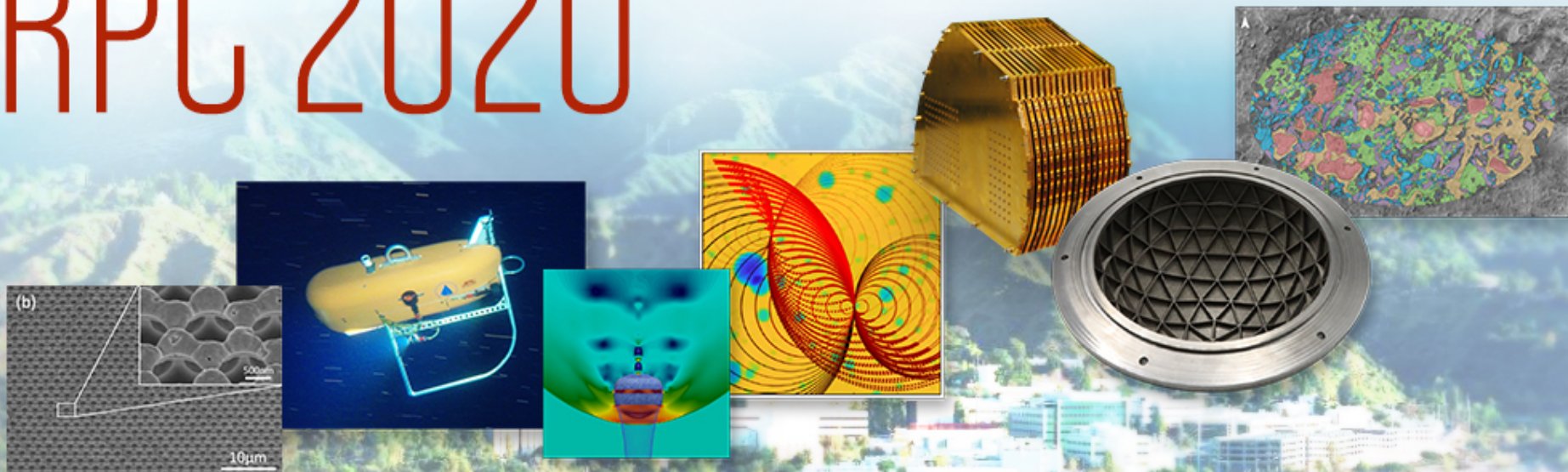


RPC 2020



Virtual Research Presentation Conference

PARVI Commissioning and Science

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Program: Strategic Initiative

Assigned Presentation # RPC-025



Jet Propulsion Laboratory
California Institute of Technology

Tutorial Introduction

Abstract

The **radial velocity (RV) technique** is the pioneering technique that first uncovered the presence of planets orbiting other stars. It uses the velocity Doppler-shift to measure the motion of the star around the common star and planetary system barycenter. A goal is to advance the precision of this technique to measure the signature of earth-like planets in the habitable zones of other stars.

The **Palomar Radial Velocity Instrument (PARVI)** is an infrared RV instrument for the Hale Telescope at Palomar Observatory. It is a radically different design from previous RV instruments. It uses an adaptive optics (AO) feed coupled to a single-mode-fiber fed compact spectrograph ($R = 100,000$; span 1200-1800 nm), and is concurrently monitored for internal distortion using a laser frequency comb (LFC) metrology. The spectrograph is 1000x smaller than the conventional instruments, making it highly affordable and relatively easy to stabilize against thermal-mechanical changes.

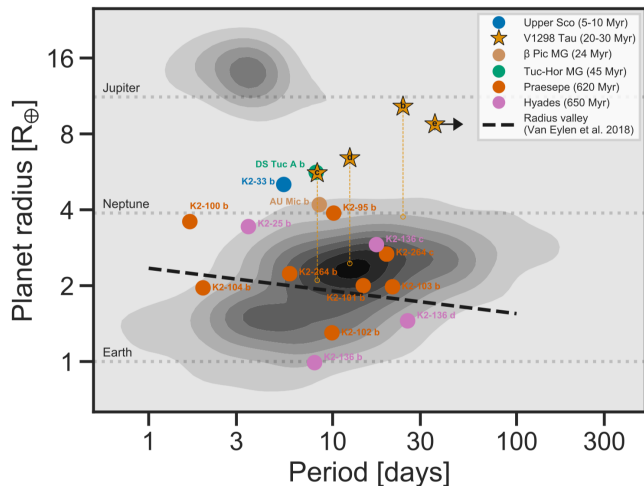
Objectives of this work are to commission PARVI at the Hale Telescope and to carry out early science investigations and gradually improve the instrument's precision radial velocity (PRV) performance and the sophistication of its science programs. Commissioning will take 30-40 nights on telescope over a year in total duration. In FY20 this aspect was severely disrupted by the COVID-19 pandemic.

Problem Description

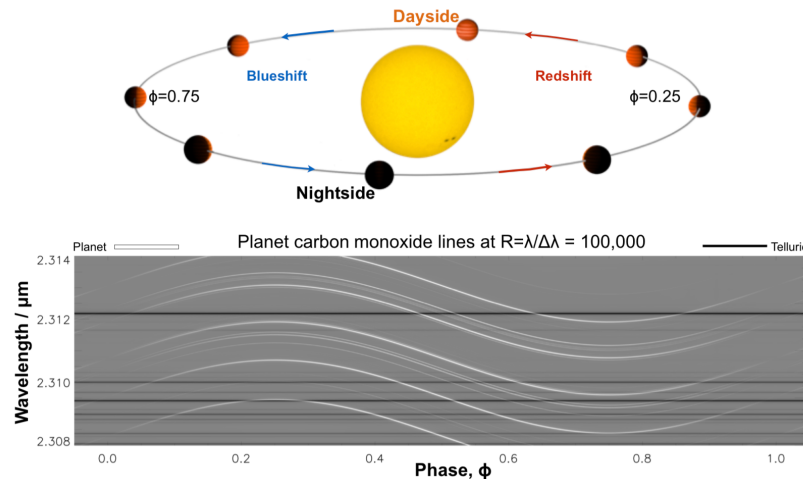
- a) **Context and Relevance to NASA and JPL** : Our proposal responds directly to the 7x strategic initiative on radial velocities, recommendations of the 2018 NAS Exoplanet Science Strategy Report, as well as the charter of the joint NASA-NSF E-PRV Working Group to explore new technologies, techniques, and strategies for overcoming PRV's current roadblocks. The proposed work is directly relevant to immediate (TESS and JWST) and future NASA missions, specifically the decadal flagship contenders HabEx and LUVOIR.

- b) **Advancement over the state of the art** : PARVI tests and validates a new type of instrument with single measurement precision of $\sim 20 \text{ cm s}^{-1}$ using its high-resolution spectrograph, single-mode fiber-feed, spectrograph thermal control, and laser frequency comb metrology. It is a pathfinder for future ambitious AO spectrographs, HISPEC at Keck Observatory and MODHIS at the Thirty Meter Telescope, and is a model for future vis-AO enabled extreme-PRV instruments targeting sub 10 cm/s performance. It also serves as a model for a possible future astrophysics probe mission called EarthFinder.

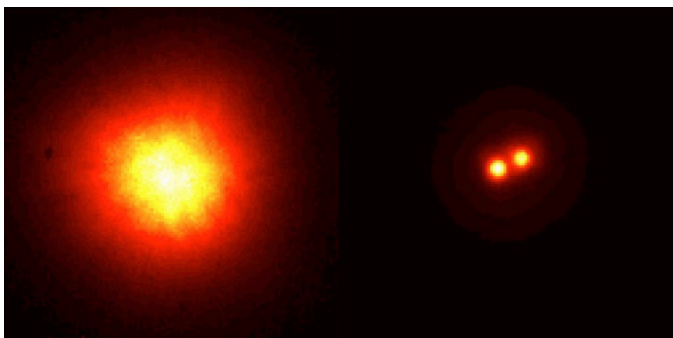
Methodology: Conduct Science Observations



Measure masses and orbital elements of planets in young star systems



High resolution Doppler spectroscopy of planetary atmospheres



Search for planets in close binary stars by resolving the binary

Results

- The COVID-19 pandemic has prevented science observations and delayed commissioning, however we have been able to carry out engineering activities on the instrument as well as analysis of existing data.
- Current PARVI velocity performance is
 - 1 m/s limited by an instability in our laser frequency comb ruler
 - And fluctuations in ambient pressure driving 10 mK RMS temperature instability in the optics
 - Our Milestone for end of FY was 50 cm/s
- Engineering fixes
 - Fixed firmware problems with the laser frequency comb
 - Abandon the current LN2 cryostat and replacing it with a new one based on a pulse-tube closed cycle cooler
- Data analysis
 - We have completed our spectral extraction pipeline and are working with Co-I Plavchan on the radial velocity pipeline
 - Our current on-sky performance on quiet RV stars is about 3 m/s RMS based a simple cross-correlation analysis on a single Echelle spectral order

Publications and References

“The Palomar Radial Velocity Instrument”

Vasisht et al., in preparation for the Journal of Astronomical Telescopes, Instruments and Systems (JATIS)