JOHANNES KEPLER
UNIVERSITÄT LINZ

PHYSIKKOLLOQUIUM
Fachbereich für Physik

Im Rahmen des Physikkolloquiums spricht

Prof. Gerard Wysocki

Electrical and Computer Engineering at Princeton University

über

Mid-infrared Quantum Cascade Laser Frequency Combs and their applications to high resolution gas spectroscopy

Abstract:

Quantum cascade laser frequency combs (QCL-FCs) are compact, all-electrically driven, broadband semiconductor laser sources of coherent mid-infrared radiation that have tremendous potential for applications in mid-infrared dual-comb spectroscopy (DCS) and chemical sensing. Unlike the near-infrared mode-locked frequency combs used for metrological-grade spectroscopy, free-running QCL-FCs are susceptible to intrinsic phase and intensity noise, which makes applications to high-resolution spectroscopy relatively difficult. In this talk I will discuss several approaches for precise control of the QCL-FCs to achieve general improvements of QCL-FC coherence, and present their impacts on spectroscopy applications. We have developed comb stabilization techniques utilizing external cavity optical feedback and radio-frequency electrical signal injection to improve comb coherence for DCS applications, as well as to generate higher-order harmonic comb-states with broader wavelength coverage. These techniques result in an improved comb stability in the presence of unwanted optical feedback, and also enable gapless frequency tuning of the comb modes in support of high-resolution DCS with sub-MHz-level frequency control. The full capabilities as spectroscopic sources will be demonstrated by probing narrow spectral features of small molecules at low pressures as well as broadband spectral measurements routinely performed with QCL-DCS.

Additionally, I will discuss examples of a variety of chemical sensing techniques based on QCL-DCS that can acquire high-resolution mid-infrared spectra with temporal resolution down to 10 µs/spectrum while providing spectral coverage up to 90 cm^{-1} in mid-IR region, and implementations in both in-situ and stand-off spectroscopic detection of trace-gases and hyperspectral imaging of solids/liquids on surfaces.

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Short biography – Gerard Wysocki

Gerard Wysocki is a Professor of Electrical and Computer Engineering at Princeton University. He received his PhD degree in physics in 2003 from Johannes Kepler University in Linz, Austria, and his MS degree in optoelectronics in 1999 from the Wroclaw University of Technology in Poland. He joined Princeton faculty in 2008 where he leads his Princeton University Laser Sensing (PULSe) research group in the areas of tunable mid-IR/THz lasers and applied spectroscopy. Wysocki conducts research that spans developments of modern laser sources, novel optical sensing techniques, advanced signal processing, and fundamental light-matter interactions. He pioneered 3D tomographic hard target LIDAR systems based on new molecular dispersion spectroscopy techniques, developed mid-IR remote spectroscopic detection and hyperspectral imaging systems based on frequency combs. He published over 120 scientific papers, co-authored over 300 conference papers and talks (>90 invited), 7 book chapters, and he also holds 15 US and international Patents. For his scientific contributions and technical innovations Wysocki has received multiple awards including the NSF CAREER Award, the Masao Horiba Award for contributions to analytical science, and the Peter Werle Early Career Scientist Award. He is a Fellow of Optica (former OSA), and a member of APS, and SPIE. He also serves as an Associate Editor of Optica, and Co-editor of Applied Physics B.

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