TRACE DETECTION WITH CAVITY RINGDOWN AND DFB DIODE LASERS.

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We recently realized a scheme of cavity ring down spectroscopy for the efficient repetitive injection of the cavity with a narrow line CW laser (CW-CRDS). This is based on the buildup of intracavity field occurring when a cavity mode passes through resonance with the laser line. The efficiency of injection is limited by two factors: The width of the laser line with respect to the cavity mode, and the speed of the passage through resonance. In fact, CW-CRDS works well with lasers having a sufficiently large power to linewidth ratio, such as single mode ring dye lasers (100mW/1MHz) and external cavity diode lasers (10mW/100kHz).

For the realization of compact trace gas detection devices, it is preferable to use DFB or Fabry–Perot diode lasers. These typically possess a linewidth in excess of 10 MHz and a relatively low power (a few mW), giving weak intracavity buildup, followed by a weak ringdown signal close or below the NEP level of photodiodes. Unfortunately, photodiodes are the only detectors available in the IR, where trace gas detection is more effective due to the strength of molecular transition.

We present here a scheme of CRDS based on optical feedback, already exploited in atomic physics to lock even broad–line Fabry–Perot diode lasers to a cavity. Proper optical feedback from the cavity induces a collapse of the laser line down to the cavity mode width (often a few kHz) together with a very efficient intracavity buildup. We devised a simple scheme, insensitive to mechanical vibrations, that allows tuning the laser wavelength regularly with a repetition rate of buildup–ringdown events of a few kHz. We achieve a detection limit on the order of 10^{-8} to 10^{-9}/cm$\sqrt{Hz}$, very far from the shot noise limit: The probable origin of the excess noise will be outlined. Even if 10 to 100 times less sensitive, this scheme is much simpler and more robust than the one used with narrow line lasers, and therefore more adapted to trace detection applications. Using a commercial DFB diode laser at 1.65 μm, we built a portable trace detector allowing direct monitoring of atmospheric methane ($\sim$2ppm) with S/N in excess of 10 in 1s integration time.