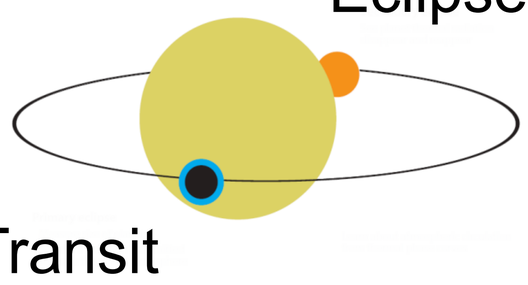
Henrietta: A new exoatmosphere spectrograph for Las Campanas Observatory

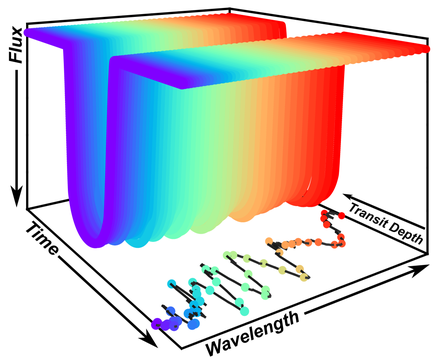
Jason E. Williams[1], Nicholas Konidaris[1], Gerrad S. Killion[1], Julia E. Brady[1], Daniel D. Kelson[1], Christoph Birk[1], Dave Rumph[3], Johanna Teske[2]

[1]Carnegie Observatories
[2]Carnegie Earth and Planets Laboratory
[3]Schmidt Academy for Software Engineering, California Insititute of Technology

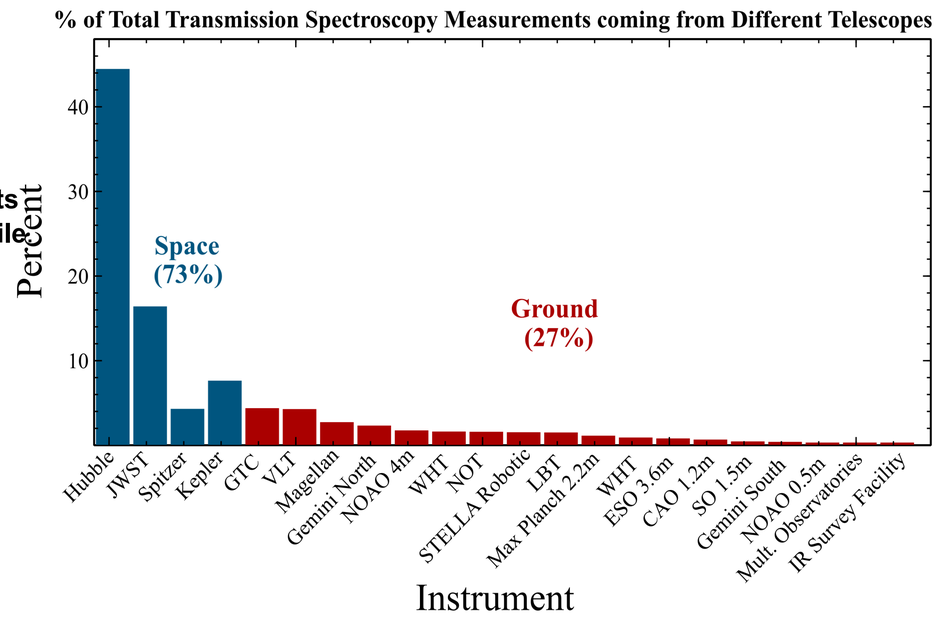
A new instrument for exoplanet atmospheres

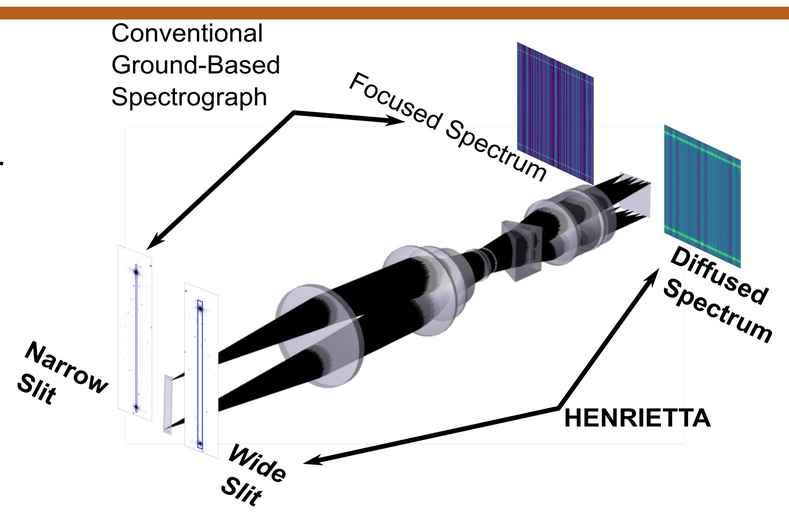


Transit and eclipse spectroscopy provide a wealth of atmospheric information about a planet such as its chemical composition and vertical temperature profile.



Most transmission and emission spectroscopy is performed using space-based instruments, despite more observing resources being available on the ground. Ground-based instruments are currently far from the spectrophotmoetric precisions needed to perform routine transmission/eclipse spectroscopy.



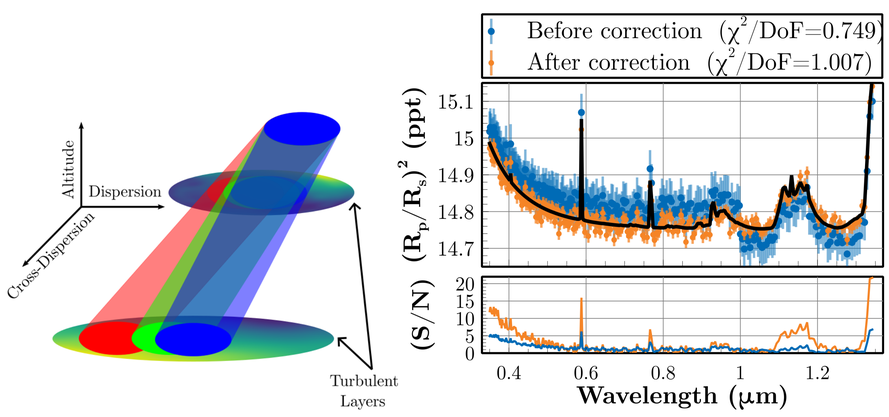


If ground-based facilities could be used, we would be able to characterize planets near the rate at which we discover them. Henrietta is designed as a pathfinder to ground-based transmission and eclipse spectroscopy.

Henrietta is a spectrograph that operates:
- **in the near-infrared (0.6 - 2.4 microns)**
- **at a low resolution (R ~ 200 or R ~ 1000)**
- **with high precision (~1.3x Poisson noise for V > 5 stars)**

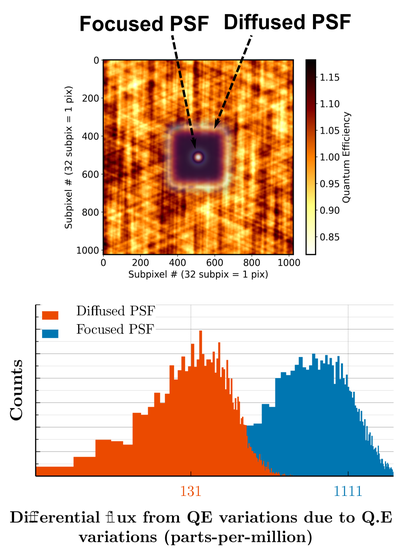
Developing tools and techniques for ground-based high-precision spectrophotometry

Identifying scintillation noise:
Scintillation noise limits the precision of bright stars (our best target for transit/eclipse spectroscopy) to that of brighter stars.
Using the covariance of scintillation at different wavelengths, spectrophotometry can be used to identify and remove scintillation noise.



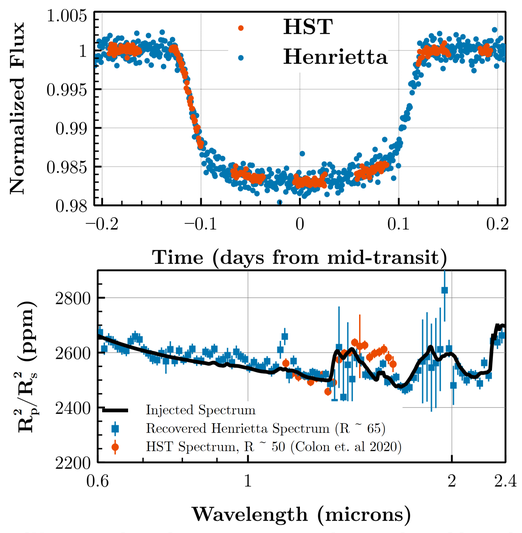
Quantum efficiency variations are more pronounced in H2RG detectors!

Suppressing the effects from quantum efficiency variations:
Henrietta incorporates a diffuser that spreads the point spread function out to tens of pixels. A larger PSF is move insensitive to flux changes when the PSF changes shape or position on the detector.



I simulated time-series of a focused and a diffused PSFs moving around on Henrietta's detector. The noise is suppressed by a factor of 10 when using a diffuser!

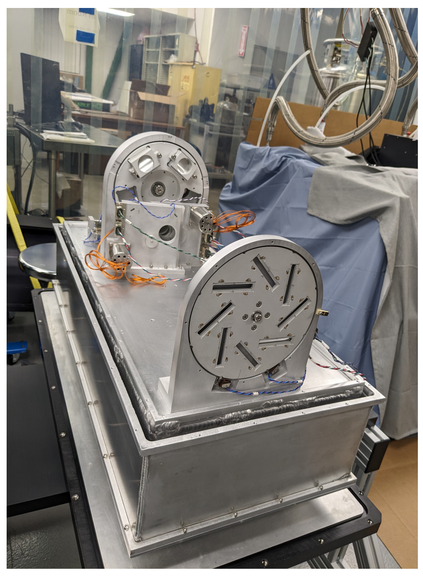
If Henrietta is able to supporess the two sources to the expected levels, then Poisson-noise limited observations can likely be achieved. This would put Henrietta in the same precision category as WFC3/HST!



This illustration is meant to show that Henrietta will have similar precision to Hubble, but will be on a telescope that has > 50% of its time dedicated to exoatmospheres.

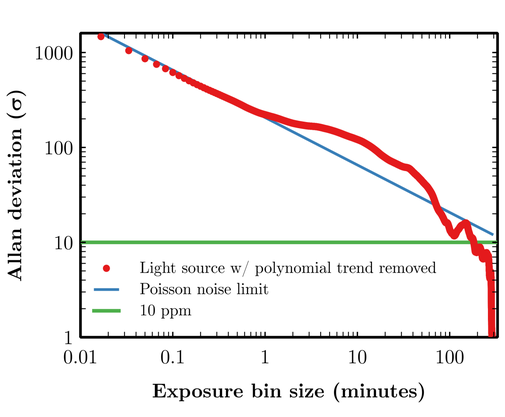
What's Next for Henrietta?

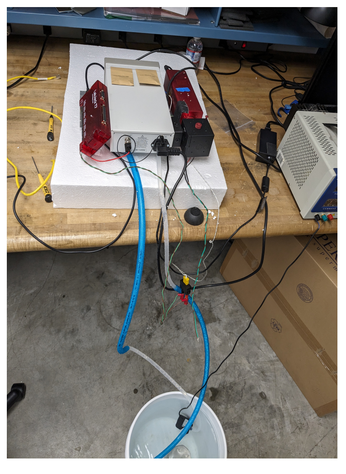
Lab Integration and testing:
Henrietta is currently in the instrument clean room at Carnegie Observatories in Pasadena. Here it is undergoing some minor construction, assembly, optical alignment, and spectrophotometric testing.



Picutred here is a picture of Henrietta, deconstructed. The mechanisms sit on the cold bench - slit wheel, filter wheel, diffuser wheel, grism wheel, and diffuser stage.

Identifiying Henrietta's noise floor.
To find where Henrietta's noise floor is, a light source with sufficient spectrophotometric precision to reveal the noise floor is necessary. Below is a photometric monitoring setup which temperature controlls a ThorLabs current-controlled Tungsten-Halogen Light Bulb. When the low order temperature variation is removed, the fluctuations are Gaussian! (A STAR IN THE LAB!)





Henrietta Commissioning:
Henrietta is planned to be on sky late summer/early fall of 2024. During the six months of commissioning we will identify the best techniques for performing high-precision spectrophotometry from the ground. After commisissioning, a large survey will begin to understand how atmospheric escape in hot gas giants change as the host star varies. Henrietta will award 10 nights to the community! Please e-mail me to discuss collaborating or with any ideas you may have for using Henrietta! (jewilliams@carnegiescience.edu)