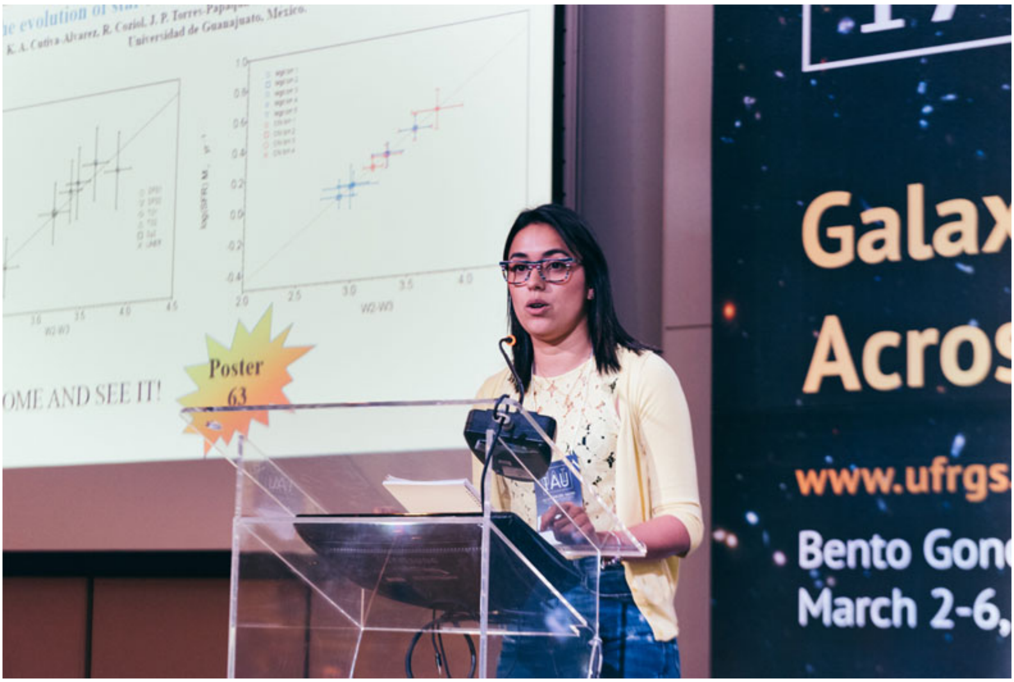
Karin Menendez-Delmestre



Karla Cutiva

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