Shear Optimization with ShOpt.jl

Edward Berman [1] Jacqueline McCleary [2]

Point Spread Function Modeling

A **Point Spread Function** or **(PSF)** is an impulse response of the optical system to light. A PSF captures the distortions and blur in an image that arises from the optics of your mirrors and atmospheric distortions for ground based observatories. Understanding the PSF of an instrument allows us to deconvolve it's affects from an image. We use stars as data points for our empirical models, an example of which is given in 1.

1. Galaxy Morphology Measurements
2. Weak and Strong Lensing Analysis
3. Active Galactic Nuclei

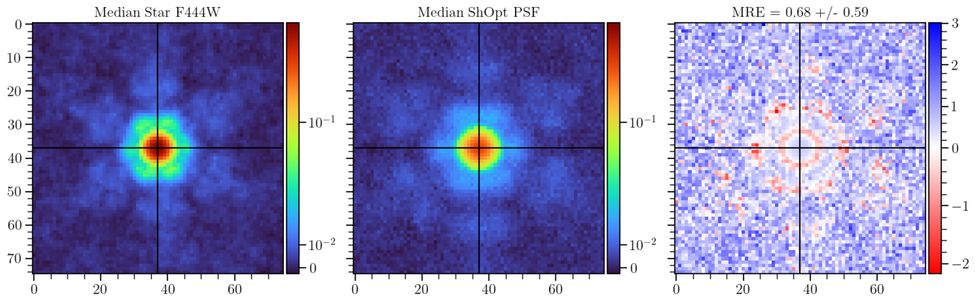

Figure 1. On the left is the median star. In the middle is the median ShOpt Point Spread Function Model for the star. On the right is the mean relative error between the two.

Analytic Profile Fitting

To first order, we can approximate a PSF as a 2D Gaussian with parameters $[s, g_1, g_2] \in B_2(r) \times \mathbb{R}_+$. Figure 2 shows ShOpt finding the correct Gaussian to parameterize a the shape star. Understanding how these parameters change spatially is crucial for a good PSF model. However, as demonstrated in Figure 3, Gaussian approximations still miss crucial details hiding in the dynamic range of the full PSF.

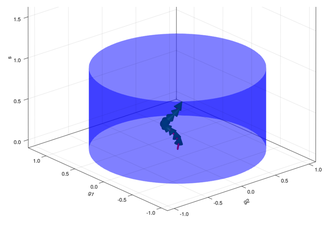

Figure 2. Path through parameter space for fitting an analytic profile.

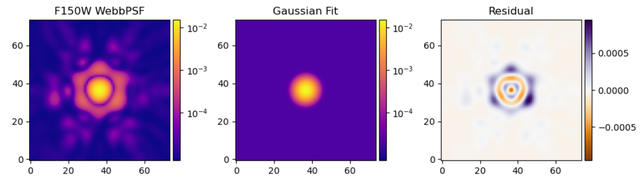

Figure 3. Shown on the left is an idealized PSF. In the middle is a Gaussian approximation, and on the right is the residual between the two.

Results

As seen in Figures 4-5, ShOpt successfuly biggest the state of the art accuracy in terms of χ^2 with the state of the art speed in an easy to use and highly extensible package.

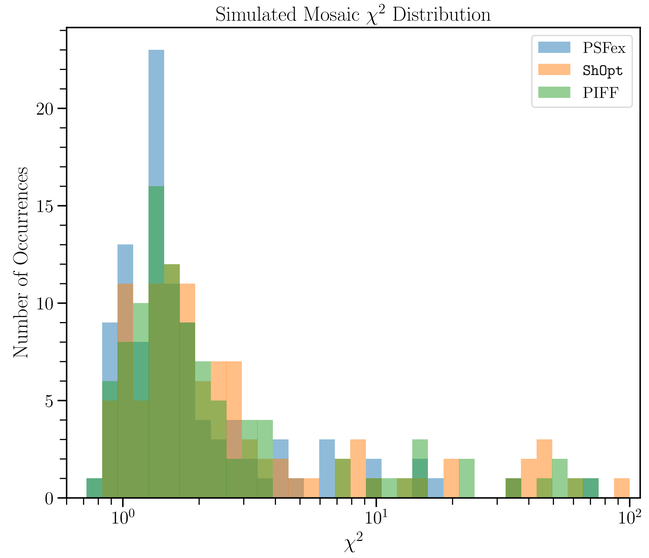

Figure 4. χ^2 residual distribution for each PSF fitter.

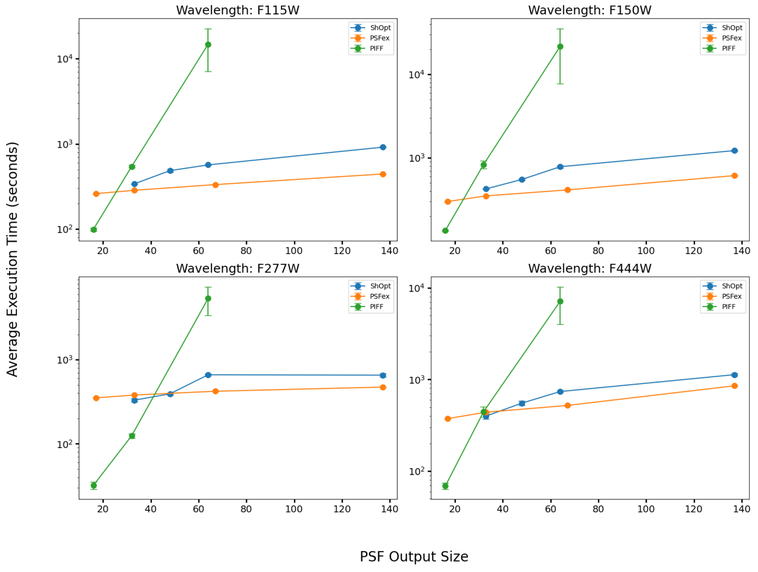

Figure 5. The average execution time in seconds as a function of the output PSF size in number of pixels on the side length of the model for each PSF fitter. Shown for four different wavelengths.