MODERN TOOLS FOR DKIST SCIENCE EXPLOITATION

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DKIST BACKGROUND

- Daniel K. Inouye Solar Telescope
- Built by consortium led by NSO
- Largest solar telescope in the world

1920 arcseconds
GOING FROM THIS...
...TO THIS
HALEAKALĀ

- DKIST site on the island of Maui
- Altitude: 3055 m (10,023 feet)
ATMOSPHERIC DISTORTION

- Refraction
- Dispersion (spectral differential refraction)
- Turbulence
A COMPARISON

Refraction

Dispersion

Turbulence

Atmosphere refracts light

Different wavelengths refract differently

Distorts image randomly and quickly

Can be corrected by telescope

Only corrected in post-processing

Mostly corrected by code

Too random to calculate effectively
DESTRETCHING

- Correcting for atmospheric turbulence
- Figure at right from Tkaczuk et. al. 2007

Fig. 6. An example of a map of displacements due to the Earth’s atmospheric distortion as sampled by granules. Regions without data have too low an image quality for a granule to be identified. X and Y are in arcsec.
WHAT’S THE POINT?

- Create software in Python
- Correct for dispersion and turbulence
- For use with DKIST
STEP 1: REFRACTION

First, calculate refractivity:

\[ n_{prop} = \left( \frac{\rho_a}{\rho_{axs}} \right) (n_{axs} - 1) + \left( \frac{\rho_w}{\rho_{ws}} \right) (n_{ws} - 1) + 1 \]
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WHAT ARE ALL THESE ANGLES, ANYWAY? OR: A SLIGHT TRIGONOMETRIC NIGHTMARE
STEP 2: DISPERSION

- First, calculate the direction of dispersion in heliocentric coordinates
  
  \[ d_{ew} = \sin(180 - (\phi - P_0)) \]
  
  \[ d_{ns} = \cos(180 - (\phi - P_0)) \]

- Then, calculate the magnitude of dispersion by interpolation
DISPERSION MAGNITUDE
STEP 3: DESTRETCHING

- Compare a target image with a reference image
- Separate each into subfields
- Calculate displacement from target to reference for each subfield
- Produces a grid of measured displacements which can then be applied in reverse
DESTRETCHING EXAMPLE: Hα
PUTTING IT ALL TOGETHER...

770-590 nm difference image
PUTTING IT ALL TOGETHER...

770-590 nm difference image
PUTTING IT ALL TOGETHER...

770-590 nm difference image
Dispersion, 589-769 nm
Dispersion Residuals, 589-769 nm

Dispersion Residuals [arcsec]

Hours [UT]
AGREEMENT–DESTRETCHING

[Image of two plots comparing IDL vs Python results]
CONCLUSIONS

- Python output in good agreement with IDL
- Moving towards Python and away from IDL
- Further refinement/testing
- SunPy/Github
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