Reducing stray light with spatial modulation and imaging spectroscopy

Combustion, Imaging Spectroscopy, Raman Spectroscopy

Reducing stray light is one of the major challenges of combustion experiments probed with laser beams such as Raman spectroscopy. Bright, constant flame background can be effectively removed using temporal filters by using a combination of ultrafast laser pulses and gated ICCD or emICCD cameras that can open an electronic shutter for ps to ns time scales exactly when the signal arrives at the detector. However, stray light from other sources still interferes with the usable signal in particular for low frequency measurements.

Researchers around Andreas Ehn from Lund University implemented a creative approach for reducing stray light based on a spatial lock-in technique called periodic shadowing. While the concept for this measurement technique was shown in previously, the researchers from Lund describe in their recent paper that they "increase its feasibility, strength, and robustness" by implementing the method using a fiber probe.

The experiment uses a bundle of 19 fibers that are arranged in a densely packed, circular pattern for signal collection side of the fiber, but in a linear pattern on the spectrograph side. Each signal carrying fiber is followed by a dark fiber to create proper spacing of the fibers along the entrance slit of an Isoplane-SCT 320 spectrograph. The fiber pattern approximates a square wave function. At the exit of the spectrograph a spectral image is collected using a fast-gated PI-MAX4, ICCD camera. The Isoplane spectrograph is an aberration corrected system that maintains high signal accuracy without distortions even across a large sensor area which helps in the reconstruction of the signal from the collected images. The periodic structure of the signal is computationally analyzed on a by column basis by Fourier transform, multiplication with reference signals and band-pass filters which results in reduction of the DC like offsets like the stray light component on the detector.

The researchers further show the application of this technique to Raman spectroscopy of gases and premixed flames. They not only show that the reconstructed signal gives quantitative correct measures of species mole fraction and the temperature in the flame, but also that the stray light is suppressed by almost 2 orders of magnitude (factor of 80). The conclude that their "concept is highly valuable for accurate spectroscopic measurements in experiments with limited optical access".

Featured Paper/ Publication: Fiber-based stray light suppression in spectroscopy using periodic shadowing

Reference Lab: Andreas Ehn

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