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Investigation of temperature and composition in a laminar flat-flame burner based on rotational shifted excitation Raman difference spectroscopy

L. Bahr[1,2*], Franz J. T. Huber[2], Stefan Will[2], Andreas S. Braeuer[1]

[1]*Technische Universität Bergakademie Freiberg (TUBAF), Institute of Thermal-, Environmental- and Resources' Process Engineering (ITUN), Germany*
[2]*Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Lehrstuhl für Technische Thermodynamik (LTT) and Erlangen Graduate School in Advanced Optical Technologies (SAOT), Germany*
leo.bahr@tu-freiberg.de

For the understanding, design and modelling of reactive flows, profound knowledge of temperature and species concentration is crucial. Here, optical, non-invasive sensing techniques are frequently chosen, yet they often require elaborate experimental effort or inhibit other disadvantages like the deployment of tracers or a calibration via a second reference technique.
In this work, we present a straight-forward sensor system – based on linear rotational Raman spectroscopy – and a corresponding data evaluation method for the simultaneous point-wise determination of temperature and species concentration. Its application is demonstrated on a premixed methane/air laminar flat-flame burner (see Figure 1 left).

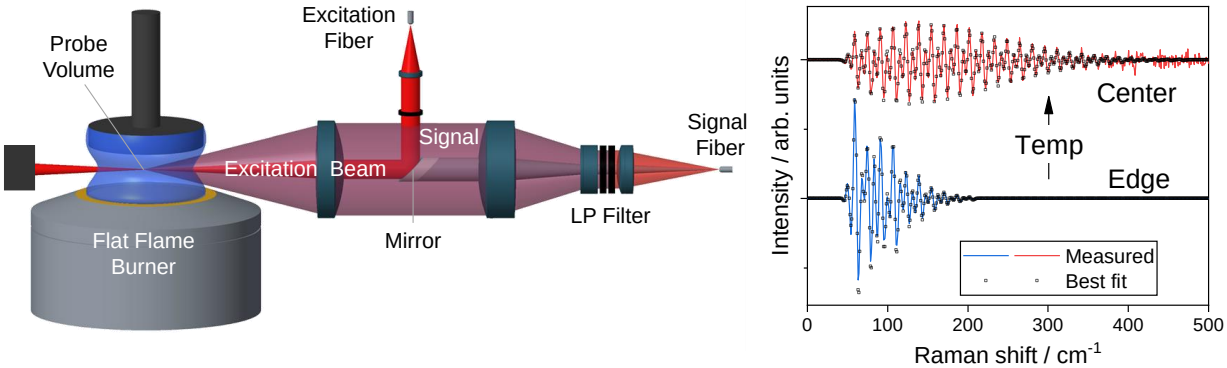

Figure 1: (left) Experimental setup with optical scheme of the Raman sensor head applied to the flat-flame burner; (right) Processed SERDS spectra (colored lines) with fit (squares) for selected radial positions at HAB13 and $\phi = 1$

The technique employs tunable NIR cw-excitation, signal acquisition in back-scattering geometry and requires no sampling from the reactive flow, no tracer inside the flow and no external temperature or composition calibration. For flame luminosity correction, shifted-excitation Raman difference spectroscopy (SERDS) is utilized. The superpositioned rotational Raman spectra of the main components N_2, O_2 and CO_2 (see Figure 1 right) incorporate information on both the local species concentration and the temperature. Via a least-square fit algorithm, the recorded spectra are compared to modelled spectra, yielding the quantities of interest and underlying correlations. Furthermore, we will show how Bayesian analysis allows for the determination of uncertainties of the results for the given application case, but also for other optical measurement techniques present in the field.