Cavity-Enhanced Optical Frequency Comb Spectroscopy of High-Temperature Water in a Flame

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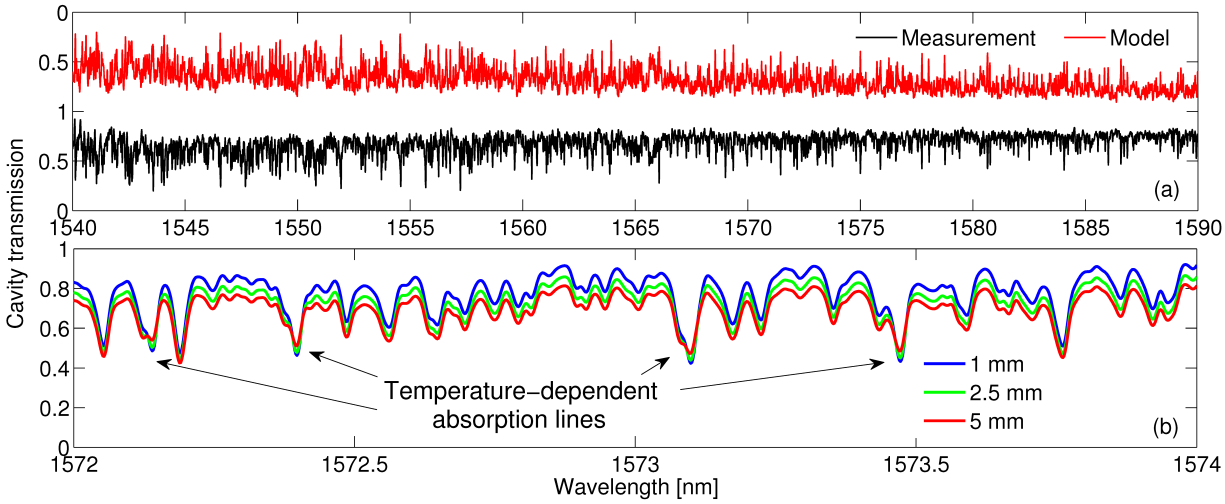
Laser-based absorption techniques are often used as a non-intrusive tool for combustion diagnostics to determine parameters such as reactant/product concentrations and temperature. However, the limited tunability of continuous wave lasers imposes restrictions on the number of detected species and the choice of absorption line pairs for thermometry. We present, for the first time, cavity-enhanced optical frequency comb spectroscopy (CE-OFCS) in a combustion environment by detecting high-temperature water spectra in a premixed methane/air flat flame[1]. The technique combines broad bandwidth with high spectral resolution and opens up the possibility for simultaneous multispecies detection and improved flame thermometry. Our comb source is an Er:fiber femtosecond laser locked to an open-to-air cavity with a finesse of ~1100. The burner[2] is placed below the intracavity beam on a vertical translation stage, which allows adjustment of the beam height above the burner (HAB). The light transmitted through the cavity is analyzed with a fast-scanning Fourier transform spectrometer equipped with an auto-balancing detector. The system allows acquiring high-temperature spectra with a bandwidth of 50 nm and resolution of 1 GHz in 0.4 s, with absorption sensitivity of 4×10^{-9} cm^{-1} $Hz^{-1/2}$ per spectral element. Figure (a) shows a normalized high-temperature H2O spectrum measured at HAB of 5 mm (black) compared to a model based on parameters from the HITEMP database for temperature of 2000 K and water concentration of 18% (red, inverted for clarity). Figure (b) shows a zoom of H_2O spectra around 1573 nm taken at three different HABs, revealing four groups of absorption lines with strong temperature dependence. We will present recent improvements to the stability of the system and the modeling of absorption spectra.



References
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[2] G. Hartung, et al., Meas. Sci. Technol. 17, 2485 (2006)