MO 7: Experimental Techniques 1

Time: Tuesday 10:30–12:30 Location: BEBEL SR144

MO 7.1 Tue 10:30 BEBEL SR144

Räumlich aufgelöste TDLAS auf Basis angepasster tomographischer Algorithmen für die Erfassung von Ammoniaksträhnen im Abgasstrang eines Dieselmotors — •Sani van der Kley[1], Steven Wagner[2], Felix Stritzke[2] und Volker Ebert[1,3] — [1]Reaktive Strömungen und Messtechnik, TU Darmstadt — [2]Hochtemperatur Prozessdiagnostik, TU Darmstadt — [3]Physikalisch-Technische Bundesanstalt, Braunschweig

Die zunehmende Verringerung der Emissionsgrenzwerte für Kraftfahrzeuge macht immer komplexere Abgasnachbehandlungsszenarien notwendig. Zur Minimierung von Stickoxiden in modernen Dieselfahrzeugen wird bei der selektiven katalytischen Reduktion (SCR) dem Abgas vor dem Eintritt in den Katalysator eine verdünnte Harnstofflösung zur Bildung von Ammoniak (NH_3) als NO_x-Reduktionsmittels zugeführt. Um eine Über- bzw. Unterdosierung des Harnstoffes zu vermeiden, sind neue Technologien zur Optimierung des Einspritzvorgangs notwendig. Zur Detektion der räumlichen Verteilung von Ammoniak vor und nach dem Katalysator wurde ein räumlich auflösendes Spektrometer auf Basis der Tunable Diode Laser Absorption Spectroscopy (TDLAS) realisiert. Als sogenannte „line-of-sight“ Messmethode, d.h. integrierende Messung der Konzentration entlang des Laserstrahls, ist die geeignete Anordnung mehrerer Laserstrahlen zur Realisierung einer räumlichen Auflösung notwendig. Wir stellen hier die Möglichkeiten zur räumlich aufgelösten TDLAS auf Basis angepasster tomographischer Rekonstruktionsalgorithmen für die in-situ Abgasdiagnostik vor und diskutieren deren Grenzen als auch Möglichkeiten.

MO 7.2 Tue 10:45 BEBEL SR144

Messung von absoluten NH_3-Konzentrationen mittels fasergekoppelter TDLAS für die Abgasdiagnostik von Dieselmotoren — •Felix Stritzke und Steven Wagner — High Temperature Process Diagnostics, Technische Universität Darmstadt, Germany

In der Entwicklung von Abgasnachbehandlungssystemen der SCR-Technik werden geringe Ammoniakkonzentrationen in heißer, korrosiver Umgebung üblicherweise durch Gasextraktion gemessen. Eine Alternative dazu bietet die Absorptionsspektroskopie mit durchstimmbaren Diodenlasern (TDLAS - *tunable diode laser absorption spectroscopy*), mit der u.a. absolute in-situ Spezieskonzentrationen mit hoher Zeitauflösung kalibrationsfrei gemessen werden können. Bei Verwendung mehrerer simultaner Messstrecken kann zusätzlich die räumliche Konzentrationsverteilung erfasst werden. Dazu wurde ein Spektrometer entwickelt, mit dem NH_3-Konzentrationen bis zu einer Nachweisgrenze von 100 ppm mit einer zeitlichen Auflösung von 10 Hz bei Verwendung eines ∼10 cm langen Absorptionspfades gemessen werden können. Erstmalig wird hierbei ein fasergekoppelter DFB-Laser zur Messung von Ammoniak im 2,3 μm-Band verwendet und die Strahlung mittels eigens entworfener Faserdurchführungen minimalinvasiv in das Messvolumen eines generischen Abgasströmungskanals eingebracht.

Hierzu wird der Versuchsaufbau vorgestellt, Detaillösungen für die Faseranbindung erläutert, erste Messergebnisse präsentiert und die Charakteristika des Systems quantifiziert.

MO 7.3 Tue 11:00 BEBEL SR144

Coherent Anti-Stokes Raman Scattering Spectroscopy for the Chemical Analysis of Solutions from Miller-Urey Experiments — •Stefan Gomes da Costa[1], Sabrina Scherer[2], Albrecht Ott[2], and Andreas Volkmer[1] — [1]3. Physikalisches Institut, Universität Stuttgart, Stuttgart — [2]Biologische Experimentalphysik, Universität des Saarlandes, Saarbrücken

Coherent anti-Stokes Raman scattering (CARS) spectroscopy has been demonstrated as a highly sensitive and chemically specific technique that enables the extraction of molecular components based on their intrinsic vibrational properties. Compared to spontaneous Raman or infrared spectroscopies, CARS offers higher detection sensitivity and is free of intrinsic background fluorescence. By exploiting these beneficial characteristics of CARS, here we demonstrate the chemical analysis of solutions from Miller-Urey (MU) experiments, where low concentrations of unknown chemical constituents in the presence of strong auto-fluorescence background are to be analysed. Using a single-laser, broadband CARS excitation source, we demonstrate simultaneous acquisition of Raman signatures over a spectral range of more than 4000 cm-1. Chemical species in the so-called fingerprint, the silent, and the CH-stretch regions were observed and classified. Furthermore, multiphoton induced fluorescence and UV absorption spectroscopies have been performed, and their results have been correlated with those of CARS spectroscopy. Our results demonstrate the high potential of CARS spectroscopy for the analysis of complex organic mixtures like MU primordial soups in the quest of the origin of life.

MO 7.4 Tue 11:15 BEBEL SR144

The microwave spectrum of the odd isotope of ytterbium fluoride, ^{171}YbF — •Jens-Uwe Grabow[1], Zachary Glassman[2], Richard J Mawhorter[2], Anh Le[3], and Timothy C. Steimle[3] — [1]Gottfried-Wilhelm-Leibniz-Universität, Hannover, Germany — [2]Pomona College, Claremont CA, USA — [3]Arizona State University, Tempe AZ, USA

Recent interest in the properties of ytterbium monofluoride, YbF, is primarily motivated by parity non-conservation (PNC) studies, and particularly the determination of electric dipole moment (e-EDM) of the electron, d_e. The advantages of utilizing heavy metal containing polar molecules like YbF for PNC measurements were recognized approximately 40 years ago and primarily stem from the very large obtainable internal electric fields, E^{int}, and the closeness of levels with opposite parity. The latter implies that the molecule can be fully polarized under application of a modest external field and the internal field realized is near the E^{int} value.

The pure rotational spectrum of a minor isotopologue of ytterbium fluoride, ^{171}YbF, in the X^2S^+ (v=0) state has been recorded using Fourier transform microwave (FT-MW) spectroscopy and pump/probe microwave optical double resonance (PPMODR) spectroscopy. The spectra were analyzed to produce an improved set of fine and hyperfine parameters for ^{171}YbF. Isotopic relationships and the determined ^{171}YbF parameters are used to predict the pure parameters and rotational transition frequency of ^{173}YbF.

MO 7.5 Tue 11:30 BEBEL SR144

Fibertest - Test for suitability of optical fiber feed-throughs and fibers in tritium atmosphere — •Kerstin Schönung and Sebastian Senst — Karlsruhe Institute of Technology (KIT), Institute of Technical Physics - Tritium Laboratory Karlsruhe (ITEP-TLK), Germany

Up to now the only possibility for tritium analytical methods, like FTIR-spectroscopy, to safely inject light into a glove box and a tritium system itself are optical windows bonded into vacuum flanges. Optical fiber feed-throughs and fibers could replace these windows and at the same time facilitate the setup.

But before fiber components can be used in a tritium system, two main questions have to be answered: Does tritium permeate through the fiber feed-through? Do optical properties change if the fiber is exposed to tritium? To answer these questions the Fibertest experiment is set up.

In this talk the setup and the measurement principle is explained. Furthermore the first results of the experiment are shown. This work is supported by the Carl-Zeiss-Foundation.

MO 7.6 Tue 11:45 BEBEL SR144

Accurate calibration of a Laser Raman system with (H,D,T) gas mixtures in thermodynamic equilibrium — •Simon Niemes and Marco Röllig — Karlsruhe Institute of Technology, ITEP-TLK, Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen

The Karlsruhe Tritium Neutrino (KATRIN) experiment aims to measure the neutrino mass via high-precision electron spectroscopy of the tritium beta decay with a sensitivity of $m_\nu = 200\,\mathrm{meV/c^2}$ (90% C.L.). This can only be achieved if systematic uncertainties are minimized. An important parameter is the isotopic composition of the gaseous beta electron source which is measured inline by Laser Raman spectroscopy. The KATRIN experiment requires a measurement trueness of better than 10% for the gas composition. Here we present a gas sampling technique for the calibration of the Raman system, with all hydrogen isotopologues (H_2, HD, HT, D_2, HT, DT, T_2). A tritium compatible loop will be set-up at the Tritium Laboratory Karlsruhe (TLK) to produce binary hydrogen gas mixtures in thermodynamic equilibrium and with well-known isotopic composition. Further analysation of the gas mixtures produced for the LARA calibration will

be done by gas chromatography, mass spectroscopy and beta induced x-ray spectrometry.

MO 7.7 Tue 12:00 BEBEL SR144

Data Analysis for the TApIR Experiment — •Alexander Kraus, Robin Grössle, and Sebastian Mirz — Karlsruhe Institute of Technology (KIT), Institute of Technical Physics (ITEP), Tritium Laboratory Karlsruhe (TLK)

Nuclear fusion reactors like ITER and DEMO require a fuel cycle with infrastructure for gas recycling. Part of this infrastructure is a facility that separates the six hydrogen isotopologues (Q_2) by cryogenic distillation. For this system, an inline, non-invasive method for real-time monitoring of the Q_2 concentrations is needed. The Tritium Absorption Infrared Spectroscopy (TApIR) experiment was deployed at the TLK in order to test the suitability of IR spectroscopy for this purpose.

With the experimental setup, Fourier Transform Infrared (FTIR) interferograms can be measured. Those interferograms are then processed by a software that applies a Discrete Fourier Transform (DFT). Results of the conventional data analysis in FTIR spectroscopy include transmission functions with a baseline different from one. For this reason, a Rolling Circle Filter (RCF) is included into the analysis procedure and optimized to remove this effect. From the resulting sample transmission functions, calibration quantities, like integrated absorbances, are then calculated. These can be used for a calibration with Q_2 concentrations, which are measured externally by an independet laser raman system, or, if a calibration exists, for the determination of Q_2 concentrations in unknown sample mixtures. In this talk, the different analysis steps will be presented and compared to the conventional analysis procedure in infrared spectroscopy.

MO 7.8 Tue 12:15 BEBEL SR144

IR spectroscopy on liquid hydrogen isotopologues with the Tritium Absorption Infrared (TApIR) experiment — •Sebastian Mirz, Robin Grössle, and Alexander Kraus — Karlsruhe Institute of Technology (KIT), Institute of Technical Physics (ITEP), Tritium Laboratory Karlsruhe (TLK)

For the purification of the fusion plasma facilities like ITER and DEMO will circulate tritium and deuterium with a throughput of several kg per hour in their fusion fuel cycle. One important part of this fusion fuel cycle is the isotope separation system (ISS) using cryogenic distillation, which is under development at the Tritium Laboratory Karlsruhe (TLK).

The cryogenic distillation column of the ISS is able to separate mixtures of all six hydrogen isotopologues H_2, HD, D_2, HT, DT and T_2. At the bottom of the cryogenic distillation column liquid tritium is accumulated. For monitoring the separation process, an inline and real-time analysis method able to measure the isotopologic concentration, is needed. As a test experiment for this analysis method the cryogenic sample cell of the TApIR experiment has been set up to simulate the conditions of the cryogenic distillation column. The TApIR experiment is able to liquefy hydrogen isotopologues at temperatures around 20 K and analyse them using infrared (IR) absorption spectroscopy. To deduce the gas composition from the recorded IR spectra calibration data of measurements with known mixtures is required. This talk will introduce the procedure for such a calibration measurement and present results with equilibrated inactive hydrogen isotopologue mixtures.