

Q 46: Laser Applications: Laser Spectroscopy

Time: Wednesday 14:30–16:15

Location: K/HS2

Q 46.1 Wed 14:30 K/HS2

Infrared spectroscopy near the diffraction limit with a high-brilliance mid-infrared femtosecond light source — ●FRANK NEUBRECH, TOBIAS STEINLE, and HARALD GIESSEN — 4th Physics Institute and Research Center SCoPE, University of Stuttgart, Germany

We demonstrated highly sensitive infrared (IR) spectroscopy of sample volumes close to the diffraction limit by coupling a fiber-feedback optical parametric oscillator (OPO) to a conventional Fourier-Transform infrared (FTIR) spectrometer. The high brilliance and long-term stable infrared radiation with bandwidths up to 100 nm is easily tunable between 1.4 and 4.2 microns and thus enables low-noise infrared spectroscopy as we showed by measuring typical infrared vibrations in the range of 3 microns. Combined with surface-enhanced infrared spectroscopy (SEIRA), where the confined electromagnetic near-fields of resonantly excited metal nanoparticles are employed to enhance molecular vibrations, we realized the noise-free spectroscopic detection of a molecular monolayer of octadecanethiol. In comparison to conventional light sources and synchrotron radiation, our table-top OPO system features a significantly improved brilliance, making it highly suitable for analytical applications in life science and medical laboratories.

Q 46.2 Wed 14:45 K/HS2

A narrow linewidth spectroscopy laser for Ar¹³⁺ — ●TOBIAS LEOPOLD¹, LISA SCHMÖGER², STEFANIE FEUCHTENBEINER², JOACHIM ULLRICH¹, JOSÉ R. CRESPO LÓPEZ-URRUTIA², and PIET O. SCHMIDT^{1,3} — ¹QUEST Institut, Physikalisch-Technische Bundesanstalt, Braunschweig — ²Max-Planck-Institut für Kernphysik, Heidelberg — ³Institut für Quantenoptik, Leibniz Universität Hannover

In the past precision spectroscopy of highly charged ions (HCIs) was limited by Doppler broadening as the ions were mostly created and investigated in an electron beam ion trap (EBIT) with temperatures of several million Kelvin. Recently, we were able to extract HCIs from an EBIT into a Paul trap and sympathetically cool them to the mK range.

We report on the setup and characterization of a spectroscopy laser for the $1s^2 2s^2 2p^2 P_{3/2} - 2P_{1/2}$ transition in Ar¹³⁺ at 441 nm with 100 kHz linewidth and long-term stability. A Titanium Sapphire laser at 882 nm is frequency stabilized to an external transfer cavity, providing short term stability, and subsequently frequency doubled using a PPKTP crystal in an enhancement cavity. Absolute frequency stability is achieved by stabilizing the length of the transfer cavity to an atomic transition. A polarization spectroscopy setup locks a 780 nm diode laser to a crossover transition of rubidium D-line hyperfine states. Using the offset sideband locking technique we can scan the resonator length and thereby tune the Titanium Sapphire laser by 700 MHz, which is more than the free spectral range of the transfer cavity.

Q 46.3 Wed 15:00 K/HS2

Near-edge x-ray absorption fine-structure at the carbon K-edge using a table-top coherent x-ray source — SETH L. COUSIN¹, FRANCISCO SILVA¹, STEPHAN TEICHMANN¹, MICHAEL HEMMER¹, ●BÁRBARA BUADES¹, and JENS BIEGERT^{1,2} — ¹ICFO - Institut de Ciències Fotòniques, Mediterranean Technology Park, 08860 Castelldefels, Barcelona, Spain — ²ICREA - Institució Catalana de Recerca i Estudis Avançats, 08010 Barcelona, Spain

Attosecond soft-X-ray absorption spectroscopy elucidates dynamics in solids, 2D materials, magnetic structures or superconducting switches with unprecedented temporal resolution. We demonstrate the first high-flux table top attosecond source reaching the soft-X-ray water window, corresponding to wavelengths between 2.3 and 4.5 nm. The water window source, which contains the fundamental absorption edges of carbon, nitrogen and oxygen, now enables element-specific, high-resolution biological and molecular imaging, spectroscopy, materials science and observation of fundamental dynamics of matter at unprecedented timescales. We demonstrate our approach by retrieving the electronic structure of a solid state polyimide target with near-edge X-ray fine-structure absorption spectroscopy (NEXAFS) at the carbon K-edge (284 eV).

Our coherent soft x-ray source is based on high harmonic generation (HHG) with carrier to envelope-phase (CEP) stable sub-2-cycle laser pulses with a central wavelength at 1.85 μm . The generated broadband

spectrum spans 200 eV to 530 eV thereby simultaneously covering the absorption edges of many relevant elements.

Q 46.4 Wed 15:15 K/HS2

Optimization of a capillary Raman system for the high-sensitivity analysis of gas mixtures — ●ANDREAS OFF¹, SIMONE RUPP¹, TIMOTHY M. JAMES¹, HENDRIK SEITZ-MOSKALIUK¹, and HELMUT H. TELLE² — ¹Institute of Technical Physics, Karlsruhe Institute of Technology — ²Instituto Pluridisciplinar, Universidad Complutense de Madrid, Spain

In many applications, e. g. in fusion or in the Karlsruhe Tritium Neutrino Experiment, it is very important to accurately know the composition of the used gases. To determine this composition is a challenging task, for which Raman spectroscopy has proved to be an advantageous analytical method. The measurement is contact-free and does not influence the system. Additionally it is possible to analyze gas mixtures within short measurement periods, measure many constituents simultaneously and to easily discriminate different species. At the Tritium Laboratory Karlsruhe a capillary laser Raman system (CLARA) has been developed to analyze gas mixtures with high sensitivity. First measurements have shown that its performance is already good with a limit of detection of 0.48 mbar in an acquisition time of 5 s. However, the sensitivity of the capillary system is limited by the fluorescence background which is emitted from optical components in the laser beam path.

In this talk optimizations of the setup are presented, which were chosen to decrease the noise while maintaining a high signal. These optimizations include replacing fluorescent components by non- or less fluorescent ones and improvements of the light coupling configuration.

Q 46.5 Wed 15:30 K/HS2

Investigation of metal capillaries for fluorescence reduction in a capillary Raman system for high-sensitivity gas analysis — ●HENDRIK SEITZ-MOSKALIUK¹, SIMONE RUPP¹, TIMOTHY JAMES¹, ANDREAS OFF¹, and HELMUT H. TELLE² — ¹Institute of Technical Physics, Karlsruhe Institute of Technology, Germany — ²Instituto Pluridisciplinar, Universidad Complutense de Madrid, Spain

Raman spectroscopy is a widely used tool for analysing the composition of gas mixtures. It allows non-contact and inline multispecies gas measurements. A highly sensitive Raman system for detecting small amounts of gases can be realised by using a glass capillary with a silvered inner surface as the gas cell. The laser light is sent through the capillary which offers a long scattering region, while the highly reflective silvering makes it possible to collect a large fraction of the Raman-scattered light. Both the long scattering region and the effective Raman light collection lead to a high signal. A disadvantage of this approach, however, is the high fluorescence background. Fluorescence light is produced by laser light in glass, in this special case if the laser hits the capillary frontally or if laser light tunnels through the silvering into the glass.

This talk presents the results of a comparison experiment in which different metal tubes were used as Raman cell. Spectra of air were taken and compared to spectra obtained with a glass capillary. It could be shown that the metal capillaries reach the same signal-to-noise ratios as the glass capillary. Further improvements are suggested to even exceed the glass capillary performance.

Q 46.6 Wed 15:45 K/HS2

Laser Raman spectroscopy a tool for tritium analytics: an overview — ●TIMOTHY M. JAMES¹, SEBASTIAN FISCHER¹, SIMONE RUPP¹, ANDREAS OFF¹, HENDRIK SEITZ-MOSKALIUK¹, MATTHIAS WECKER¹, MICHAEL STURM¹, MAGNUS SCHLOESSER², HELMUT H. TELLE², and BEATE BORNSCHEIN¹ for the KATRIN-Collaboration — ¹Karlsruhe Institute of Technology, Karlsruhe, Germany — ²Univesidad Complutense de Madrid, Madrid, Spain

Laser Raman spectroscopy is a non-contact, non-destructive, multi-species analysis method, which can provide accurate and quantifiable composition information. Our laser Raman system has been developed such that it can be used to monitor inline the source gas composition of the Karlsruhe Tritium Neutrino Experiment and as a standard gas processing system at the Tritium Laboratory Karlsruhe (TLK).

In this presentation we give an overview of the recent research ac-

tivities on the various aspects of Raman spectroscopy in gas analytics at the TLK. A stable and precise ($<0.1\%$) composition with a high calibration accuracy of better than 3% is obtained from the system. Recent long term measurements with acquisition times of the order of 60s over periods of several weeks verify the usability of the system for real-time, inline and accurate gas analysis. During longer term operation laser induced contamination of optical components has been observed which reduces the Raman intensity over the run period. Potential solutions to this problem will be summarised. Finally, new approaches are also pursued at the TLK to further enhance the sensitivity of Raman spectroscopy for gas analytics. These techniques will be summarised.

Q 46.7 Wed 16:00 K/HS2

Temperature dependent Raman spectra of CsCdBr₃ and

CsCdCl₃ crystals — ●RIZA DEMIRBILEK¹, RUDOLF FEILE², and AYŞEGÜL ÇELİK BOZDOĞAN¹ — ¹Department of Physics, Faculty of Science and Letters, Yildiz Technical University, 34210 Davutpaşa Istanbul, Turkey — ²Institut of Solid State Physics, Technische Universität Darmstadt, Hochschulstraße 8, 64289 Darmstadt, Germany

Abstract

Temperature dependent Raman spectra of the crystals CsCdCl₃ and CsCdBr₃, grown by Bridgman method, were measured in the temperature range 5K-300K. Comparison of the temperature dependence of the observed Raman-lines of the modes of common sites in both crystals gives the possibility to compare the anharmonicity of the lattice vibration of both materials. The breathing mode of both CsCdCl₃ and CsCdBr₃ crystals is the strongest and comparable mode in this manner. In this presentation, the results and their analysis will be presented and discussed.