Q 18: Laser and Laser Applications

Time: Tuesday 10:30–12:00 Location: Q-H15

Q 18.1 Tue 10:30 Q-H15

Spectroscopy of High Pressure Rubidium-Helium-Mixtures — •Till Ockenfels, Paško Roje, Frank Vewinger, and Martin Weitz — Institut für Angewandte Physik der Universität Bonn, Wegelerstr. 8, D-53115 Bonn

Spectroscopy of alkali-buffer gas mixtures in a regime beyond the impact limit of collisional broadening is relevant in a wide range of fields, ranging from collisional redistribution laser cooling to laboratory astrophysics [1,2]. Here we report recent spectroscopic measurements of dense rubidium-helium gas mixtures recorded in a pressure cell equipped with soldered sapphire optical viewports, where the sapphire window is bonded to a metal flange via active soldering making use of a compound intermediate structure allowing to mediate thermally induced stress [3]. In the gas cell, we have recorded rubidium absorption and emission spectra subject to 250bar helium buffer gas pressure at 500K temperature. The spectra to good accuracy fulfill the Kennard-Stepanov Boltzmann-like frequency scaling of the ratio of absorption and emission spectral profiles.

[1] U. Vogl and M. Weitz, Nature 461, (2009).
[2] F. Bouhadjar et al., J. Phys. B 47 (2014).
[3] T. Ockenfels et al., Rev. Sci. Instrum. 92, 065109 (2021).

Q 18.2 Tue 10:45 Q-H15

Argon Trap Trace Analysis: Applications on age determination in ocean science and stratified lakes — •Yannis Arck[2], Julian Robertz[1], Maximilian Schmidt[1,2], David Wachs[1,2], Florian Meienburg[1,2], Werner Aeschbach[2,3], and Markus Oberthaler[1] — [1]Kirchhoff Institute for Physics, Heidelberg, Germany — [2]Institute of Environmental Physics, Heidelberg, Germany — [3]Heidelberg Center for the Environment, Heidelberg, Germany

The radioisotope ^{39}Ar serves as an environmental tracer in natural science. It is an inert noble gas with a half-life of 269 years, thus suited for dating processes in the age range of 50 to 1000 years. Due to the relative atmospheric abundance of only 10^{-15}, a special quantum-optical technology analysis method is required, if the desired sample sizes should not exceed 10 L of water. In Heidelberg, Argon Trap Trace Analysis (ArTTA) has emerged over the last few years to provide major advances in applicability concerning this difficult tracer.

This is especially relevant for oceanographic studies. In summer 2021, ocean water samples were collected during the Synoptic Artic Survey onboard the Swedish icebreaker Oden. The aim is to investigate circulation and ventilation patterns in combination with noble gas saturation anomalies in the central Arctic Ocean to estimate the uptake of anthropogenic carbon. The most recently completed campaign was on the stratification of Lake Kivu, located in central Africa, a region strongly influenced by volcanic activity. This 450 m deep lake has several resilient stratified layers caused by subsurface groundwater and volcanic gas intrusions. Both studies will be presented in this talk.

Q 18.3 Tue 11:00 Q-H15

3D-Printed Fresnel Lenses for Terahertz Frequencies Using a Cyclic Olefin Copolymer (TOPAS) — •Konstantin Wenzel[1], Sarah Klein[2], Martin Traub[2], Jonas Merit[2], Christian Vedder[2], Martin Schell[1,3], Björn Globisch[1,3], and Lars Liebermeister[1] — [1]Fraunhofer Heinrich Hertz Institute, Einsteinufer 37, 10587 Berlin, Germany — [2]Fraunhofer-Institute for Laser Technology, Steinbachstraße 15, 52074 Aachen, Germany — [3]Technische Universität Berlin, Institut für Festkörperphysik, Hardenbergstraße 36, 10623 Berlin, Germany

In recent years, the field of terahertz (THz) technology has developed rapidly. With the improvement of transmitters and detectors, optics is in the need to catch up. Currently, off-axis parabolic mirrors or lenses are used as focusing THz optical-elements. Such lenses are usually manufactured from bulk materials as polymers or silicon, e.g. by grinding or cutting, or by compression molding of powders. With the advent of affordable and accurate 3D printers that utilize fused material deposition, a flexible and readily available method for fabricating complex terahertz optical components is now available. Here, we present two- and three-zone Fresnel lenses fabricated by a commercial 3D printer using a cyclic olefin copolymer (TOPAS). TOPAS exhibits particularly low absorption and dispersion and prints well with standard printers. We measured the frequency-dependent beam profile of lenses up to 4 THz and the effects of fabrication onto the scattering. The direct comparison with traditionally manufactured lenses of equal design demonstrates the potential of this fabrication technique.

Q 18.4 Tue 11:15 Q-H15

Integration of a DSTMS based THz emitter into a fibre-coupled THz time-domain spectroscopy system. — •Tina Hesselmann[1,2], Konstantin Wenzel1[1], Robert Kohlhaas[1], Martin Schell[1,3], Björn Globisch[1,3], and Lars Liebermeister[1] — [1]Fraunhofer Heinrich Hertz Institute, Einsteinufer 37, 10587 Berlin, Germany — [2]Berliner Hochschule für Technik, Luxemburger Str. 10, 13353 Berlin, Germany — [3]Technische Universität Berlin, Institut für Festkörperphysik, Hardenbergstraße 36, 10623 Berlin, Germany

In recent years, Terahertz (THz) time-domain spectroscopy (TDS) has gained relevance in science and is now established on the market. THz spectroscopy is particularly used in contactless and non-destructive thickness measurement of coatings. Due to their user-friendly operation, fibre-coupled THz spectrometer are commonly utilized for such applications. By combining a fs-pulse fibre laser with state-of-the-art semiconductor-based photoconductive antennas, these systems reach bandwidths up to 6.5 THz. However, a recently developed detector, based on a photoconductive membrane, accomplishes an effective bandwidth of 10 THz. A fibre coupled emitter with comparable bandwidth is still needed. An alternate approach uses non-linear optical rectification, e.g. based on DSTMS-crystals in free space excitation, which allows for a wider bandwidth. This study integrates a DSTMS crystal as a emitter into a fibre-coupled TDS system while applying the novel photoconductive antenna as receiver. We find that this setup can utilize the bandwidth of the new receiver by demonstrating a THz bandwidth up to 9.5 THz in a fibre-coupled THz TDS-system.

Q 18.5 Tue 11:30 Q-H15

Highly localized field enhancement at sputter-sharpened tungsten nanotips — •Leon Brückner[1], Timo Paschen[1,2], Mingjian Wu[3], Erdmann Spiecker[3], and Peter Hommelhoff[1] — [1]Department Physik, Friedrich-Alexander Universität Erlangen-Nürnberg (FAU), 91058 Erlangen — [2]Korrelative Mikroskopie und Materialdaten, Fraunhofer-Institut für Keramische Technologien und Systeme IKTS, 91301 Forchheim — [3]Department Werkstoffwissenschaften, Friedrich-Alexander Universität Erlangen-Nürnberg (FAU), 91058 Erlangen

Nanotips, i.e., ultrasharp, nanometer-scale protrusions on the surface of field emitter needle tips, are known to have intriguing properties, such as highly localized field enhancement and electron emission, and a narrow transverse energy distribution through emission from surface states. We fabricated nanotips from regular tungsten needle tips via an in-situ ion sputtering technique and investigated their geometry through transmission electron microscope imaging. The field enhancement at the nanotip is probed via laser-driven electron rescattering. Extracting the near-field enhancement factor from the electron energy spectra yields an increase of more than a factor of 2 compared to a regular needle tip, i.e., 8.2 ± 0.2 as compared to 4-5. The experimental results are well reproduced by finite-difference time-domain simulations and bode well for potential applications in strong-field physics or as electron sources for ultrafast electron microscopy.

Q 18.6 Tue 11:45 Q-H15

Impact of the Raman Effect on Two-Color Compound States — •Stephanie Willms[1,2], Oliver Melchert[1,2,3], Surajit Bose[2,3], Uwe Morgner[1,2,3], Ihar Babushkin[1,2], and Ayhan Demircan[1,2,3] — [1]Cluster of Excellence PhoenixD, Wlefengarten 1, 30167 Hannover, Germany — [2]Leibniz University Hannover, Institute of Quantum Optics, Welfengarten 1, 30167, Hannover, Germany — [3]Hannover Centre for Optical Technologies, Nienburger Str. 17, 30167, Hannover, Germany

Soliton molecules usually refer to objects, consisting of two solitons with a fixed temporal separation, which propagate stably in a waveguide. Such molecule states appear, e.g., in dispersion-managed fibers. Recently, a fundamentally different kind of soliton molecule was demonstrated: Two-color compound states. They consist of subpulses at vastly separated center frequencies with similar group-velocities. Therefore, a suitable propagation constant requires at least two separate domains of anomalous dispersion. Such compound states have recently been demonstrated experimentally in a mode-locked laser cavity. Here, we demonstrate that compound states show intriguing propagation dynamics when perturbed by the Raman effect as only one of its subpulses is restrained by a zero dispersion point. Moreover, the generation of such two-color compound states is difficult, since access to two incommensurable, group-velocity matched frequencies is required. For a possible experimental realization, we propose a self-generation scheme enabled by the Raman effect. In particular, we show that a compound state can be generated with a single initial input frequency.