Liger at W.M. Keck Observatory: IFS Wavelength Calibration

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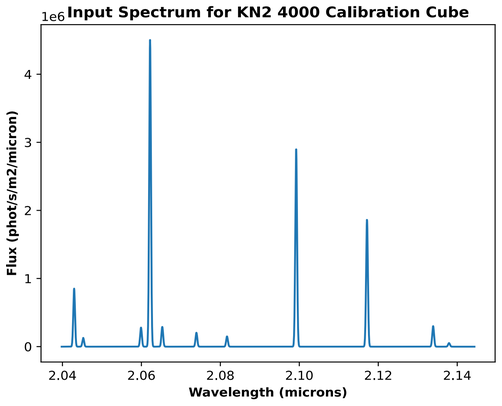
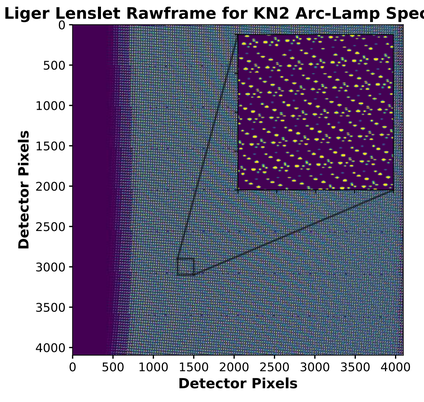
Abstract

Liger is a next generation imager and integral field spectrograph (IFS) for the Keck All-sky Precision Adaptive-optics (KAPA) system on the Keck I telescope. Liger's IFS will consist of a slicer assembly and lenslet array with higher spectral resolution capabilities (R=4,000 - 10,000) than other IFS instruments. Enabling Liger's diverse science cases will require a robust characterization of the IFS wavelength solution, especially across its higher spectral resolution modes. We investigate the calibration of the wavelength solution for the Liger IFS, as well as the current capabilities of the calibration arc lamp sources in Keck I AO. We utilize simulations of Liger's Lenslet IFS based on optical modeling of the instrument with Zemax, starting with a spectrum of emission lines for each Liger mode from the arc lamps to simulate an arc lamp scan. Our simulations include an end-to-end noise model of the instrument to generate a reduced data cube, which we then analyze to extract the per-lenslet wavelength solution. Initially, we have performed these simulations for a subset of lenslet modes suggesting good wavelength solution characterization in K band, with the future goal of investigating all IFS modes and determining the limiting factors in measuring the wavelength solution. Preliminary analysis of the current arc lamp spectrum at Keck suggests that bands such as Y and H might require additional sources on the Keck I AO calibration bench.

Methodology



Simulated Lenslet Exposure with Noise



Weighted Least Squares Extraction

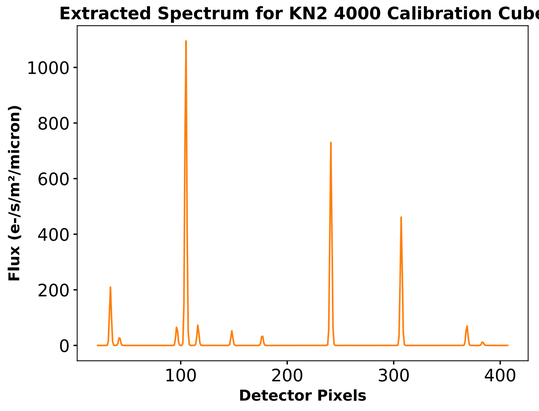
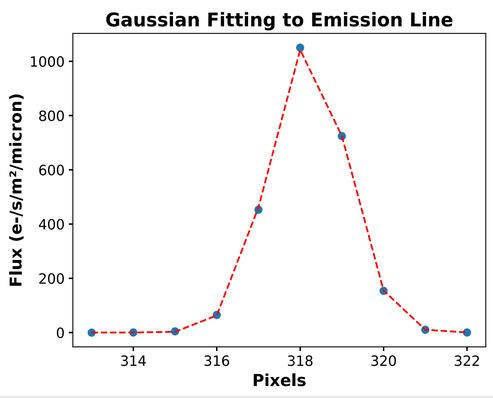


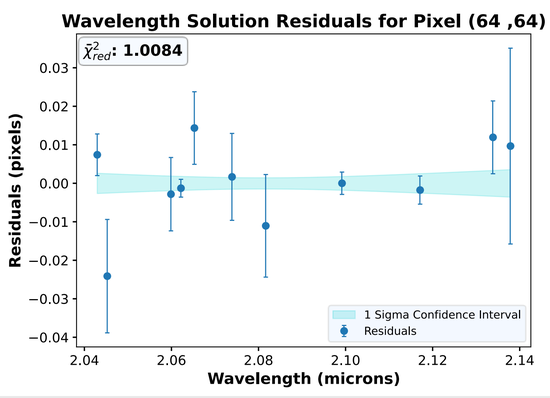
Fig 1: Summarizes the process of characterizing the wavelength solution for KN2 at R=4000 with an end-to-end simulator.

The apparent flux drop in the extracted spectrum is caused by an ~8% loss in resolution, which is largely attributed to the binning onto the detector pixels.

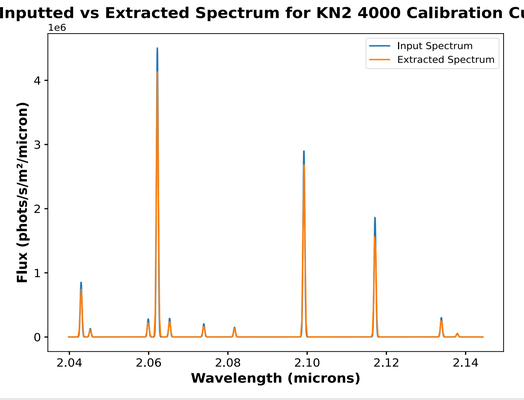
Gaussian Fitting



Chebyshev polynomial wavelength solution model

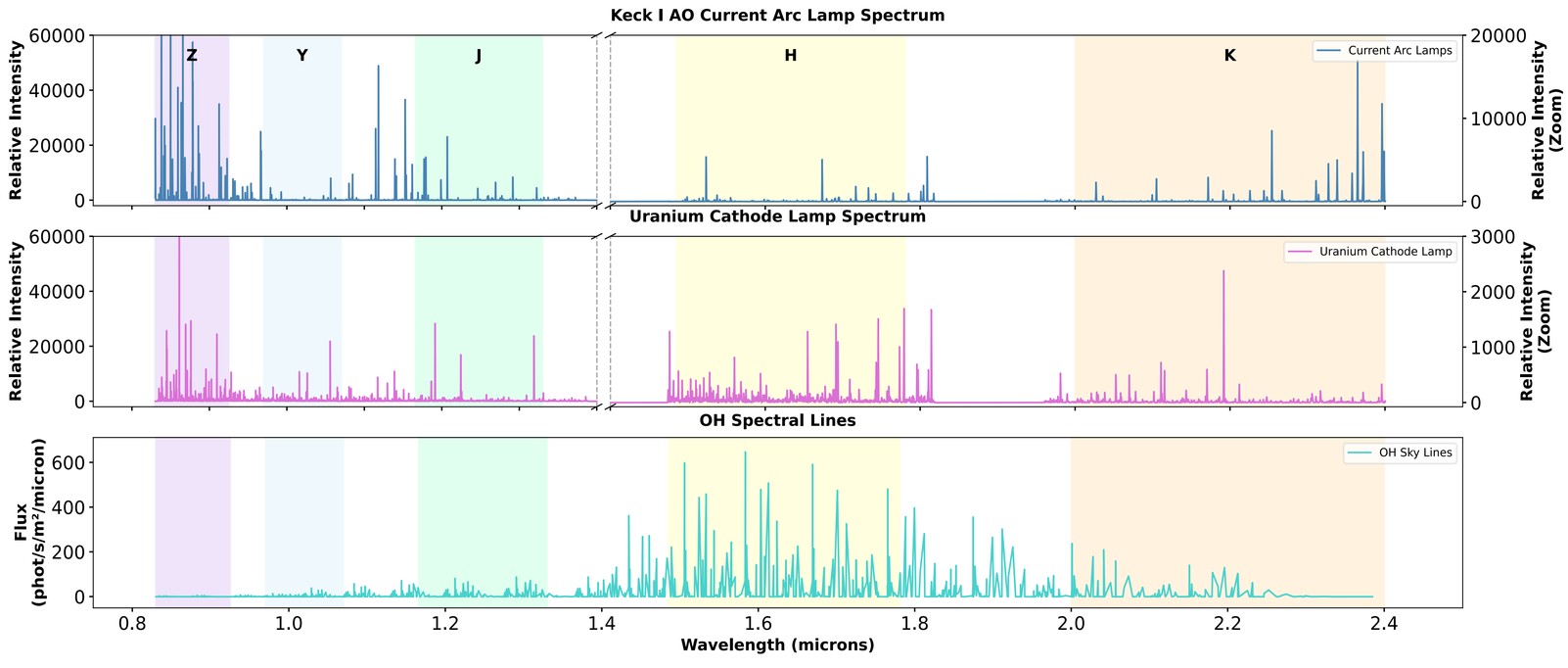


Comparison of Input and Output Spectrum



Keck Calibration Bench

- **Current Capabilities:** Keck I AO arc lamps include Argon, Neon, Krypton, and Xenon emission lamps. However, these lamps have limited coverage in certain bands, such as Y and H, leading to worse wavelength solution characterization.
- **Additional lamps**, such as a Uranium Cathode lamp, will provide additional emission lines in these bands and will improve the wavelength solution calibration.
- **OH lines** may be useful for wavelength solution calibration in the redder wavelengths, such as H-Band, where arc lamps may have few or faint emission lines.



Next Steps

- **Investigating Other Liger Modes:** We have only completed this analysis for the KN2, R=4000 lenslet mode for the IFS. Eventually, we will investigate other Liger modes, especially higher spectral resolution modes as those will require a robust characterization of the wavelength solution.
- **Potential New Arc Lamp Sources:** Further analysis of other liger modes may indicate that the current arc lamps in the Keck I AO bench may not provide enough coverage of certain filters for robust wavelength solution characterization. Thus, new arc lamps may be needed in order to adequately calibrate Liger upon delivery.

References

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