Aluminum Nitride Microchip Frequency Comb to Advance Exoplanet Discovery
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The EXtreme PREcision Spectrograph

Aluminum Nitride (AlN)

Optically nonlinear material being developed into microchip waveguides by the Yale Nanodevices Lab

Extremely suitable for frequency comb generation:
- Widest bandgap among all semiconductors
- Known for UV (below 450 nm) transparency
- Strong second-order optical nonlinearity, enabling frequency doubling and self-referencing
- Can be easily fabricated into compact chips

AIN Microring Resonator

Tunable CW Laser 1545-1560 nm 3 mW
Erbium-Doped Fiber Amplifier 1.5 W
Polarization Controller

TM Mode

- 3.2-3.8 µm waveguide width
- 40-50 µm microring radius
- 700-900 nm gap between waveguide and microring
- Produces ~500 GHz FSR frequency comb

AIN Microring

Microcomb Setup at the Discovery Channel Telescope

Infrared Comb

Second and third harmonic generation produce visible comb lines

Point Spread Function Modelling

We use data from the microring resonator to measure the point spread function of EXPRES and more precisely extract high resolution spectra.

EOM + AlN Waveguide Astro-comb

As a supplement (or alternative) to the Menlo AstroComb, we are developing an astro-comb based on a straight AlN waveguide. To be suitable for precision radial velocity measurement on EXPRES, this comb must:
1. Have a night-to-night precision of 10⁻¹¹
2. Have an FSR of >10 GHz and <30 GHz
3. Cover a significant portion of EXPRES's spectral range (380-800 nm)

Therefore, we combine a 16 GHz Infrared Electro-Optic Modulation (EOM) comb with the AlN waveguide. This gives us the tunability and stability of EOM technology along with the spectral broadening of the AlN.

EOM Comb

The laser is finely tunable via temp control and the radio frequency (RF) synthesizer is lockable to GPS

CW Laser 1550 nm 16 GHz RF Synthesizer

2x Phase Modulators
Amplitude Modulator

HNLF
SMF
EDFA

Spectral Broadening (work in progress)
After amplification and dispersion compensation through both single-mode fiber (SMF) and highly nonlinear fiber (HNLF), supercontinuum generation can be induced in the AlN waveguide

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