

A WIDELY TUNABLE HIGH-POWER CONTINUOUS-WAVE OPTICAL PARAMETRIC OSCILLATOR (CW-OPO) SYSTEM FOR MID-INFRARED SPECTROSCOPY AND FREQUENCY METROLOGY

HAMZEH TELFAH, *Department of Chemistry, University of Louisville, Louisville, KY, USA*; S M SHAH RIYADH, *Department of physics and astronomy, University Of Louisville, Louisville, KY, USA*; JINJUN LIU, *Department of Chemistry, University of Louisville, Louisville, KY, USA*; DAVID B. FOOTE, WALTER HURLBUT, MATTHEW J. CICH, *TOPTICA Photonics, Inc, Farmington, NY, USA*; ULRICH EISMANN, *TOPTICA Photonics, Inc, Munich, Bavaria, Germany*; ADAM HEINIGER, CHRIS HAIMBERGER, *TOPTICA Photonics, Inc, Farmington, NY, USA*.

Continuous-wave optical parametric oscillators (CW-OPOs) can offer broad tuning with high resolution and high power in the mid-infrared (MIR) and have many important potential applications in precision spectroscopy. The widely tunable cw-OPO system (TOPO) developed by TOPTICA Photonics is capable of covering the wavelength range of 1.45-4.0 μm (with a degenerate gap between 2.07-2.19 μm) without optics or nonlinear optical crystal exchanges. A computer-controlled automation system has been developed to achieve a broad (up to 300 GHz) mode-hop-free (MHF) tuning range of the idler wavelengths and high output power (>1 W). Its narrow linewidth is demonstrated in the direct absorption measurements and the Doppler-free saturated absorption spectroscopy of atmospheric molecules. Furthermore, a much-improved frequency accuracy has been achieved by referencing the OPO to a frequency comb and creating a phase-coherent bridge between the NIR and MIR spectral ranges. Frequency noise from both the OPO cavity and the seed laser is eliminated by (i) beating the OPO signal output against the fundamental of the frequency comb and (ii) beating the seed laser against a 1064 nm comb extension. The TOPO system has been incorporated in the MIR cavity ring-down (CRD) system and the CRD-based two-photon spectroscopy system in our lab.