INTRACAVITY ABSORPTION VERSUS RING–DOWN, RELATIVE PERFORMANCE

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Cavity ring–down spectroscopy (CRDS) and intra–cavity laser absorption spectroscopy (ICLAS) are the direct absorption methods most performant in terms of sensitivity ($\sim 10^{-10}$ cm^{-1}) and spectral capabilities.
In CRDS, the losses of an optical cavity are monitored by observing the exponential decay (ring–down) of light injected into the cavity by a narrow–band laser pulse. The sample is placed inside the cavity and its absorption spectrum is given by the variations in the ring–down rate as the laser is tuned. The spectral resolution is practically limited by the laser, while the spectral extent that can be covered in a single experiment is limited by the working range of the mirrors composing the optical cavity, which is typically more than 50 nm in the visible. In CRDS the broad–band losses of the cavity should be less than about 1% per pass, a fact that constitutes a serious limitation in many practical applications.
In ICLAS, the sample is placed directly into the cavity of a laser operating broad–band. Then, broad–band cavity losses are compensated by the laser gain, so that samples having broad–band losses of more than 1% can be studied without the degradation of the sensitivity. Here, the sample absorption lines are detected as dips in the wide laser emission spectrum. They increase according to the Lambert–Beer law over a pathlength equal to $c\,t_g$, where t_g is the time since when the laser is started (generation time) and c is the speed of light.
A major limitation of ICLAS is that one can detect only spectral features sufficiently narrower than the laser emission profile, which is typically less than 10 nm wide at $t_g \sim 100$ μs ($c\,t_g \sim 30$ km). Things become gradually worse when pushing to higher sensitivity, since the laser emission spectrum narrows as the square root of t_g. On the other hand, since the emission spectrum is recorded as a whole, this technique has the definite advantage of an intrinsic multiplexing capability.
In conclusion, CRDS and ICLAS are somewhat complementary methods with respect to the fields of possible practical application. Current perspectives of technical improvement, partly based on the availability of new solid–state and semiconductor lasers, lead us to believe that in the near future it will be possible to build very compact and portable devices based on CRDS and ICLAS. These devices would cover the spectral range from the near infrared to the near UV with a sensitivity which theoretically could be as high as 10^{-12} cm^{-1} for both techniques.