Fringing in MonoCam Y4 Filter Images

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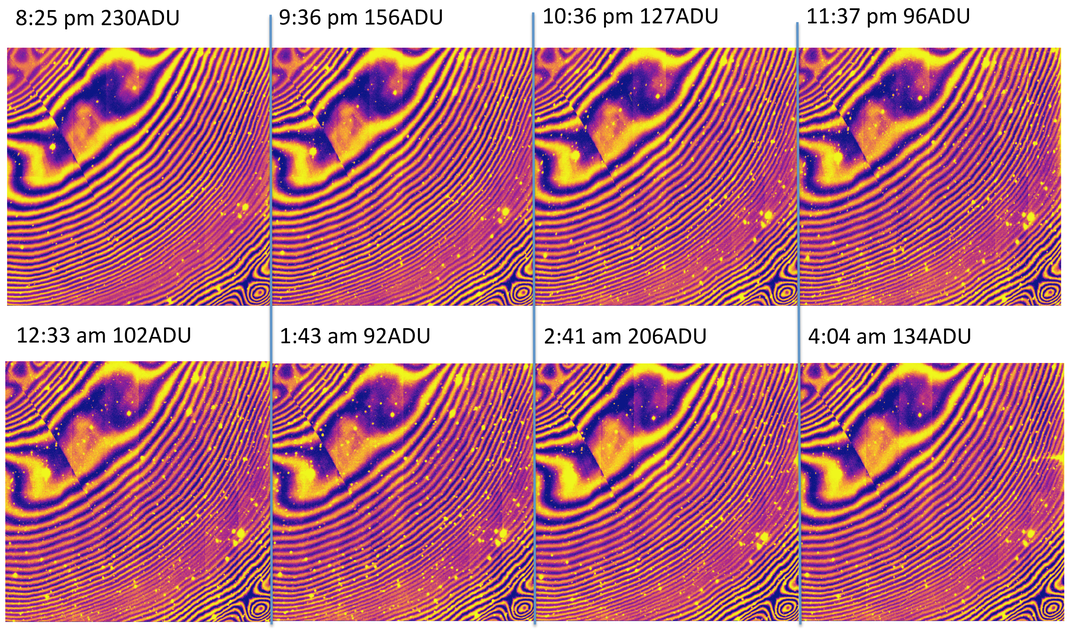
Introduction

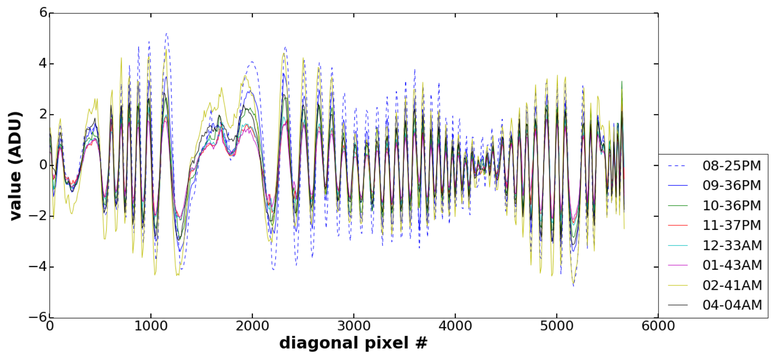
We study the fringing patterns observed in the MonoCam camera with images taken at the U.S. Naval Observatory near Flagstaff, Arizona using its 1.3m telescope with f/4.0 optics. Images were taken at regular intervals over the night of May 11 to morning of May 12. Fringing occurs due to the reflection of light at the bottom surface of the CCD that constructively or destructively interferes with incident light to produce a net "fringe" pattern that is superimposed on all images taken. It is thought that emission lines from the atmosphere (dominated by OH spectra) will change in their relative intensity as the night goes on and produce different fringe patterns in the images taken throughout the night. We found through several simple methods that the general shape of fringe patterns remains constant, though slight changes in fringes might occur.



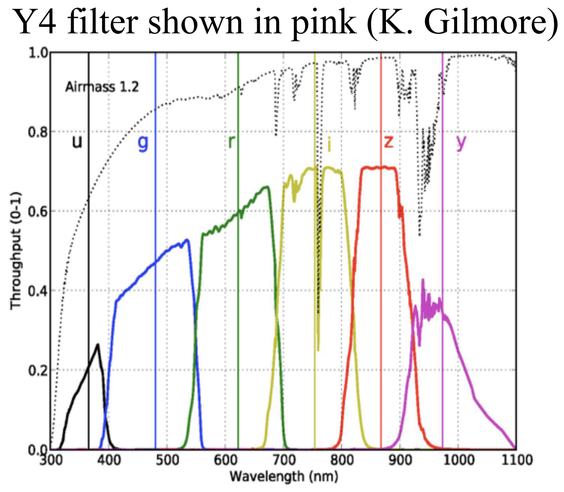
Fringe Patterns

Displayed to the right are the main fringe patterns observed throughout the night using the LSST Y4 filter. Each image represents the average of ten images taken in ten back-to-back 60 second exposures processed with LSST DM. Note that the median flux (shown in ADUs) changes in each image. All slice plots below show the values taken across a line that stretches from the top left corner of an image to the bottom right corner.

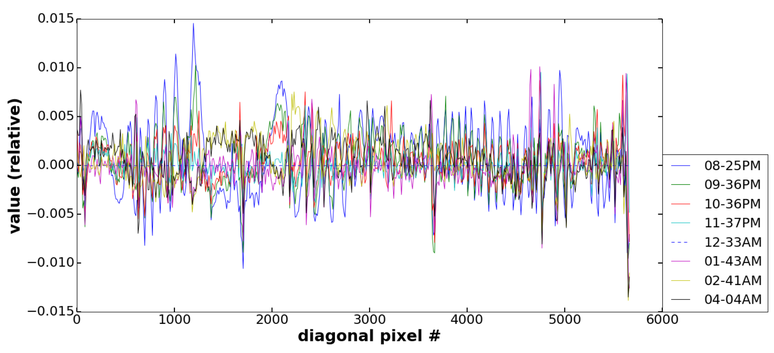
All slice plots shown together



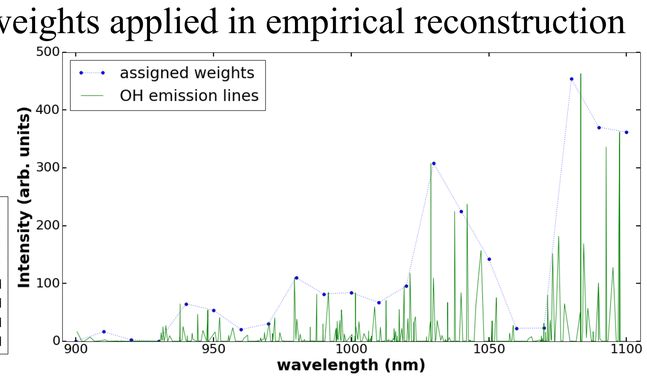
Y4 filter shown in pink (K. Gilmore)



All slice plots subtracted by 12:33 am pattern (individual plots shown to the left).

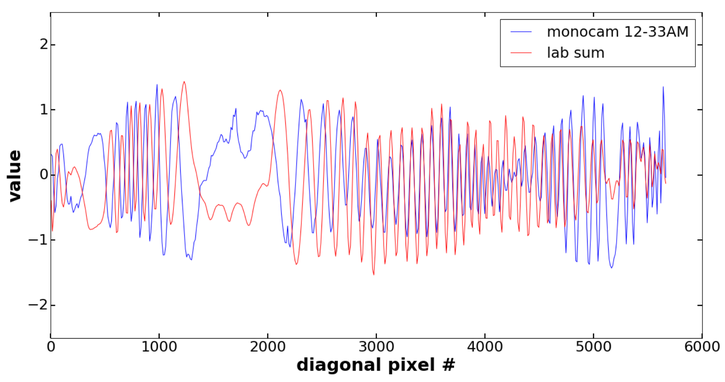


Theoretical OH emission line[1] intensities and weights applied in empirical reconstruction

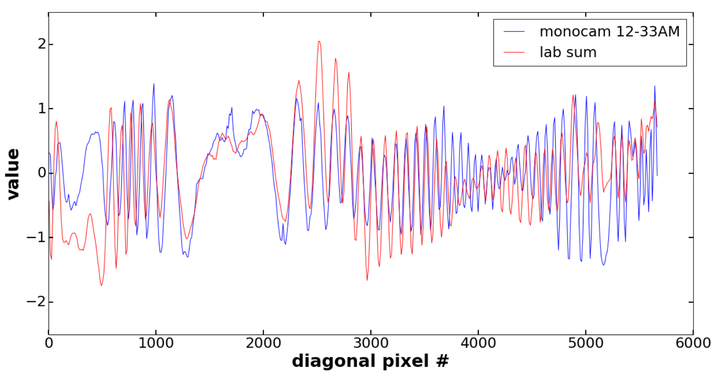


Comparison With Lab Measurements

Monochromatic flats ranging from 900nm to 1100nm in steps of 10nm were taken of the same 113-03 e2v sensor that was used in MonoCam. Shown below is a sum of all fringe patterns with weights assigned to each wavelength that roughly correspond to theoretical OH emission line intensities. Final image shown has been divided by its median value and lines in both slice plots shown below have been divided by their respective interquartile range. Notice that the node position (around 4000) in the lab slice plot occurs when we include all wavelengths of light in the range 900-1000nm and 1000-1100nm.



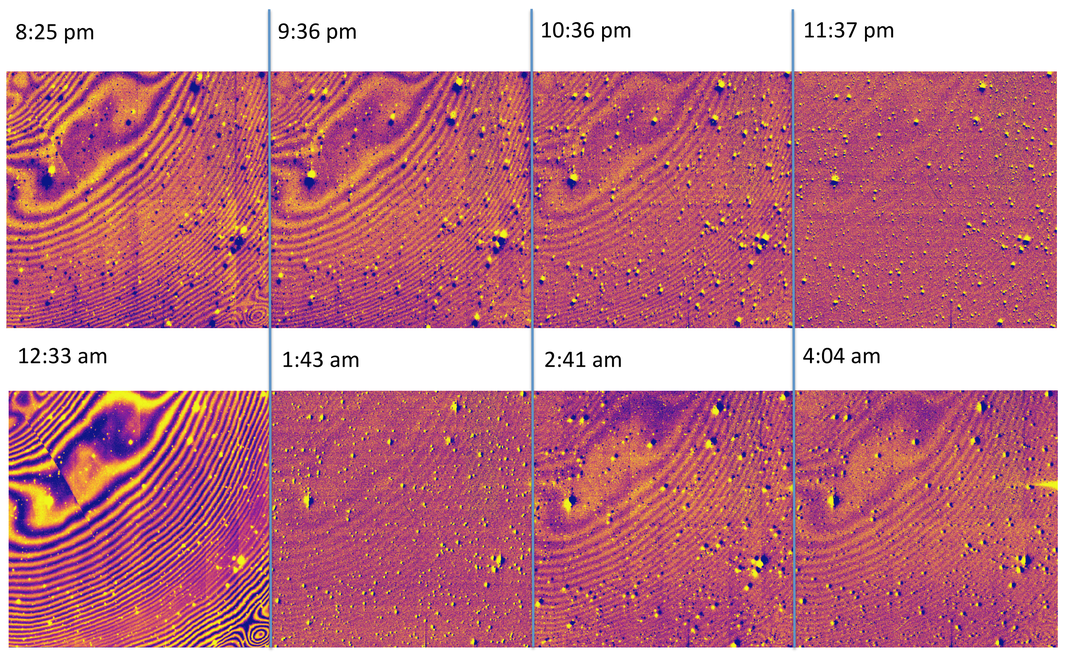
Diagonal slice plot of lab fringe pattern with wavelengths > 1000nm removed

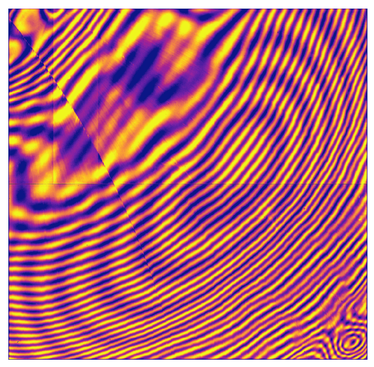


Diagonal slice plot of lab fringe pattern with MonoCam 12:33 am fringe pattern

Subtraction by Midnight Pattern

Below are the same patterns in the top right subtracted by the fringe pattern that appears at 12:33 am (however 12:33 am image below is was not subtracted by itself). Before subtraction was performed, each image was first divided by its median value to normalize flux. Notice in the images that the dark regions at the beginning of the night roughly correspond to the bright regions at the end of the night.





Lab flat at 1000 nm. Secondary fringing is visible.

Conclusions

Major fringe pattern does not appear to change by much over the course of the night; slice plots (mostly) remain in phase, and lab data suggests that observed fringe pattern is a superposition of several patterns fringes in the range from 900-1100 nm.

References

[1]Rousselot et al., 2000, A & A, 354, 1134

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