

IN APPLICATION

Laser Imaging for Flame Composition and Temperature Measurements

FlameMaster Raman Imaging System

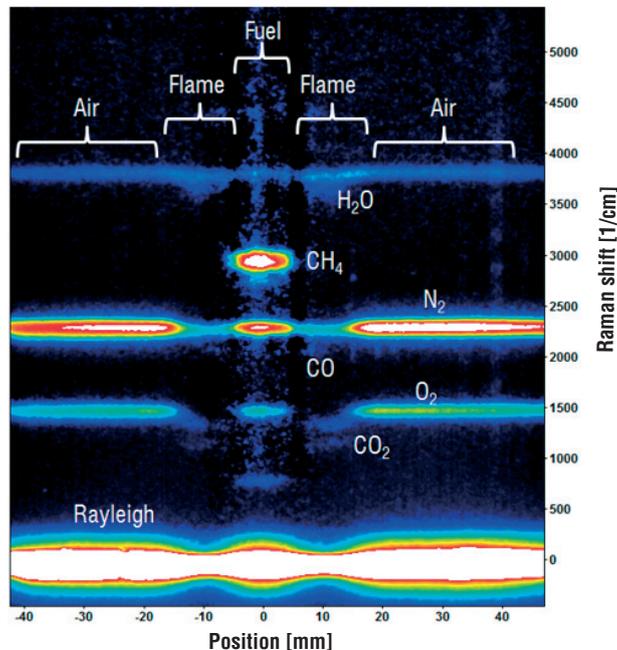
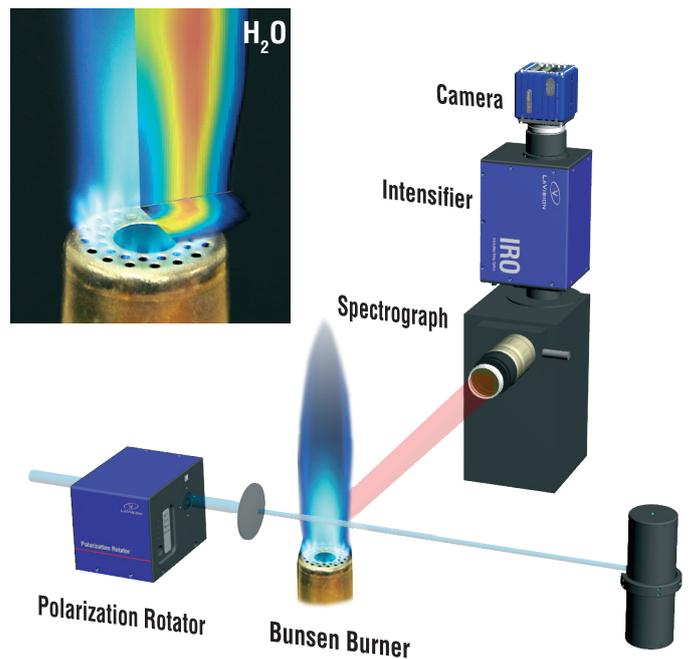
Introduction

The Raman technique is widely used to determine the composition of solids and liquid mixtures. LaVision provides this approach for in-situ gas and flame measurements. Raman imaging measures simultaneously the concentration profiles of all majority species together with the gas temperature. Typical molecules detected are hydrocarbon fuels, O₂, H₂, N₂, CO₂, CO and H₂O. Raman imaging is most suitable in clean flames, reactive flows and gas mixing processes.

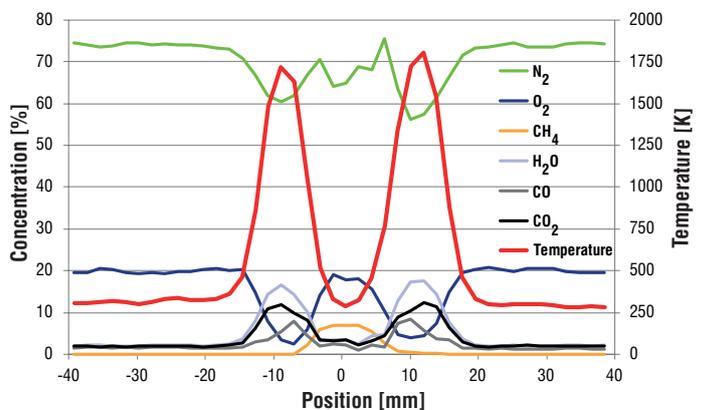
Raman Technique

Compared to the elastic Rayleigh scattering process spontaneous Raman scattering is inelastic, i. e. its spectral response is shifted from the laser line. This Raman shift is characteristic for each kind of molecule. Raman as well as Rayleigh are instantaneous scattering processes and, therefore, are independent of collisional quenching effects.

Raman imaging setup



However, due to the weak nature of the Raman signals only 1D time averaged measurements of all majority species and gas temperature are possible with standard lasers.



1D Raman imaging of gas composition and temperature in a propane-fueled Bunsen burner: spectrally separated Raman lines and corresponding concentration (temperature) profiles.

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Laser Imaging for Flame Composition and Temperature Measurements

FlameMaster Raman Imaging System

FlameMaster Raman imaging system

LaVision's multifunctional **FlameMaster** laser imaging system upgraded with an imaging spectrograph measures simultaneously all major species concentration together with flame temperature along a line focus (1D). The line focus of the laser beam probing a flame segment is imaged onto the entrance slit of the spectrograph, which spectrally separates the Raman signals of the different flame species. An intensified camera serves as a sensitive multi-channel detector for all Raman lines and the attenuated Rayleigh signal. Scanning the line focus over the flame generates 2D or even 3D views of the flame composition.

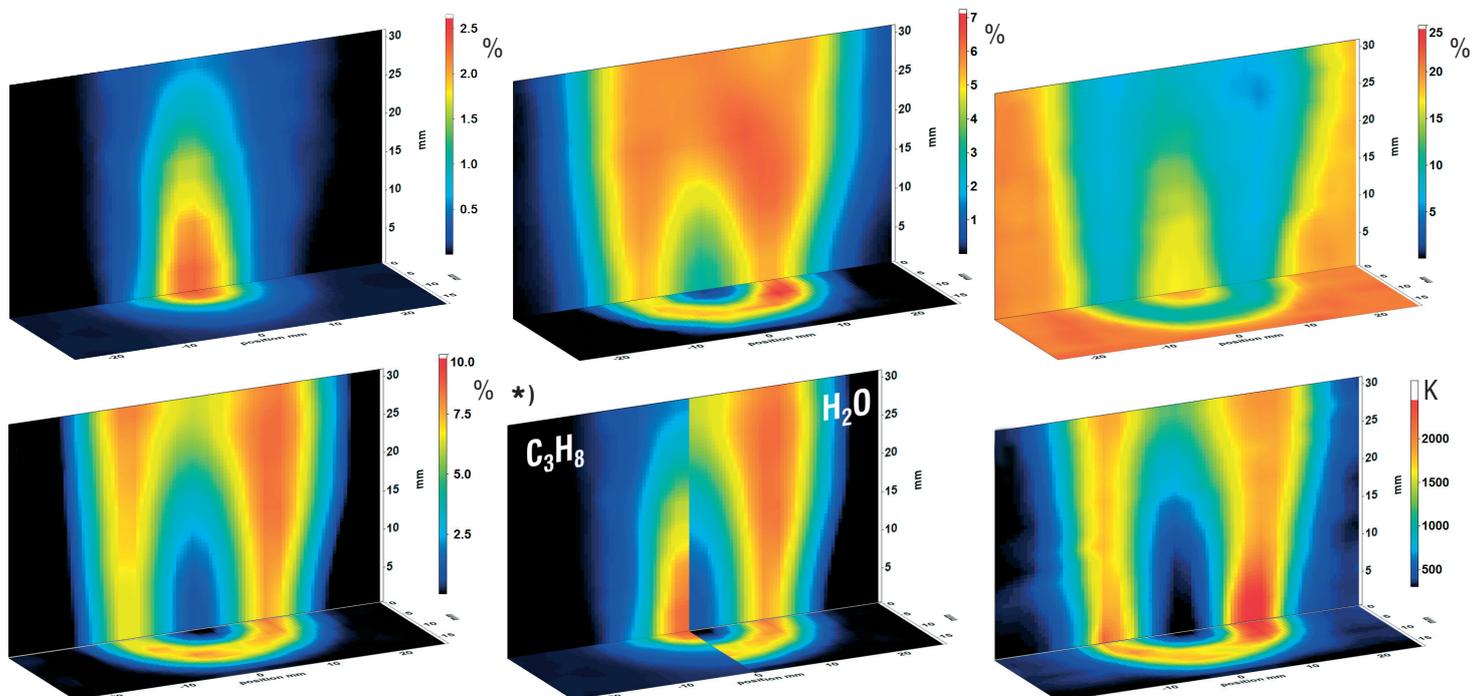
Unwanted and unpolarized background light is separated from the polarized Raman and Rayleigh signals applying the polarization rotation technique. The simultaneously recorded Rayleigh signal measures the total gas density and is used in combination with the gas composition information of the Raman measurement for a higher temperature measurement precision. A built-in Raman data base is applied in the analysis process, and a wizard guides through the calibration process using calibration gases.

System Features

- ▶ 1D gas composition monitoring incl. temperature profile
- ▶ efficient background reduction using polarization rotation
- ▶ data analysis based on calibration measurements
- ▶ line scanning for 2D or even 3D distributions

Applications

- ▶ flame composition monitoring (e. g. air/fuel ratio imaging)
- ▶ gas mixing
- ▶ validation of computational models



Axial and radial cuts of the propane-fueled Bunsen burner showing fuel (C₃H₈), CO₂, O₂, H₂O concentrations and flame temperature. The *)-marked image presents the complementary fuel and water distribution.

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