Assessing the precision and accuracy of cavity ring-down spectroscopy measurements

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Three attributes of CRDS: immunity to intensity fluctuations, spectra that comprise data pairs based on observations of laser frequency and cavity decay time, and long effective pathlengths, make it the method of choice in many applications requiring spectrum fidelity, high accuracy and high sensitivity. In this context, I will discuss how the precision and accuracy of ring-down spectra can be optimized and quantified. This point of view requires that one consider numerous real-world effects which lead to measured decay signals and line profiles that deviate from those predicted using overly simplistic models. I will introduce basic concepts of relative precision in decay signals, Allan deviation analysis, technical- and shot-noise-limited statistics, as well as systematic effects linked to transverse-mode-beating, finite extinction ratio, detector nonlinearity, coupled-cavities (etalons), mirror birefringence, polarization-dependent losses and optical saturation. I will also address how uncertainty in the *x*-axis (frequency) can determined and minimized using active stabilization methods. These concepts will be illustrated using a variety of cavity ring-down experiments.