Explore Point Spread Function
Combing Star and Galaxy Images

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Outlines

• Weak lensing background
• Basis function and PSF reconstruction
• Our new algorithm
• Testing
• Summary
Weak lensing background
Point Spread Function

Usually, the distortion introduced by PSF is larger than that caused by cosmic shear!
How do we do the reconstruction?

A) Star identification.
B) Parameterized image of stars.
C) Interpolate the parameters in the field of view.
D) Create the expected PSF at the position of galaxies.
Parameterization of PSF
PCA, Gaussianlets and Moffatlets
Test with GREAT10 data

One star in different data set

Principal Component Analysis (PCA)

Moffatlets

Gaussianlets
Motivation

- Interpolation doesn’t always work when the number of star is too few or the PSF changes too fast in the field.
- Galaxy images themselves contain the local information of the PSF
Unknows: $\text{NgxNg} + 3\text{xNPgxNPg}$

Knows: $3\text{xNgxNg}$
The number of unknowns of PSF can decrease to several by using basis functions.

\[
PSF_i = \sum_{l}^{N_{PC}} c_{il} PC_{il},
\]

\[
NPg \times NPg \rightarrow N_{PC}
\]

\[
G_{0} \quad PSF_{i} \quad PSF_{j} = G_{i} \quad PSF_{j} = G_{j} \quad PSF_{i} = G_{0} \quad PSF_{j} \quad PSF_{i}
\]

\[
2_{ij} = \frac{N_{\text{pixel}}^{2}}{k} \left( G_{i} \quad PSF_{j} \quad G_{j} \quad PSF_{i} \right)_{k}^{2}
\]
Define \[ G_{ijl} = G_i \quad PC_{jl} \]

\[
2 = \frac{N_{image} \cdot N_{pixel}}{l} \left( c_{jl} G_{ijkl} + c_{il} G_{jilk} \right)^2
\]

The minimization \[ \frac{2}{c_{mn}} = 0 \] leads to

\[
C_{ml} \frac{G_{imnk} G_{imlk}}{2} = 0
\]
\[
C_{il} \frac{G_{imnk} G_{milk}}{2} = 0
\]
With noise

\[ G'_i = G_i + n_i \]

Define

\[ n_{ij} = n_i \quad PSF_j \]

We get

\[
\sum_{i,j,k} \left( c_{jl} G_{ijkl} c_{il} G'_{jilk} \right)^2 + (n_{ijk} n_{jik})^2
\]

The final equation is:

\[
\sum_{i,m,k} w_k G'_{imnk} G'_{imlk} = 0
\]
Gaussian noise: PSN<20

PSF1

PSF2

PSF3

Gaussian noise: PSN<100

$c_{11x}$  $+$  $c_{12x}$  $+$  $c_{13x}$  $+$  $c_{14x}$  $=$  PSF1
The Reconstructed PSFs
Summary

• It works!
• It needs multi-exposed images with different PSF.
• Principal Components Analysis of stars provides the most compact basis function.
• More tests needed: center disalignment, noise estimation of the cross-convolved images, incomplete PCs.
Thanks