FREQUENCY-AGILE DIFFERENTIAL CAVITY RING-DOWN SPECTROSCOPY

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The ultimate precision of highly sensitive cavity-enhanced spectroscopic measurements is often limited by interferences (etalons) caused by weak coupled-cavity effects. Differential measurements of ring-down decay constants have previously been demonstrated to largely cancel these effects, but the measurement acquisition rates were relatively low [1,2]. We have previously demonstrated the use of frequency agile rapid scanning cavity ring-down spectroscopy (FARS-CRDS) for acquisition of absorption spectra [3]. Here, the method of rapidly scanned, frequency-agile differential cavity ring-down spectroscopy (FADS-CRDS) is presented for reducing the effect of these interferences and other shot-to-shot statistical variations in measured decay times. To this end, an electro-optic phase modulator (EOM) with a bandwidth of 20 GHz is driven by a microwave source, generating pairs of sidebands on the probe laser. The optical resonator acts as a highly selective optical filter to all laser frequencies except for one tunable sideband. This sideband may be stepped arbitrarily from mode-to-mode of the ring-down cavity, at a rate limited only by the cavity buildup/decay time. The ability to probe any cavity mode across the EOM bandwidth enables a variety of methods for generating differential spectra. The differential mode spacing may be changed, and the effect of this method on suppressing the various coupled-cavity interactions present in the system is discussed. Alternatively, each mode may also be differentially referenced to a single point, providing immunity to temporal variations in the base losses of the cavity while allowing for conventional spectral fitting approaches. Differential measurements of absorption are acquired at 3.3 kHz and a minimum detectable absorption coefficient of 5 $\times 10^{-12}$ cm^{-1} in 1 s averaging time is achieved.

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