Long-term operation of a laser frequency comb with the Habitable Zone Planet Finder

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Near Infrared Radial Velocity Calibration
- We have constructed and installed a laser frequency comb (LFC) calibrator for the Penn State Habitable Zone Planet Finder (HPF) at the Hobby-Eberly telescope
- The LFC has now been running continuously for over two years. Here we provide details of its long-term operation

30GHz EOM Comb
- Electro-optic modulators (EOM) convert the continuous wave (CW) laser into a 30GHz comb
  - 10nm bandwidth
  - 300fs pulse duration

Supercontinuum Generation and Spectral Flattening
- 1st Stage Broadening
  - 2W (66pJ) optical power (pulsed energy)
  - Normal dispersion highly nonlinear fiber (HNLF)
  - Generate bandwidth for ultrashort pulse
  - >70fs pulse duration now possible
- 2nd Stage Broadening
  - 252mW (16pJ) optical power (pulsed energy)
  - Anomalous dispersion SiN chip waveguide
  - Supercontinuum from 700nm to 1600nm
- Combination of static optical filter and spatial light modulator (SLM) flatten intensity profile

Autonomous Frequency Comb
- The comb has been running autonomously at McDonald Observatory since May 2018
- Built on robust fiber-integrated electro-optic modulator technology
- The entire comb fits on a 2 x 5 optical breadboard
- Power supplies and control electronics fit in a standard electronics rack
- Control software automates the upkeep of the comb and interfaces with the HPF

Stable and Reliable Supercontinuum
- A SiN nonlinear photonic waveguide broadens the spectrum by 20x with only ~18 pJ of input pulse energy
- Over 2x10^14 spectra have been reliably generated at the 30GHz rate
- The supercontinuum spectrum has a stationary point where the overall (bulk) spectral amplitude is maximized at a given input power
- The dispersive wave (DW) power at 700 nm shows a linear dependence in this region and its power is used to lock the spectrum and minimize amplitude fluctuations

Absolute Frequency Stabilization
- The frequency comb is referenced to the SI second
- The short-term frequency reference is a Rb clock
- This is quoted long-term by GPS
- An auxiliary 125 MHz Er fiber comb locks the output of the 1064 nm CW laser

Enabling Tool for NIR Precision RVs
- HPF yields state-of-the-art long-baseline stellar RVs at NIR wavelengths

References

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Image of the LFC spectrum with the HPF’s H2RG Detector

Multiple new publications, and more results coming......