Performance Comparison of new Keck Adaptive Optics System

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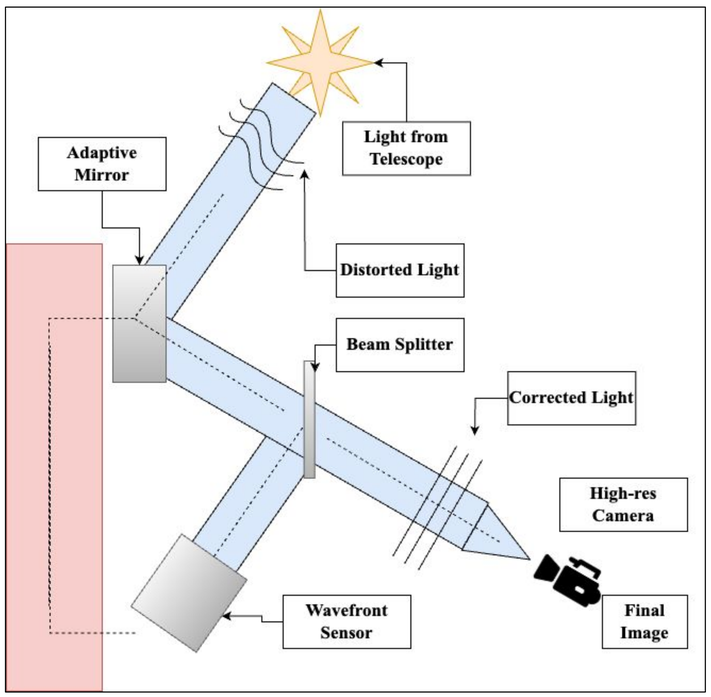
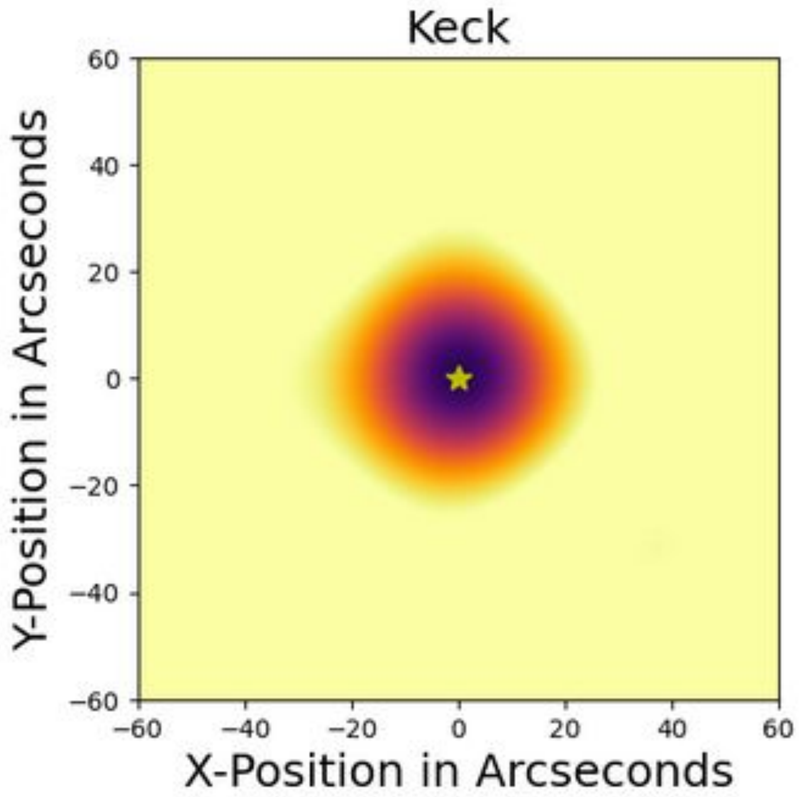
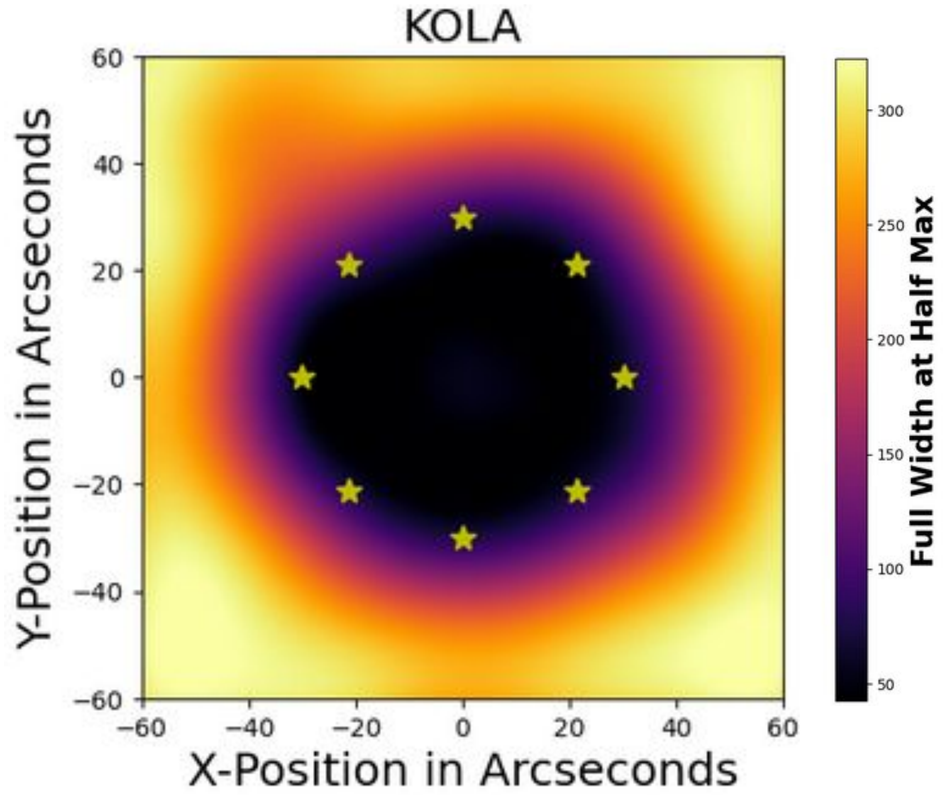


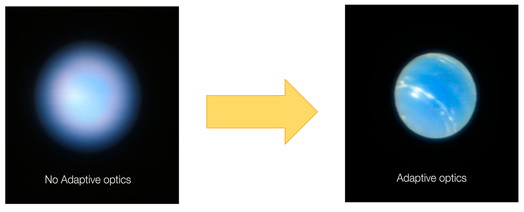




Full Width at Half Max Value for 810 nanometers

Background:

- An Adaptive optics system within a telescope corrects distortions from the atmosphere in real time to create a clearer image
- Full Width at Half Max (FWHM) is a measure of a telescope's performance, quantifying how spread out (wide) from a point source the received light is at its half maximum; lower values therefore indicate a better image
- Our project models how an improved adaptive optics system would improve quality of images the Keck observatory could produce.



Improvements to Keck:

- The upgrade is called KOLA, which stands for Keck Optical Laser guide star Adaptive optics system.
- KOLA uses 8 laser guide stars compared to Keck's current one.
- A single laser only corrects distortion at a point, but multiple lasers allow us to correct in 3D.
- KOLA's additional lasers also allows for much more accurate corrections across a much wider field of view.

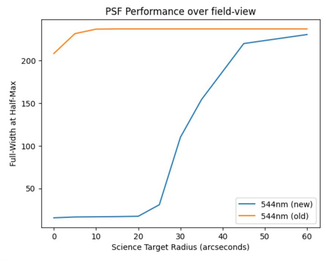
Methods:

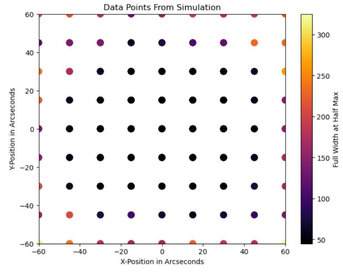
1. Gaussian Regression

- assumed 3d Gaussian distribution throughout our data to interpret 81 data points per graph

2. PAARTI

- PSFs (point spread functions) with AO for Astronomical Research, Testing and Instrumentation (PAARTI) is a python package developed by Moving Universe lab to turn PSF data derived from NERSC (National Energy Research Scientific Computing Center) into more useable arrays for analysis





3. Code

- First plotted single-wavelength performance plots, then plotted raw data, and finally interpolated to attain full color map.
- [Graph on left]: PSF performance comparison: KECK in yellow & KOLA in blue
- [Graph on right]: Data plotted on color map before interpolation

Conclusions and Analysis:

From the graphs created above it becomes clear that KOLA is able to produce clearer images for a wider radius, which is shown by the greater area of lower FWHM values in Figure 2. In comparison, the current system is unable to produce as clear of an images outside of a small radius surrounding the origin.
Additionally, this also reveals that KOLA would allow Keck to operate efficiently at wavelengths closer to the visible.

Future Work:

Further investigation of KOLA could include: focusing on additional variables such as strehl ratio to get an even better grasp of the new system's capabilities: 3D visualization; running additional simulations for extra data points for more detailed map; or creating an animation showcasing the improvement of the image.

Acknowledgements & References :

Lianqi, Wang, Brent Ellerbroek, "Computer simulations and real-time control of ELT AO systems using graphical processing units," Proc. SPIE 8447, Adaptive Optics Systems III, 844723 (13 September 2012).

Lu, J. R., Dekany, R., Peck, B., Bouchez, A., Millar-Blanchaer, M., Hinz, P., ... & Claveau, C. A. (2024, August). KOLA: a concept for an optical multi-conjugate adaptive optics system for the WM Keck Observatory. In *Adaptive Optics Systems IX* (Vol. 13097, p. 130970H). SPIE.

Neptune, European Southern Observatory: Very Large Telescope

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