The Pathfinder High Resolution NIR Spectrograph at the Hobby Eberly Telescope: Exploring Radial Velocity Precision in the NIR with an Un-cooled Instrument

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The Pathfinder Spectrograph: Spectral Format & Coverage

The Pathfinder Spectrograph has been designed to cover the Y band part of the NIR, where M dwarfs have deep absorption features that encode significant radial velocity information. The Y band in particular has low telluric absorption and low OH emission. Pathfinder is an uncooled fiber-fed spectrograph that has been designed to deliver a spectral resolution of R~50,000 with a 4.4 pixel sampling of the resolution element. Thermal blocking interference filters coupled with a PK50 glass filter enable Pathfinder to observe in the Y and J without the need for a cooled pupil.

Abstract

Precision radial velocities in the Near-infrared to detect low mass planets around mid to late M dwarfs require a stable high resolution infrared spectrograph with a good wavelength calibration source. We present commissioning results with the Pathfinder instrument at the 9m Hobby-Eberly Telescope demonstrating on sky observations with a high spectral resolution (R~50,000) fiber fed instrument in the NIR and 10-20m/s velocity precision. The fiber coupled Pathfinder prototype instrument has been designed from the ground up to enable high precision spectroscopy. Precise calibration of the instrument drift is accomplished using a uranium-neon hollow cathode lamp fed down a simultaneous calibration fiber. The Pathfinder is a warm bench spectrograph, made possible using thermal blocking filters and glasses that enable Y & J band observations with an un-cooled instrument. The configurability and accessibility of Pathfinder, coupled with its temperature stabilized fiber fed design, enables many tests to understand the limitations of precision RV in the NIR, and overcome potential obstacles. Frequency combs calibration sources that are now under development can easily be fed into the Pathfinder instrument. The high resolution near infrared capability will be critical for exoplanet searches and characterization. Improvements in velocity extraction algorithms, and telluric correction, are expected to improve the achievable precision.

Radial Velocities obtained on Reference Stars at the HET May'10

The giant star HD106714 is known to be stable to ~10m/s (Hekker et al. 2006). Binned velocities from 3 nights show a scatter of 11.3 m/s, including the first two nights (where the instrument was still thermally stabilizing) and ~23m/s for all nights.

The Penn State Pathfinder instrument has already demonstrated ~7-10m/s precision on solar observations (Ramsey et al. 2008) in the lab, and is now yielding 10-20m/s on stars with the HET with preliminary reduction of the data from our commissioning run in May 2010. The Pathfinder is a warm fiber-fed bench top cross-dispersed echelle spectrograph and a very useful testbed in exploring issues affecting the extraction of precision radial velocities in the NIR such as detector systematics, calibration velocity references and telluric contamination. Pathfinder is designed with two optical fibers so that one of the fibers can be used as a velocity reference with a stable source like a hollow cathode lamp. Since Thorium-Argon lamps have weak Thorium lines and strong Argon lines (with are not stable at microns in the NIR) we have used Pathfinder to explore Uranium hollow cathode lamps. Uranium lamps are very promising for this wavelength regime since Uranium has a large number of lines in the NIR Y band compared to Thorium.

Discussion

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