MULTISPECIES SENSING WITH A SINGLE LASER SOURCE IN HCCI COMBUSTION

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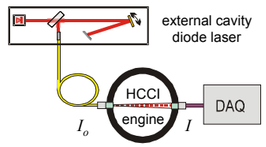
1. Hydrogen Peroxide and Water (H_2O_2 and H_2O)

Goal

- Absorption spectroscopy in an n-heptane fueled optical HCCI engine
- Measure H_2O_2 mole fraction, H_2O mole fraction, and gas temperature

Experimental approach

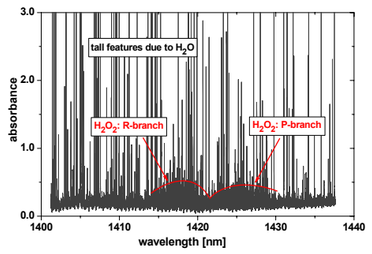
- Scanned near-infrared (1410 to 1490 nm) laser, ~0.3 nm resolution, 8 kHz spectral rate



Beer Lambert: $absorbance = -ln(I/Io) = k_\nu \cdot L$

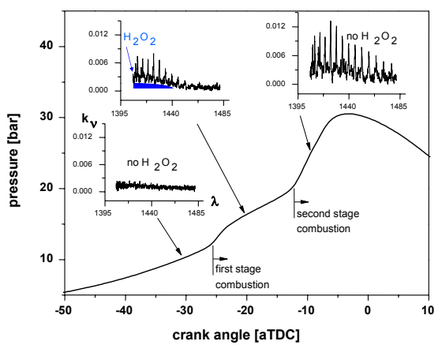
Bench test

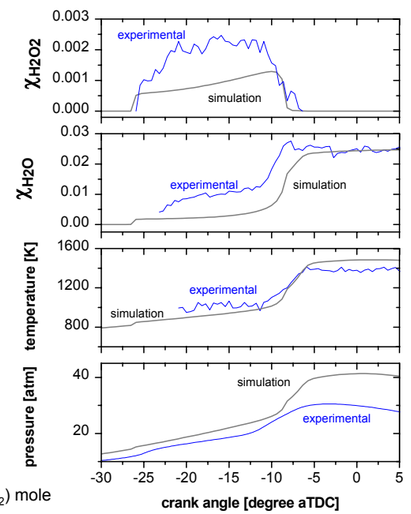
- Vacuum cell containing H_2O_2 & H_2O mixture
- H_2O_2 lines distinguishable amid H_2O lines



Results

- Spectra and resultant thermodynamic properties





Conclusions

- Measured combustion product (H_2O) and intermediate (H_2O_2) mole fractions and temperature
- Fair model agreement
- Absorption spectroscopy measurements for overlapping broad and narrow absorber are a challenge to deconvolve

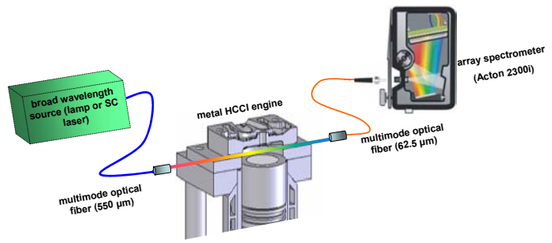
2. Isooctane and Water (C_8H_{18} and H_2O)

Goal

- Absorption spectroscopy in an isooctane fueled metal HCCI engine
- Measure C_8H_{18} density, H_2O density, and gas temperature

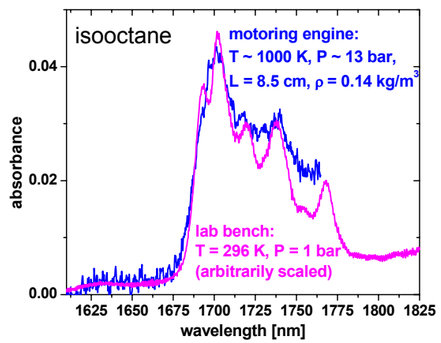
Experimental approach

- Broad wavelength near-infrared source (~100's nm)
- Tested with both a quartz tungsten halogen (QTH) lamp and supercontinuum (SC) laser (work shown here is from QTH source)
- Light collected by an extended InGaAs array spectrometer (1x1024 pixels), ~ 0.75 nm resolution, 1 kHz spectral rate



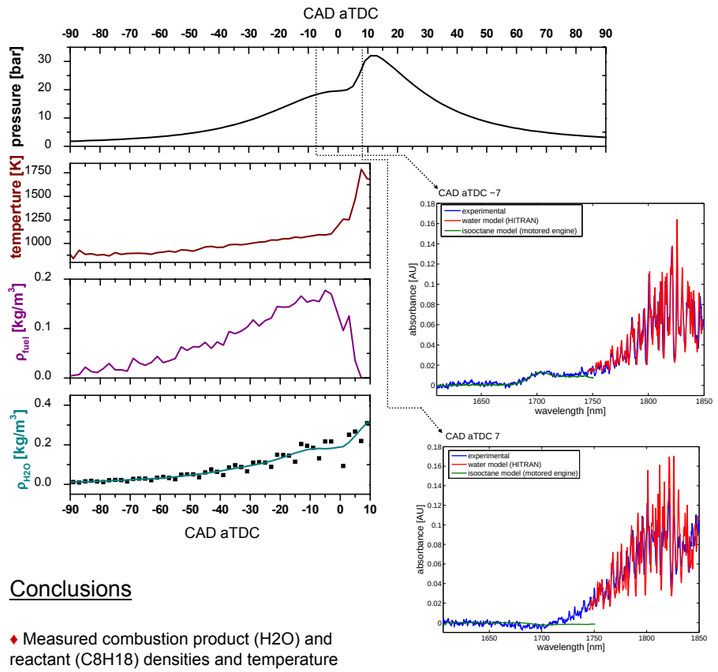
Bench test

- Measured C_8H_{18} vapor absorption in test cell at lab conditions and in motored engine
- At increased temperate and pressure, finer isooctane absorption features less distinguishable



Results

- Spectra and resultant thermodynamic properties



Conclusions

- Measured combustion product (H2O) and reactant (C8H18) densities and temperature
- Absorption spectra of water and fuel in the 1600 – 1850 nm range separable

Comparing experiment 1 & 2

- Scanned laser (1) offered high resolution (~0.3 nm) over a moderate spectral range (80 nm)
- Broad source & spectrometer (2) offered acceptable resolution (~0.75 nm) over an expanded spectral range (250 nm), while investigating further into the infrared and resulted in a reliable baseline for tracking broad absorbers