DIRECT FREQUENCY COMB SPECTROSCOPY WITH AN 8.5 μm OPO

KANA IWAKUNI, *JILA, National Institute of Standards and Technology and Univ. of Colorado Department of Physics, University of Colorado, Boulder, CO, USA*; THINH QUOC BUI, JUSTIN NIEDERMEYER, *JILA, National Institute of Standards and Technology and Univ. of Colorado Department of Physics, University of Colorado, Boulder, Boulder, CO, USA*; BRYAN CHANGALA, MARISSA L. WEICHMAN, *JILA, National Institute of Standards and Technology and Univ. of Colorado Department of Physics, University of Colorado, Boulder, CO, USA*; TAKASHI SUKEGAWA, *Optical Products Operations, CANON, Utsunomiya, Japan*; JUN YE, *JILA, National Institute of Standards and Technology and Univ. of Colorado Department of Physics, University of Colorado, Boulder, CO, USA*.

Direct frequency comb spectroscopy provides high-resolution spectra over a broad bandwidth. Its high sensitivity has also enabled real time detection for gas sensing and chemical reaction kinetics[a]. Previous work has focused in the near-infrared or mid-infrared (1 - 5 μm), but there are stronger absorption lines in the $>$5 μm wavelength region. In addition, at longer wavelengths spectral congestion is significantly reduced owing to the decreasing strength of intramolecular vibrational energy redistribution. We have developed a new frequency comb spectrometer within 8.5 – 9.5 μm. The light source is a synchronously pumped optical parametric oscillator (OPO)-based frequency comb using a 2 μm Tm fiber comb as the pump wave. In direct frequency comb spectroscopy, several options exist to read out the spectrum, such as FTIR or highly dispersive optics like a virtually-imaged phased array (VIPA)[b]. In this work, an immersion grating and a reflective grating are used as cross dispersers and each comb mode is mapped to a 2D image in the same way as a VIPA spectrometer. Immersion gratings have been applied in astronomy and have resolving power ($\lambda/\Delta\lambda$) exceeding 10^5, which is suitable for high-resolution real-time comb spectroscopy. We report work done with this new spectrometer.

[a] T. Q. Bui, B. J. Bjork, P. B. Changala, T. L. Nguyen, J. F. Stanton, M. Okumura, J. Ye, Direct measurements of DOCO isomers in the kinetics of OD+CO, Science Advances, 4, eaao4777 (2018)

[b] L. Nugent-Glandorf, T. Neely, F. Adler, A. J. Fleisher, K. C. Cossel, B. Bjork, T. Dinneen, J. Ye, S. A. Diddams, Mid-infrared virtually imaged phased array spectrometer for rapid and broadband trace gas detection, Opt. Lett. 37, 3285 (2012)