BROADBAND MID-INFRARED COMB-RESOLVED FOURIER TRANSFORM SPECTROSCOPY

ANDREW MILLS, KEVIN LEE, CHRISTIAN MOHR, JIE JIANG, MARTIN FERMANN, Laser Research, IMRA AMERICA, Inc, Ann Arbor, MI, USA; PIOTR MASŁOWSKI, Institute of Physics, Faculty of Physics, Astronomy and Informatics, Nicolaus Copernicus University, Torun, Poland.

We report on a comb-resolved, broadband, direct-comb spectroscopy system in the mid-IR and its application to the detection of trace gases and molecular line shape analysis. By coupling an optical parametric oscillator (OPO), a 100 m multipass cell, and a high-resolution Fourier transform spectrometer (FTS), sensitive, comb-resolved broadband spectroscopy of dilute gases is possible. The OPO has radiation output at 3.1-3.7 and 4.5-5.5 μm. The laser repetition rate is scanned to arbitrary values with 1 Hz accuracy around 417 MHz. The comb-resolved spectrum is produced with an absolute frequency axis depending only on the RF reference (in this case a GPS disciplined oscillator), stable to 1 part in 10^9. The minimum detectable absorption is 1.6x10^-6 cm^{-1}Hz^{-1/2}.

The operating range of the experimental setup enables access to strong fundamental transitions of numerous molecular species for applications based on trace gas detection such as environmental monitoring, industrial gas calibration or medical application of human breath analysis. In addition to these capabilities, we show the application for careful line shape analysis of argon-broadened CO band spectra around 4.7 μm. Fits of the obtained spectra clearly illustrate the discrepancy between the measured spectra and the Voigt profile (VP), indicating the need to include effects such as Dicke narrowing and the speed-dependence of the collisional width and shift in the line shape model, as was shown in previous cw-laser studies.\(^a\) In contrast to cw-laser based experiments, in this case the entire spectrum (≈ 250 cm^{-1}) covering the whole P and R branches can be measured in 16 s with 417 MHz resolution, decreasing the acquisition time by orders of magnitude. The parallel acquisition allows collection of multiple lines simultaneously, removing the correlation of possible temperature and pressure drifts. While cw-systems are capable of measuring spectra with higher precision,\(^b\) this demonstration opens the door for fast, massively parallel line shape parameters retrieval combined with analysis reaching beyond the VP and with absolute frequency calibration delivered by frequency combs.