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Laser-induced plasmas in ambient air for incoherent broadband cavity enhanced absorption spectroscopy

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The emission from a laser-induced plasma in ambient air, generated by a short pulse laser, was utilised as a pulsed incoherent broadband light source in the centre of a high finesse optical cavity for incoherent broadband cavity enhanced absorption spectroscopy (IBBCEAS). The time-dependent spectra of the light leaking from the cavity were compared with the laser-induced plasma emission and it was found that the light was sustained in the cavity despite the initial large optical loss presented by the plasma itself. IBBCEAS measurements of trace gas species in ambient air using this approach have been demonstrated [1].
The laser-generated plasma initially constitutes a substantial loss in the cavity, which decreases as the plasma expands and cools down. Three time scales can be identified for the time-dependent development of the loss. (i) Immediately after plasma generation the plasma presents a significant loss, which is dominated by its black-body properties. (ii) After the initial cooling period of the plasma, on a time scale of $\sim$1 μs, the plasma medium still constitutes a hot (non-linear) medium, leading to the significant distortion of light propagating in the cavity. (iii) When recombination emission of the colder plasma has ceased, modes can establish in the transparent cavity and the imaging efficiency of the light leaking from the cavity is maximised (the corresponding light can be used for absorption measurements). The influence of the loss mechanisms and to what extent they affect the sustainment of light within the cavity is dependent on the geometry of the optical cavity.
While this technique is typically employed for intensity-dependent CEAS measurements, if desired, the pulsed nature of the laser-induced plasma facilitates an effective calibration of the mirror reflectivity curve based on the wavelength-dependent ring-down time of the light sustained within the cavity, in the absence of an absorbing sample. This in situ reflectivity calibration provides a simple means of determining absolute absorption coefficients with this approach. In principle, determination of absolute absorption coefficients via broadband cavity ring-down spectroscopy (CRDS) is also possible.
The most relevant aspects, including the advantages and drawbacks, of this method will be discussed in this presentation.

References:
[1] A.A.Ruth, S. Dixneuf, and J. Orphal, Laser-induced plasmas in ambient air for incoherent broadband cavity-enhanced absorption spectroscopy, Optics Express, Vol. 23(5), pp. 6092-6101 (2015).