A fringe projector–based study of PSF

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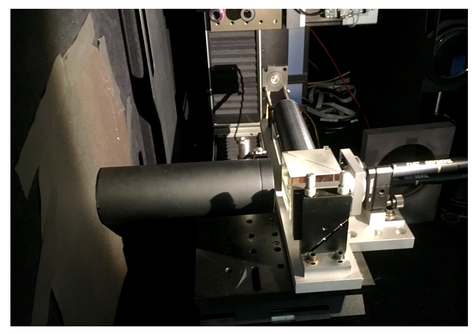
Background

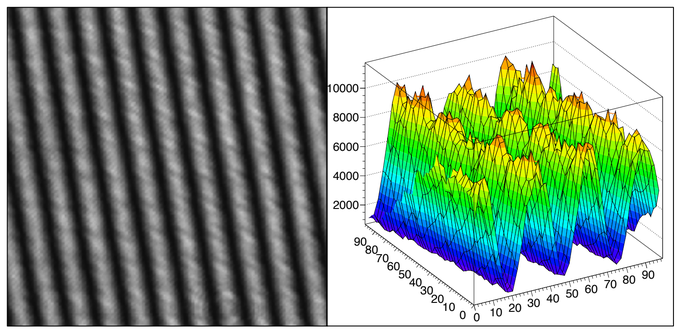
- The DESC Sensor Anomalies Working Group is studying CCDs in-depth to determine limitations for dark energy science
- One sensor effect known to cause smearing in images is called the Brighter-Fatter Effect
- If an object is too bright, space charge effects such as repulsion of electrons can be significant
- Thus, bright stars may look larger than weaker stars. Since PSF calibrations are done mostly with bright stars this will affect WL measurements performed at the lower threshold for detection

Methods

- A Michelson Interferometer was used as a fringe projector to create patterns of light and dark on the CCD. This method should allow for an easier PSF measurement than through a spot projector or knife-edge measurements[1]
- The peaks and troughs should be symmetric, but the Brighter-Fatter Effect causes an expected asymmetry



The fringe projector setup



The fringes captured by the CCD and plotted in 3D

- The contrast of the fringes was maximized at ~80%
- The images taken varied in angle, period, and exposure time
- The data is plotted in three dimensions and fitted with a curve to quantify the Brighter-Fatter Effect

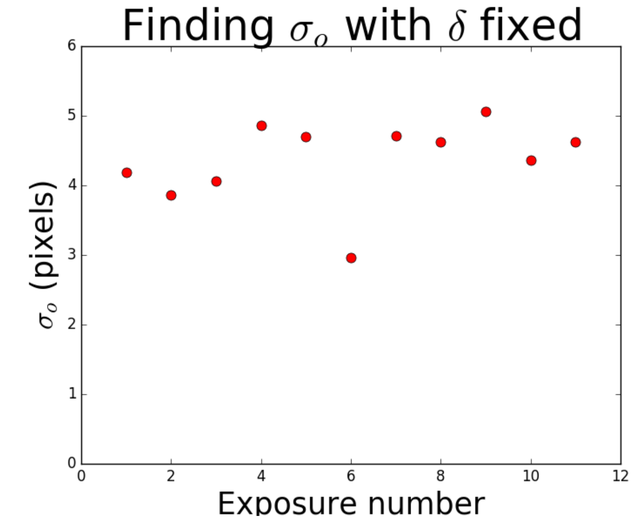
Results

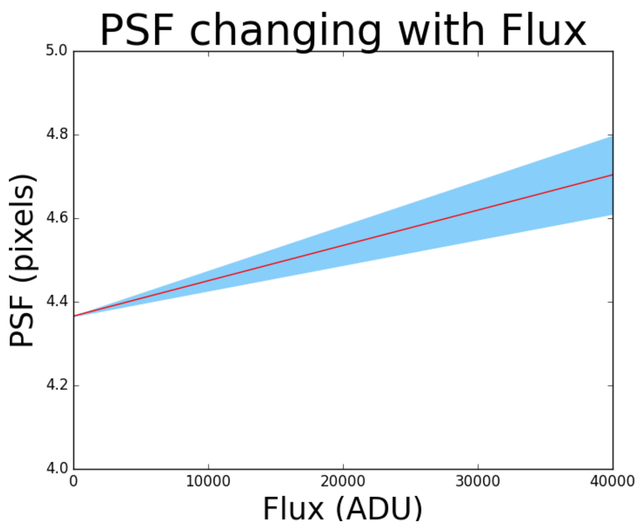
The distribution of flux through the fringe projector should be modeled by the following equation[2] :

$$\rho(x') = \int_{-\infty}^{\infty} flux \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-x')^2}{2\sigma^2}} dx$$

To observe how the PSF depends on flux, a substitution was made based on a linear relation between the two:

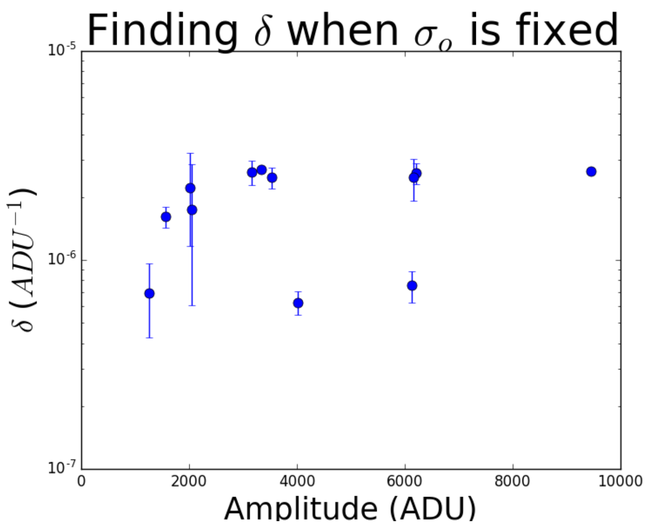
$$\sigma = \sigma_o(1 + \delta * flux)$$





The red line and blue region represent the mean value for delta and one standard deviation

- In practice, σ_o and δ could not be fitted reliably if both are free parameters in the fit
- Short exposures were fitted with δ fixed to be zero to give σ_o
- Using this σ_o value the fitting procedure found δ, which appears to be independent of flux
- These values can be used to calculate the change in PSF with increasing flux
- These results suggest a 7.7% ± 2.1% change in PSF over the full dynamic range due to the Brighter-Fatter Effect



References

[1]Takacs, P.Z. et al., in: Proceedings of SPIE (SPIE, 2010) p. 207-217
[2]Kotov, I.V. et al., Nucl. Intrs. And Meth. **652,** 524 (2011).

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