Theory and Experimental Characterization of Lead Salt Diode Laser Frequency Modulation Spectroscopy

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It has long been recognized that modulation techniques applied to tunable diode lasers improve sensitivity to the detection of weak molecular absorption lines. In this paper we will present the results of an extensive set of measurements designed to evaluate the efficacy of combining two levels of modulation, one at a relatively high frequency and usually termed frequency modulation spectroscopy and the second at a much lower frequency and usually termed wavelength modulation spectroscopy. The first modulation boosts the signal output of the photodetector to a sufficiently high frequency that laser technical noise has dropped below detector induced noise and thus allows maximum detection sensitivity. The second modulation adds the flexibility to adjust the modulation depth to discriminate against periodic interference fringes induced by windows in the laser beam path and which frequently limits the sensitivity boost afforded by the high frequency modulation.
In this paper we will present results of a complete modeling analysis of the dual modulation process as well as experimental measurements made on a tunable lead salt laser. We also discuss the applicability of these techniques to the new types of mid-infrared tunable diode lasers under development at various laboratories around the world.