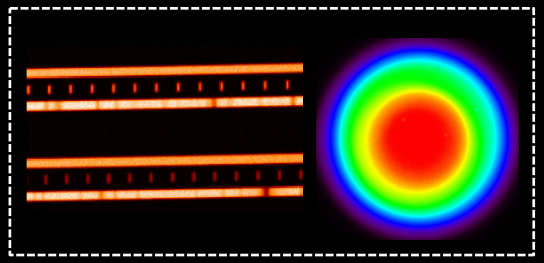
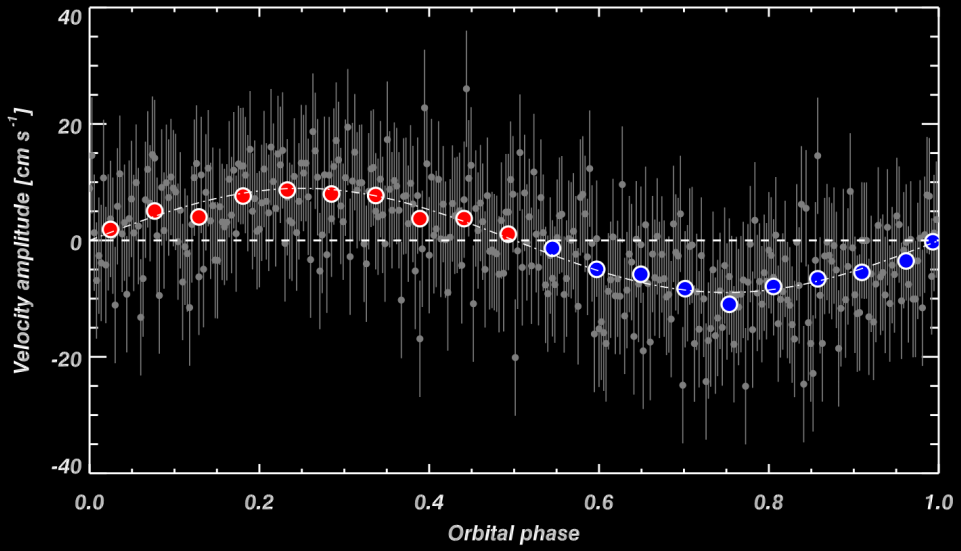
Enabling Technologies for Extreme Precision Radial Velocity Measurements

Improved Doppler spectroscopy instrumentation



Higher precision radial velocity measurements



Better sensitivity to Earth-like planets

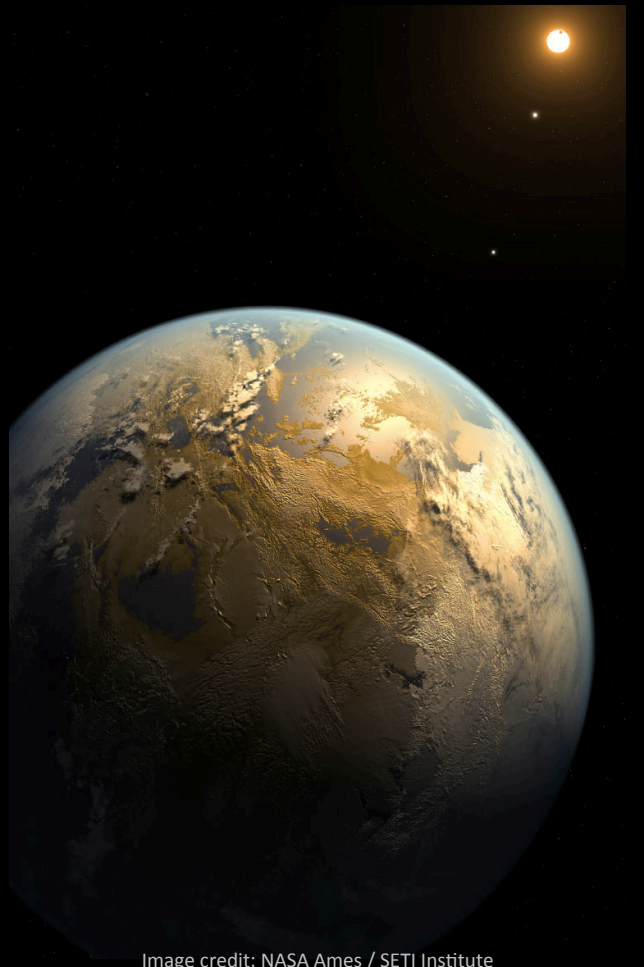


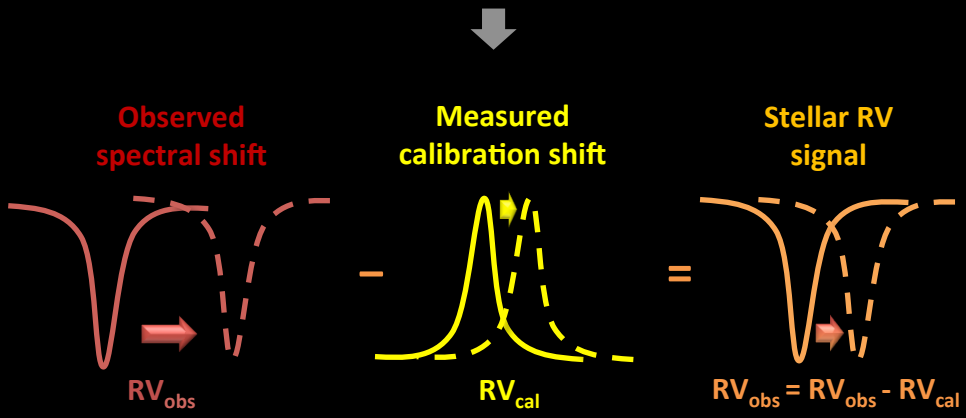
Image credit: NASA Ames / SETI Institute

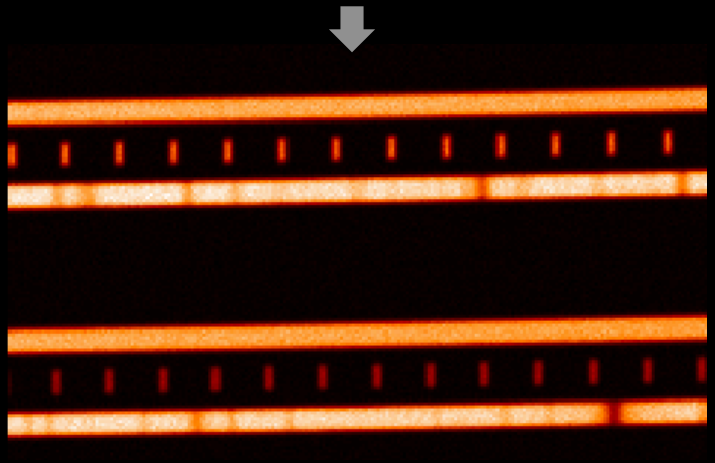
Sam Halverson
Class of 2016 Sagan Fellow

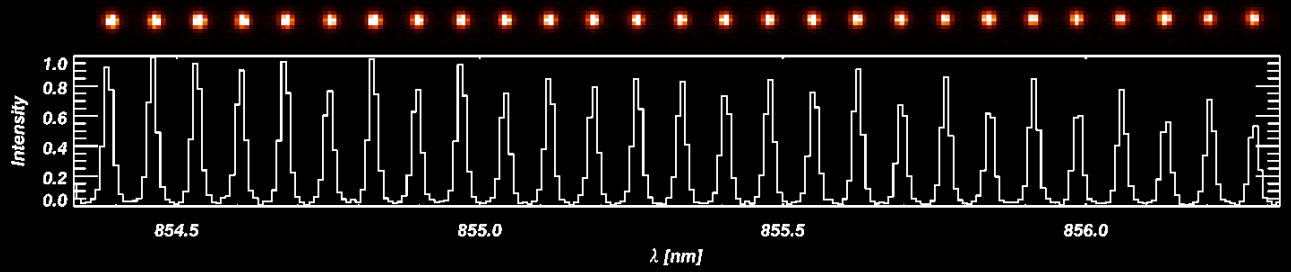
Calibration is key for high precision RV measurements

10 cm/s velocity change is a 0.3 part per billion spectral shift. Measuring this minute shift requires extremely precise wavelength calibration sources to discern instrumental drift from true stellar reflex motion.

I will develop new photonic calibration sources that are tied to atomic standards, resulting in extremely accurate, precise, and repeatable spectral calibration.





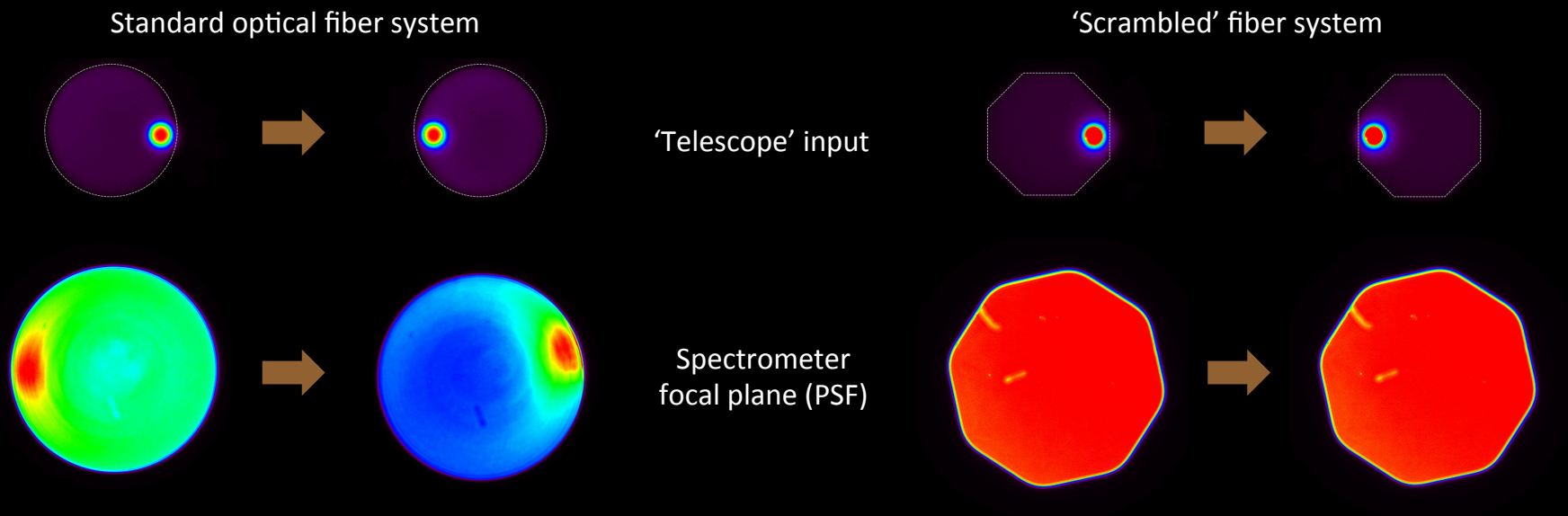


Measured spectrum of prototype photonic calibration source showing rich density of spectral features

Improving spectrometer illumination stability is crucial

Any change in spectrometer illumination will mimic spectral shifts, compromising measurement performance. A 1 nm shift of the instrument PSF is equivalent to a 5 cm/s Doppler shift.

I will develop new image 'scrambling' techniques that will homogenize illumination of spectrometer optics, resulting in a fundamentally stable PSF that is insensitive to input illumination variations.



Illumination errors, due to telescope guiding errors or seeing variations, masquerade as stellar Doppler shifts in the spectrometer focal plane.

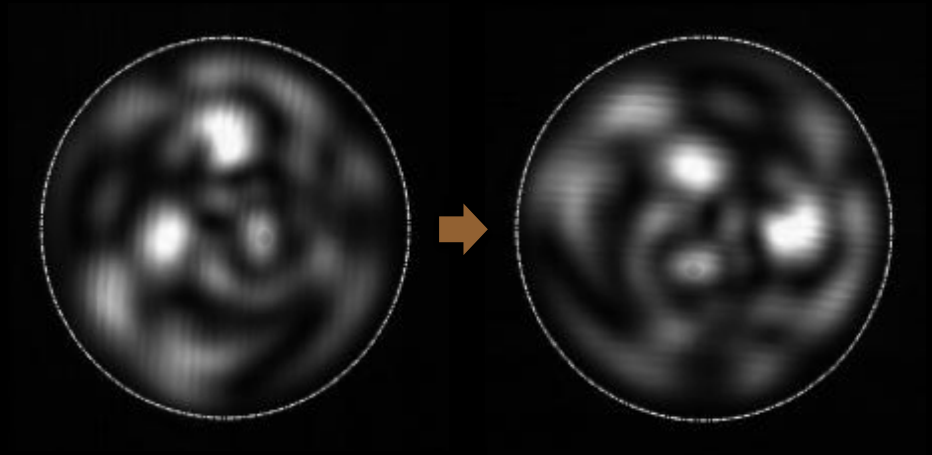
Delivering a stable PSF is not only critical for RV measurements, but is also essential for measuring precise line profiles of stellar activity indicators.

Tackling speckle-noise in optical fibers

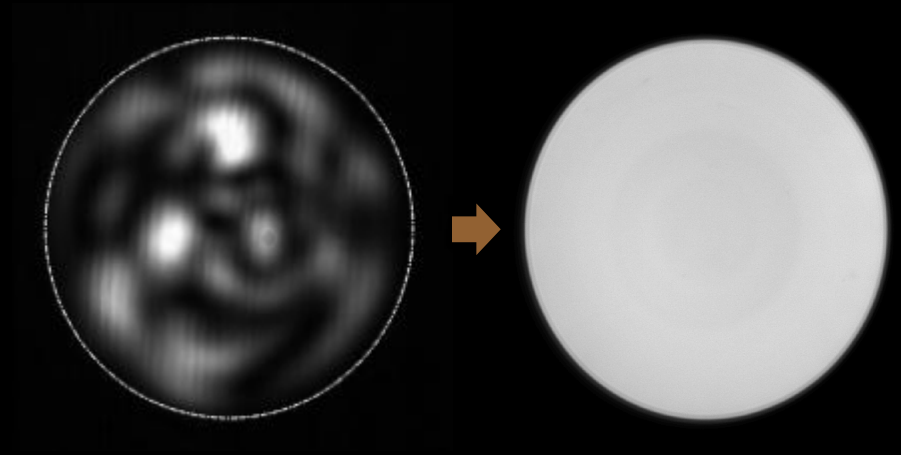
Typical astronomical optical fibers support a finite number of modes, which interfere within the fiber. This interference places a fundamental limit on RV precision, and is especially problematic for calibration sources.

I will develop new optomechanical coupling techniques to reduce phase coherence within fibers, thereby ensuring the exquisite precision of future calibration sources is fully realized by next generation spectrometers.

Output of optical fiber illuminated by laser calibration source



Interference of modes within the fiber results in a variable speckle pattern, degrading instrument precision and introducing instabilities into the instrument PSF.



Measurements of prototype optical fiber coupling scheme showing the 'washed' out speckle pattern.