Draft version October 4, 2019
Typeset using LATEX twocolumn style in AASTeX62

FPFS Shear Estimator: Systematic Tests on the First Year Hyper Suprime-Cam Survey

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ABSTRACT

1. INTRODUCTION

2. MASS MAP

2.1. *Kaiser-Squires reconstruction*

Subsequently, the shear field is converted to the convergence field via (?)

$$\kappa(\vec{\theta}) = \frac{1}{\pi}\int d^2\theta' \frac{\gamma_t(\vec{\theta'}|\vec{\theta})}{|\vec{\theta}-\vec{\theta'}|^2}, \tag{1}$$

where $\hat{\gamma}_t(\vec{\theta'}|\vec{\theta})$ is a tangential shear at position $\vec{\theta'}$ computed with respect to the reference position $\vec{\theta}$. The shear-to-convergence relationship is a convolution in two dimensional angular plane. Such convolution is computed in Fourier space with the Fast Fourier Transform (FFT) to reduce the computational time. Shear fields are padded with zero beyond their boundary to avoid the periodic boundary condition assumed in FFT. The complex shear field is denoted as $\gamma(\vec{\theta}) = \gamma_1(\vec{\theta}) + i\gamma_2(\vec{\theta})$. The Fourier transform of complex shear field and complex kappa field is denoted as $\tilde{\gamma}(\vec{l})$ and $\tilde{\kappa}(\vec{l})$, respectively. Eq. (1) can be expressed in Fourier space

$$\tilde{\kappa}(\vec{l}) = \pi^{-1}\tilde{\gamma}(\vec{l})\tilde{D}^*(\vec{l}) \quad for \quad \vec{l} \neq \vec{0}, \tag{2}$$

where $\tilde{D}(\vec{l})$ is the Fourier transform of the convolution kernel in eq. (1)

$$\tilde{D}(\vec{l}) = \pi\frac{l_1^2 - l_2^2 + 2il_1l_2}{|\vec{l}|^2}. \tag{3}$$

Then the mass map in configuration space ($\kappa(\vec{\theta})$) is reconstructed by inverse Fourier transforming $\tilde{\kappa}(\vec{l})$. Note that the real part of the reconstructed mass map is referred as an E-mode mass map, whereas the imaginary part of the reconstructed mass map is referred as an B-mode mass map which is used to check for certain types of residual systematics in weak lensing measurements.

The relation between γ and κ is

$$\gamma(\vec{\theta}) = \int D(\vec{\theta}-\vec{\theta'})\kappa(\vec{\theta'})d^2\theta. \tag{4}$$

Denote γ and κ as vectors $\vec{\gamma}$ and $\vec{\kappa}$, respectively. $\vec{\kappa}$ is the mass map to be reconstructed on equally spaced coordinates. $\vec{\gamma}$ is the shear observed from non-equally spaced galaxies. Then the operation of convolution can be denoted as a matrix multiplication

$$\vec{\gamma} = \mathbf{D}\vec{\kappa} + \vec{n}. \tag{5}$$

And $\vec{\kappa}$ can be determined by minimize

$$\chi^2 = (\vec{\gamma} - \mathbf{D}\vec{\kappa})^T(\vec{\gamma} - \mathbf{D}\vec{\kappa}). \tag{6}$$

We require

$$dim\,(\vec{\kappa}) \leq dim\,(\vec{\gamma}) \tag{7}$$

Find an orthogonal vector space and decompose $\vec{\kappa}$ onto the orthogonal space, the decomposition factor are denoted as $\vec{\alpha}$, where

$$\begin{aligned} \vec{\alpha} &= \mathbf{\Phi}\vec{\kappa} \\ \vec{\kappa} &= \mathbf{\Phi}^{-1}\vec{\alpha} \end{aligned} \tag{8}$$

If $\vec{\alpha}$ only has a small number of nonzero coefficients,

$$\vec{\gamma} = \mathbf{D}\mathbf{\Phi}^{-1}\vec{\alpha} + \vec{n} \tag{9}$$

$$\chi^2 = ||(\vec{\gamma} - \mathbf{D}\mathbf{\Phi}^{-1}\vec{\alpha})||_2^2 + \lambda||\vec{\alpha}||_1 \tag{10}$$

$$\begin{aligned} ||\vec{v}||_1 &= \sum_i^N |v_i| \\ ||\vec{v}||_2^2 &= \sum_i^N v_i^2 \end{aligned} \tag{11}$$

REFERENCES

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