Q 3: Photonics and Laser Development

Time: Monday 16:30–18:30 Location: P

Q 3.1 Mon 16:30 P

Modelling of beam propagation for partially coherent light waves in diffractive systems — •Ulf-Vincent Sponholz and Edeltraud Gehrig — RheinMain University of Applied Science, Germany

In many technical applications diffractive systems are used to guide and shape light waves. Typically, these systems are designed according to properties and parameters of an ideal light beam. For a realistic description it is of interest to explicitly consider the beam properties as well as the spectrum of a given light source. We present a mathematical-physical model for the simulation of beam propagation and superposition of partially coherent waves. In the model, using the Fraunhofer approximation for imaging between optical planes, the propagation of light with variable spectral composition and coherence properties is explicitly considered. The beam passes a diffractive system (e.g. phase grating), realized by a corresponding transmission function in the imaging plane. Based on the model equations a practice-oriented Python program was developed, that allows the simulation and comparative analysis of different diffractive optical elements exposed to various light sources. Variable coherence properties (e.g. laser light or LEDs) are captured via a superposition of individual light components using Fourier transform methods. The program enables the realistic calculation of beam profiles after passing through an optical system as well as the adaptation of an imaging optics to a given light source.

Q 3.2 Mon 16:30 P

Hybrid Microring Resonators: towards Integrated Single Photon Emitters with a Novel Fabrication Approach — •Giulio Terrasanta[1], Timo Sommer[1,3], Manuel Müller[2,1], Matthias Althammer[2,1], and Menno Poot[1,3,4] — [1]Department of Physics, Technical University Munich, Garching, Germany — [2]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany — [3]Munich Center for Quantum Science and Technology (MCQST), Munich, Germany — [4]Institute for Advanced Study, Technical University Munich, Garching, Germany

Aluminum nitride (AlN) is an emerging material for integrated quantum photonics, thanks to its excellent linear and nonlinear optical properties. Its second-order nonlinearity allows the realization of single photon emitters, which are a critical component for quantum technologies. Nevertheless, the fabrication of AlN, in particular its etching, can be challenging. Here, we demonstrate the integration of AlN on Silicon Nitride (SiN) photonic circuits with a novel approach that depends only on the SiN reliable fabrication. By sputtering c-axis oriented AlN on top of pre-patterned SiN, we realized hybrid microring resonators. The material properties were characterized using XRD, optical reflectometry, SEM, and AFM. We varied AlN thickness, ring radius, and waveguide width in different chips to benchmark the optical properties, such as the quality factor, propagation losses and group index. The hybrid resonators can have quality factors as high as 500K, thus being a promising platform to amplify the nonlinear optical properties of AlN.

Q 3.3 Mon 16:30 P

Characterising and tracking the three-dimensional motion and rotation of individual nanoparticles using a high-finesse fibre-based microcavity — Larissa Kohler[1], •Shalom Palkhivala[1], Matthias Mader[2], Christian Kern[1], Martin Wegener[1], and David Hunger[1] — [1]Karlsruher Institut für Technologie, Karlsruhe, Germany — [2]Ludwigs-Maximilians-Universität, Munich, Germany

While many current techniques for nanoparticle sensing are based on labelling, we present a fibre-based high-finesse Fabry-Perot microcavity capable of sensing unlabelled nanoparticles. The optical microcavity is integrated with microfluidic channels for the detection of nanoparticles in solution. Silica nanospheres with radii of 25 nm have thus been detected, and their mean refractive index deduced.

Furthermore, the three-dimensional Brownian motion of a single nanoparticle in the cavity is tracked by the simultaneous measurement of the fundamental and two higher-order transverse modes. The particle's position can be derived with spatial and temporal resolutions of 8 nm and 0.3 ms respectively. In addition, the rotation of nanoparticles is measured by the polarisation splitting of the fundamental mode. The rotation of nanospheres with a specified roundness of 0.98 can already be investigated with this method.

Work is being done to increase the detection bandwidth and sensitivity, to eventually allow characterisation of the optical and dynamic behaviour of single biomolecules.

Q 3.4 Mon 16:30 P

Transportable Laser System Employing Fourier Limited Picosecond Pulses for Laser Cooling of Relativistic Ion Beams — •Benedikt Langfeld[1], Daniel Kiefer[1], Sebastian Klammes[1,2], and Thomas Walther[1] — [1]TU Darmstadt — [2]GSI Darmstadt

Laser cooling of relativistic ion beams has been shown to be a sophisticated technology [1]. To prevent intrabeam scattering (IBS) of the ion beam, the use of white-light cooling with broad laser bandwidths has been proposed and demonstrated in non-relativistic ion beam cooling [2]. Laser cooling of relativistic C^{3+} ion beams was demonstrated with the presented pulsed laser system this year at GSI (see poster by S. Klammes et al).

In this work we present the transportable master-oscillator-power-amplifier system supplying laser pulses of 70 to 740 ps length with a scannable centre wavelength of 1029 nm, using a combination of acousto-optic and electro-optic modulators. The system generates Fourier transform limited pulses with a continuously adjustable pulse length and repetition rate of 1 to 10 MHz. With two SHG stages, the desired wavelength of 257.25 nm can be achieved.

[1] S. Schröder et al, Phys. Rev. Lett. 64, 2901-2904, (1990).
[2] S.N.Atutov et al, Phys. Rev. Lett. 80, 2129, (1998).

Q 3.5 Mon 16:30 P

Towards microcombs for high-resolution astronomy — •Ignacio Baldoni[1], Arne Kordts[1], Junqiu Liu[2], Arslan Raja[2], Tobias Kippenberg[2], and Ronald Holzwarth[1] — [1]Menlo Systems GmbH, Munich, Germany — [2]École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland

Precise and accurate calibration of astronomical spectrometers is crucial for the detection of extra-solar planets or direct measurements of cosmological expansion. A decade ago, Laser Frequency Combs presented an improved solution for the traditional calibration light sources where its regular spaced frequency grid spectrum is filtered to higher repetition rates, broadened and flattened to equal comb line intensities of the spectrometer. This system referred as astrocomb has still some drawbacks, especially in the mode filtering and spectral broadening schemes. An alternative to overcome those issues relies in the demonstration of frequency-combs through soliton formation on a low-loss microresonator (microcomb) driven only by a single cw laser. This platform provides large mode spacing on a photonic chip making it attractive for astrocombs. Here, a microcomb system is developed to replace the comb source of current astrocombs operating at 1550 nm. The microresonator fabrication via photonic Damascene process allowed high-Q based on ultralow-loss Si_3N_4 waveguides. Single soliton state at 12 GHz line-spacing was accomplished and stabilized for reliable long-term measurements, alongside with a repetition rate locking scheme. Once broadened, this spectrum will enable high-resolution calibration for astronomical spectrographs.

Q 3.6 Mon 16:30 P

A next generation laser driver and temperation controller — •Patrick Baus, Thomas Sattelmaier, and Gerhard Birkl — Institut für Angewandte Physik, TU Darmstadt, Schlossgartenstraße 7, 64289 Darmstadt, Germany

We present a fully open source hardware solution for the next generation of diode lasers. Our solution provides superior performance in comparison to typical commercial solutions in the field, while being more economical and versatile due to its open source platform. Our laser current driver offers full digital control, sub-ppm drift and the lowest noise in class. Additional features are a high compliance voltage of more than 10 V to drive modern and exotic laser diodes and a modulation bandwidth with linear response of more than 1 MHz.

Our temperature controller features best in class noise of $<5\ \mu K_{RMS}$ and stability of $<100\ \mu K$ (@ 25 °C) over several weeks limited only by ambient humidity. Our system offers two channels with independant control and up to 60 W.

For both devices, we intend to make the hardware and software publicly available under an open source license to allow full customization.

Q 3.7 Mon 16:30 P

PHONQEE: Playful Hands-on-Quantum Early Education — •Slava Tzanova[1], Wolfgang Dür[2], Stefan Heusler[3], and Ulrich Hoff[4] — [1]qutools GmbH, Munich, Germany — [2]University of Innsbruck, Innsbruck, Austria — [3]University of Muenster, Muenster, Germany — [4]Technical University of Denmark, Kongens Lyngby, Dänemark

The PHONQEE project is exploring novel didactical approaches to teaching of quantum physics, spurring curiosity about quantum phenomena and their interpretation and applications, and stimulating scientific creativity and inquisitive learning in high-school education. The ambition is to facilitate deep learning and assist the students' assimilation of new knowledge about quantum physics by creating a cheerful learning environment and making the abstract concrete. The project has an undivided focus on 'hands-on' as physical and tactile activity has unique learning and retention benefits over purely digital approaches. Specifically, we will merge humour-driven and game-based approaches into a novel highly stimulating and fun-to-work-with educational material that prepares students in a strongly inquisitive state which is the ideal starting point for an encounter with a minituarized photonics laboratory - the Quantenkoffer. The PHONQUEE project will contribute to the creation of awareness, fascination, and understanding of quantum physics.

Q 3.8 Mon 16:30 P

Lasersystem for Control of Magnsium Atoms — •Lennart Guth, Philip Kiefer, Deviprasath Palani, Florian Hasse, Ulrich Warring, and Tobias Schätz — Physikalisches Institut, Albert-Ludwigs-Universität Freiburg

Trapped ions present a promising platform for quantum simulations and computations. High fidelity control of this platform requires versatile and robust laser systems with narrow bandwidth and a high level of power and intensity stability. The latest systems are based on vertical external-cavity surface-emitting lasers(VECSEL)[1] in the near-infrared. The light is sent into two modular-built frequency doubling stages: (i)a lithium triborate cavity and (ii)a beta barium borate cavity to generate the required ultra-violet light. Here, we present benchmark measurements and demonstrate the performance for photoionization($\lambda \approx$ 1140nm, P=1.7W) and sideband cooling($\lambda \approx$ 1120nm, P> 3W, linewidth on short time scales $\nu \simeq$ 0.6MHz) of magnesium ions.

[1]Burd, S. et al.(2016), VECSEL systems for generation and manipulation of trapped magnesium ions, Optica Vol. 3, Issue 12, pp. 1294-1299 (2016)

Q 3.9 Mon 16:30 P

Fluorescent Silica Aerogels for Random Lasing — •Matthias F. Kestler, Theobald Lohmüller, and Jochen Feldmann — Chair for Photonics and Optoelectronics, Nano-Institute Munich and Department of Physics, Ludwig-Maximilians-Universität (LMU), Königinstr. 10, 80539 Munich, Germany

Aerogels are translucent, low density materials that display a high surface-to-volume ratio and an extremely low thermal conductivity. Being a porous network of colloidal particles, they scatter light at visible wavelengths. Furthermore, the aerogel matrix can be doped with fluorescent dyes or nanoparticles, which enables their wider use for optical applications such as random lasing. Here, we report on the synthesis of fluorescent silica aerogels by supercritical drying of dye-doped liquid gels. By our refined process, we obtain large amorphous samples with micrometer-sized pores, where scattering events lead to closed photon paths that can act as micrometer range cavities. We analyze the corresponding photoluminescence, amplified stimulated emission and random lasing spectra that are obtained for different dye-loaded aerogel samples. In the case of random lasing, we observe that the extraordinary thermal stability of aerogels benefits the use of high laser pumping energies without visible sample degradation.

Q 3.10 Mon 16:30 P

Terahertz spectroscopy with undetected photons — •Mirco Kutas[1,2], Björn Haase[1,2], Jens Klier[1], Georg von Freymann[1,2], and Daniel Molter[1] — [1]Center for Materials Characterization and Testing, Fraunhofer ITWM, Kaiserslautern, Germany — [2]Department of Physics and Research Center OPTIMAS, Technische Universität Kaiserslautern (TUK), Germany

Terahertz technology has proven its applicability to scientific and industrial tasks, but generation and detection of terahertz waves is often still technically complex. New quantum optical concepts provide highly attractive alternatives for the access to this spectral range. By using nonlinear interferometry, it is possible to transfer the photon properties after interaction with the sample to visible photons. As a result, the detection can be realized by widely available and highly developed CMOS sensors without the need of cooling or expensive pulsed lasers. We report on the demonstration of spectroscopy in the terahertz frequency range measuring absorption features of chemicals by only detecting visible photons [1].

[1] Kutas et al., Optica 8(4), 438-441 (2021)