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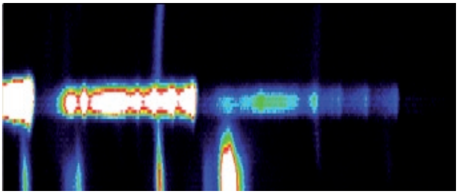
Multi-scalar Laser Diagnostics in Combustion of Fuel Containing Complex Hydrocarbons



Raman line (6mm) spectra of a laminar jet (horizontal: spectral axis, vertical: spatial axis. Raman signals from O_2, CO_2, N_2, Ethane, H_2O, H_2, and on the horizontal center line strong broadband interference from C_2 fluorescence)

Motivation

For fundamental understanding of turbulent reacting flows and the validation of numerical simulations a detailed knowledge of the velocity field and the thermo kinetic state is indispensable. Generic flames represent effects or geometries of technical combustion devices. Gained insights could serve to design and optimize future combustors. To guarantee fuel flexibility in future energy conversion processes, the understanding of combustion with complex hydrocarbons is inevitable.

Methods

Spectroscopic techniques are very efficient, non intrusive methods to provide various data about reacting and non reacting flows. Laser spectroscopy is a sensitive state-of-the-art technique featuring the possibility of high spatial and temporal resolution measurements.

- Spontaneous Raman/Rayleigh line scattering (1D) is used to obtain at once all major species concentrations and the temperature on single shot basis. For this a high power laser pulse is focused into the probe volume. The scattered light is collected using low f number imaging optics, dispersed by a transmission spectrometer, and detected by sensitive CCD cameras.
- Laser induced fluorescence (LIF) spectroscopy is used to detect resonantly minor species such as OH, CH, or CO. Combined with simultaneous Raman/Rayleigh scattering it can be extended to a quantitative technique. The presence of these radicals and intermediate species gives information about the chemical reaction state and the position of the flame front.

Field of Interest

More complex hydrocarbons emit more broadband spectra in spectroscopic diagnostic techniques and are more difficult to separate from the other species in the Raman spectra. To determine the thermo kinetic states experimentally also in these more challenging cases the existing Raman/Rayleigh diagnostic systems need to be extended. As a fist step in the context of understanding turbulence-chemistry interaction with more complex hydrocarbons a laminar stationary dimethyl ether, ethane, propane, and ethylene flame configuration will be examined.

$$CH_4 + 2O_2 \leftrightarrow 2H_2O + CO_2$$
$$2C_2H_6 + 7O_2 \leftrightarrow 6H_2O + 4CO_2$$
$$C_3H_8 + 5O_2 \leftrightarrow 4H_2O + 3CO_2$$
$$2C_4H_{10} + 13O_2 \leftrightarrow 10H_2O + 8CO_2$$
$$C5H_{12} + 8O_2 \leftrightarrow 6H_2O + 5CO_2$$
$$C2H_4 + 3O_2 \leftrightarrow 2H_2O + 2CO_2$$

Redox reactions of methane, ethane, propane, butane, pentane and ethylene.