TUNABLE MID-IR FREQUENCY COMB FOR MOLECULAR SPECTROSCOPY

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A mid-infrared frequency comb tunable from 2.7μm to 4.7μm (3700cm^{-1} to 2100cm^{-1}) has been produced using a fiber laser and difference frequency generation in a periodically poled $LiNbO_3$ (PPLN) crystal. An amplified Yb-doped femtosecond fiber laser is centered at a wavelength of 1.04μm, with 100MHz repetition frequency and up to 2.5W average output power. Part of this laser power is focused into a photonic crystal fiber to produce a Raman-shifted soliton tunable over a range from 1.3μm to 1.7μm. The remaining 1.04μm light is combined with the wavelength-shifted spectrum and focused into the PPLN to produce a difference frequency comb spanning $\sim$200nm (180cm^{-1}) in the mid-infrared. By adjusting the Raman-shifted soliton and PPLN, the center wavelength of the MIR comb is tuned over the output range, with a maximum power of up to 35mW near 3.3μm.

Sum frequency generation between the MIR comb and a CW 1064nm laser shifts the frequency comb spectrum back into the near-infrared around 800nm. This sum frequency step is taken in order to utilize detectors and techniques that are currently more accessible in the visible and near-infrared ranges. Preliminary results have shown MIR methane absorption lines observable in the upconverted 800nm spectrum on a commercial optical spectrum analyzer. We intend to measure this upconverted spectrum at high resolution using a two-dimensional dispersion and imaging technique[a] to take advantage of the precisely known frequency characteristics of each individual MIR comb line.

[a] L. Hollberg, V. Mbele, and S. A. Diddams, *Nature* **445**, 627 (2007).