National Aeronautics and Space Administration

PARVI: A Habitable Zone Planet Finder

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Program: Strategic Initiatives

Project Objective:

The primary objective of this initiative is to develop and deploy a precision radial-velocity spectrograph using a radically different design approach.

The PARVI spectrograph is an AO-coupled compact Echelle, operating at near infrared wavelengths (1.1-1.8 microns) on Hale telescope at Palomar. Its goal is to measure the Doppler velocities of stars to 1 m/s to search for the reflex signal imposed by orbiting planets. With its near IR spectral grasp PARVI will target late-type dwarf stars and well as young stars. PARVI achieved first light on the Hale on June 14, 2019, and will commence science operations during the next observing semester.

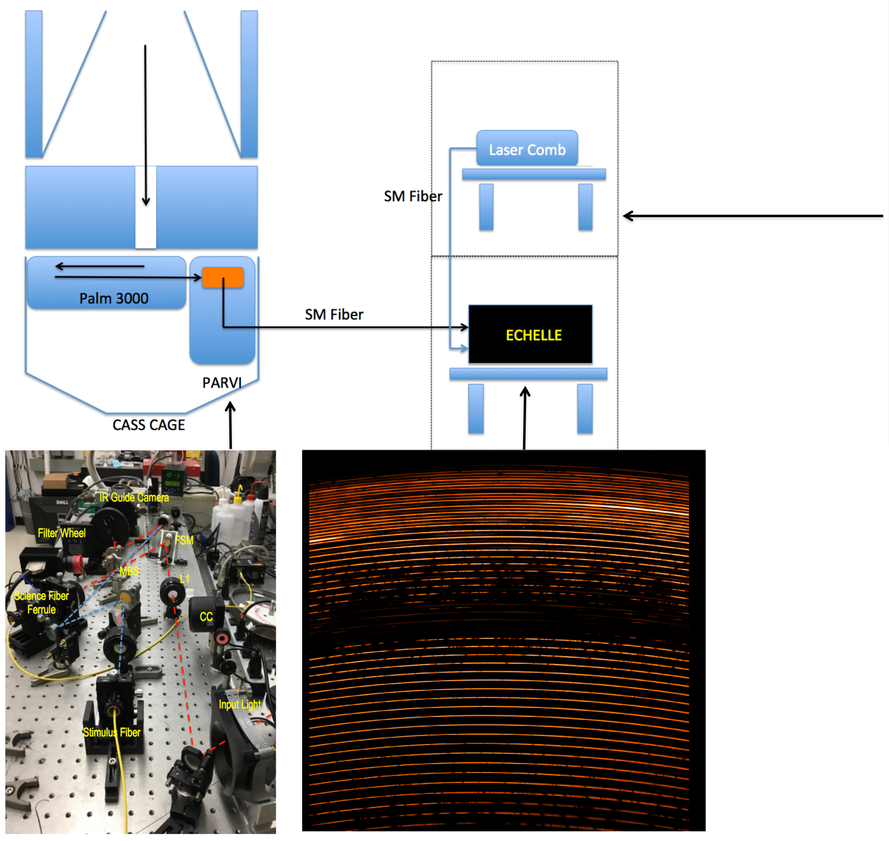
FY19 Results:

- The project four major subsystems were independently tested and deployed to Palomar in early June: These are the R=100,000 Echelle spectrograph, the Fiber Injection Unit, the Fiber optical transport between the telescope and the remote Echelle, and the laser frequency comb for monitoring and calibration the spectrograph wavelength scale.
- First light observations were achieved on June 14, followed by five more nights of observing, culminating in observations of ~30 diverse astrophysical targets. An early version analysis pipeline is being used to analyze these new type of data.
- We measured a number of instrument performance and data quality metrics, and have identified key areas of improvement which are being worked on at present.

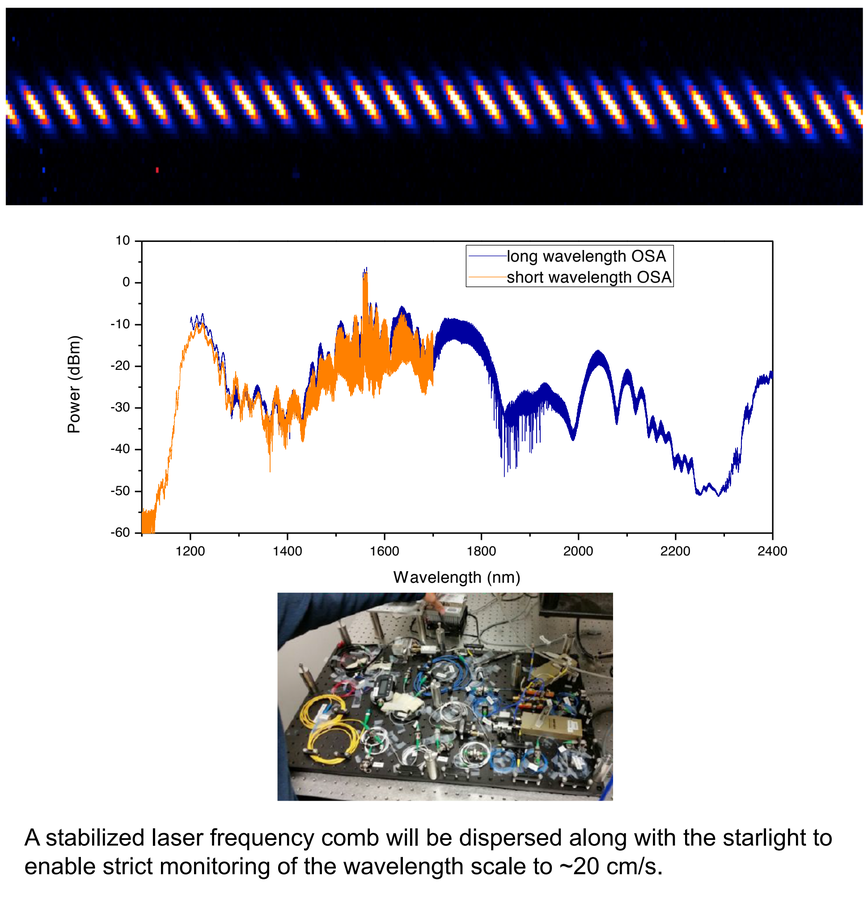
Benefits to NASA and JPL:

Direct imaging of habitable zone earth-analogs requires a flagship mission; HabEx and LUVOIR are two concepts presently under NASA study for the upcoming NRC/NAS Decadal Review. Prior to the launch of either of these missions, comprehensive EPRV searches of the nearby sample of sun-like stars are needed to identify potential earths and determine their masses. Advance knowledge of the existence and location of suitable targets will reduce the search space and thus the requirements on the size, cost and risks of the mission. In particular, the smaller of the two designs under consideration, JPL's HabEx, may become more attractive compared with the much larger LUVOIR. A second consideration is that PRV from the ground may have a systematic noise floor which would preclude detection of true analogs and therefore necessitate a EPRV space probe or even an instrument on the flagship itself. Finally, Pasadena scientists must be vital players in this kind of exoplanet research and developing the needed technologies to ensure a major role in flagship and other NASA opportunities. These reasons---scientific, technological and programmatic---all point to the strategic importance of a multi-pronged involvement in PRV, and argue for a technically new albeit highly promising PRV capability for Palomar. (The need for a major new thrust in EPRV is written in the NAS Exoplanet Strategy Report (2018); in response to the report NASA and the NSF have organized a strategy working group tasked to make recommendations to the two agencies in 2020)

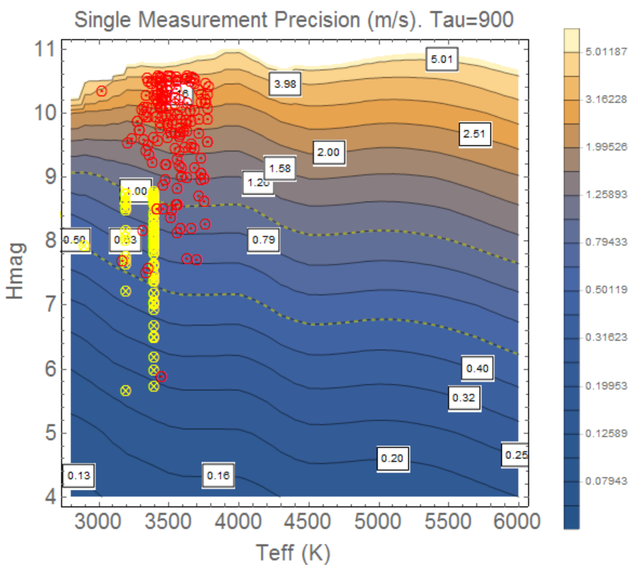
PARVI Characteristic	Value
Spectrograph	• Diffraction Limited Single Mode • Waveband 1.2-1.8 microns • R = 100,000 at 1.6 microns • H2RG • Vacuum/77 K operation/1 mK
Wavelength calibration	• EOM Laser frequency comb
Location/Feed	Remote/SM fiber feed
AO system	Palm 3000 with • New OCAM2k EMCCD • SH sensor • 64x64 (ExAO); also 16x16
Throughput	Loss over conventional spectrograph = mode matching loss x Strehl
Stabilization Non common path correction	Tip-tilt 50 Hz Phase diversity (MGS algorithm)
Hardware / instrument software heritage	Project 1640



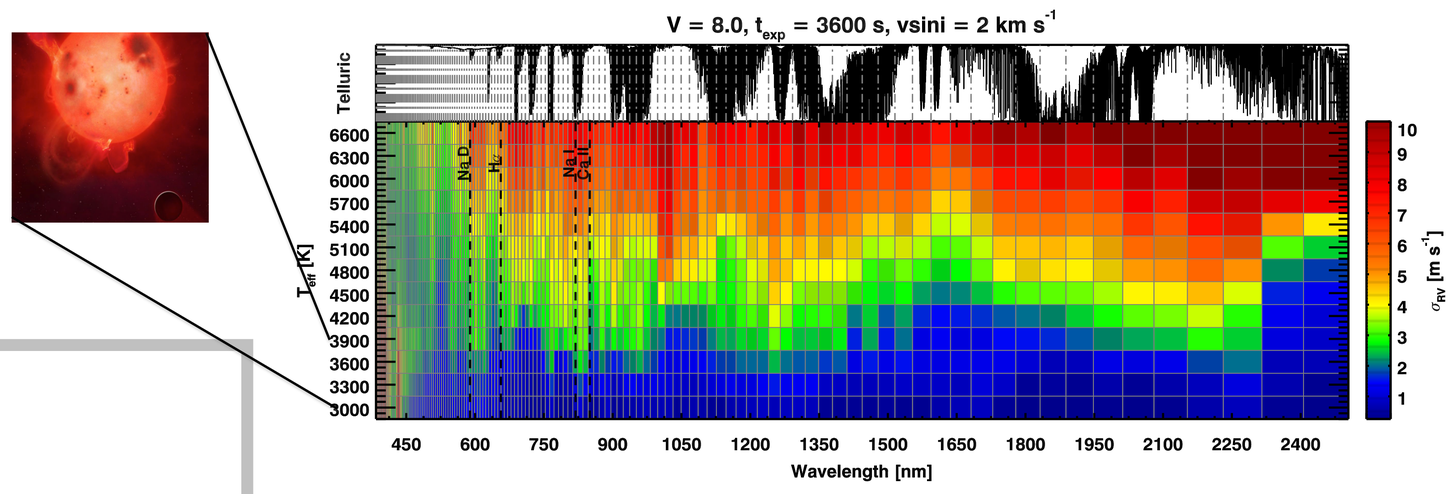
PARVI: (top) instrument characteristics; (middle) schematic layout (bottom) fiber injection bench and first light spectrum of the star Arcturus



A stabilized laser frequency comb will be dispersed along with the starlight to enable strict monitoring of the wavelength scale to ~20 cm/s.



PARVI RV projected precision (photon noise only) as a function of stellar H magnitude and the stellar effective temperature.



The RV content of stars as a function of wavelength and effective temperature. Late tyoe stars have high content at near IR wavelengths

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