FREQUENCY COMB PHASE-LOCKED CAVITY RING-DOWN SPECTROSCOPY

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Cavity ring-down spectroscopy (CRDS) is a widely used tool for trace gas sensing and molecular lineshape studies which involves the use of high-finesse optical cavities to provide long effective pathlengths and high spectral resolution. Here, we present a novel implementation of CRDS where the probe laser is phase locked to a self-referenced octave-spanning optical frequency comb referenced to a Cs clock, and in which the optical cavity is subsequently locked to the stabilized probe laser beam. This approach provides an absolute frequency axis and increased coupling efficiency. It allows for frequency steps of arbitrary size to be made, which can be as small as the order of the linewidth of the stabilized probe laser. The optical cavity follows tunable optical sidebands of the probe laser generated with an electro-optic modulator. This allows for up to 40 GHz of tuning in a single spectral scan, with spectral intervals as small as 200 kHz. The optical cavity is locked to the stabilized probe laser by inducing a slight axial dither (20 kHz modulation amplitude in the optical domain) on a piezo-driven cavity mirror. The resulting transmitted probe beam generates an error signal which can be used to center the piezo offset voltage with a low-bandwidth lock. The absolute frequency uncertainty of the locked probe laser is 1 kHz on a timescale of several hours, which is well in excess of the measurement time. We present a variety of measurements that highlight the power of this technique. Line positions and pressure shifting coefficients can be determined with nearly an order of magnitude smaller uncertainty by comparison to those obtained using conventional FS-CRDS measurements. We apply this technique to several H_2O and CO_2 transitions in the 1.6 μm wavelength region and report standard uncertainties in line positions as low as 20 kHz.