**INTRODUCTION**

Searches for extrasolar planets using the periodic Doppler shift of stellar spectral lines have recently achieved a precision of 60 cm s\(^{-1}\) (ref. 1). To find a 1-Earth-mass planet in an Earth-like orbit, a precision of ~5 cm s\(^{-1}\) is necessary. The combination of a laser frequency comb with a Fabry–Pérot filtering cavity has been suggested as a promising approach to achieve such Doppler shift resolution via improved spectrograph wavelength calibration\(^2\). Here we report the fabrication of such a filtered laser comb with up to 40-GHz (~1-Å) line spacing, generated from a 1-GHz repetition-rate source, without compromising long-term stability, reproducibility or spectral resolution. This wide-line-spacing comb (astro-comb) is well matched to the resolving power of high-resolution astrophysical spectrographs. The astro-comb should allow a precision as high as 1 cm s\(^{-1}\) in astronomical radial velocity measurements.

**LIMITATIONS OF OTHER CALIBRATORS**

- Iodine absorption cells
  - attenuate star light
  - only cover 5,000-6,200 Å band
  - have non-uniform spectrum
- Thorium-Argon discharge lamps
  - deteriorate over time
  - have low intensity
  - have non-uniform spectrum
  - have unstable bright Ar lines
  - only calibration source in the red to IR band
  - no identical lamps

**ASTRO-COMB : IDEAL WAVELENGTH CALIBRATOR**

- Systematic control
  - long-term stability
  - reproducibility
  - frequency defined by UTC (Coordinated Universal Time) frequency standard
- Wavelength calibration ability
  - uniform density and intensity of the calibration lines
  - calibration line spacing matches resolving power of astrophysical spectrographs
  - potentially able to provide lines covering entire spectral range of interest
  - allows comparison of data from all observatories over years
- Only requires 1-MHz stability on the FP cavity while the astro-comb lines are stable to 10 kHz.

**1-GHz SOURCE COMB**

- Frequency of >10\(^5\) emission lines uniquely determined by 2 parameters
  - \(f_{\text{comb}} = m f_{\text{rep}}\)
- Octavius (Menlosystems)
  - octave spanning (600 nm – 1,200 nm)
  - Ti:Sa oscillator
  - 6 fs mode lock pulse laser
  - double chirped mirror design
- Stabilization
  - \(-2\)f\(^{-1}\) self-referencing
  - >30 dB f\(_{\text{rep}}\) beat (100-kHz BW)
  - 1-GHz f\(_{\text{rep}}\)
  - \(f_{\text{comb}}\) and \(f_{\text{rep}}\) referenced to GPS
  - Compact and robust housing provides optimal temperature and environmentally stabilization.

**CALIBRATION LINES AT ~8,500 Å**

- Enables 1-cm s\(^{-1}\) sensitivity in radial velocity detection
  - Search for exo-Earths
  - A direct measurement of the expansion of the universe in <10 years. (Sandage-Loeb test) – the study of dark energy
  - Search for dark matter in globular clusters
  - Search for temporal variation of fundamental physical “constants”
  - Study of stellar seismology
  - Will be deployed to calibrate Hectochelle spectrograph at the MMT as first demonstration.
  - Will be deployed at HARPS-NEF in 2009.

**REFERENCE:**