Q 7: Poster I

Time: Monday 16:30–19:00 Location: Empore Lichthof

Q 7.1 Mon 16:30 Empore Lichthof

Power scaling of an Yb-doped diode-pumped mode-locked laser — •Thomas Konrad[1], Andy Steinmann[1], Tobias Steinle[1], Monika Ubl[1], Matthias Seibold[2], Gabriele Untereiner[3], Mario Hentschel[1], Philipp Flad[1], and Harald Giessen[1] — [1]4th Physics Institute, Research Center SCoPE, and IQST, University of Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany — [2]IHFG, Universität Stuttgart, Allmandring 3, 70569 Stuttgart, Germany — [3]1st Physics Institute, University of Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany

Today's high power solid-state lasers are often constructed as thin-disk lasers. They require complex and expensive pumping systems. An easier and cheaper way is using solid-state lasers with conventional bulk crystals. They cannot reach the power levels of thin-disk lasers, but can still provide sufficient peak power for many applications such as nonlinear frequency conversion, yet being cheaper than disk lasers. In this work we follow different approaches to increase the average power of a femtosecond mode-locked Yb:KGW laser with a dual crystal cavity design. One important aspect is improving the crystal cooling to overcome thermal limitations. This can be realized by soldering the crystal to the heat sink to improve the thermal contact. Other aspects include optimizing crystal dimensions, doping concentrations, as well as pump and mode sizes.

Q 7.2 Mon 16:30 Empore Lichthof

5 W high power femtosecond laser at 2060 nm from a stabilized doubly resonant optical parametric oscillator — •han rao[1,2], Christian markus dietrich[1,2], José ricardo cardoso de andrade[3], robin mevert[1,2], fridolin jakob geesmann[1], ayhan demicran[1,2], ihar babushkin[1,2,3], and uwe morgner[1,2] — [1]Leibniz University Hannover, Institute of Quantum Optics, Hannover, Germany — [2]Cluster of Excellence PhoenixD, Hannover, Germany — [3]Max Born Institute, Berlin, Germany

A high power 2 μm femtosecond laser source is demonstrated by a degenerate doubly resonant optical parametric oscillator (DROPO), which is synchronously-pumped by a home-built Yb:YAG Kerr-lens mode-locked thin-disk laser, emitting pulses at wavelength of 1030 nm with a pulse duration of 270 fs, 25 W output power and 32.5 MHz repetition rate. By using a dither-free scheme which utilizes a "parasitic" sum-frequency generation (SFG) of the signal and pump intracavity as error signal, we stabilize our degenerate DROPO. A stable output power of 4.9 W at degeneracy is observed with a pump power of 18.7 W, which results in a conversion efficiency of 26%. The long-term stability measurement of the power over 40 minutes showed a root mean square (RMS) power noise of 1.1%.

Q 7.3 Mon 16:30 Empore Lichthof

Towards generation of high power 2 μm pulses in the few cycle regime — •Jon Morten Drees[1], David Zuber[1,2], Ihar Babushkin[1,2,3], and Uwe Morgner[1,2,4] — [1]Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover, Germany — [2]Cluster of Excellence PhoenixD (Photonics, Optics, and Engineering-Innovation Across Disciplines) 30167 Hannover, Germany — [3]Max Born Institute, Max-Born-Straße 2a, 10117 Berlin, Germany — [4]Laser Zentrum Hannover e.V., Hollerithallee 8, 30419 Hannover, Germany

Ultrashort pulses in the short-wavelength infrared (SWIR) can be used for various applications such as high harmonic generation or an all-optical Attoclock. Most of the systems that provide such radiation are built with laser materials based on thulium or Cr:ZnSe. While such Systems can achieve high output powers they usually have relatively long pulse durations and require additional pulse compression to reach the few cycle regime. Due to this disadvantage we wanted to go another way to create 2 μm radiation. A regenerative amplifier, providing 750 μJ pulses at 1030 nm with a repetition rate of 100 kHz, is used to generate white-light at 700 nm, which is amplified in a non-collinear optical parametric amplifier (NOPA). By difference frequency generation with the 1030 nm pump a 2 μm seed can be generated efficiently. With two additional NOPA stages the SWIR pulse can then be amplified to achieve high pulse energies. This approach will allow us to achieve pulse durations of approximately 20 fs with pulse energies of up to 100 μJ.

Q 7.4 Mon 16:30 Empore Lichthof

Compression of Laser Pulses by Nonlinear Multipass Cells — •Peer Biesterfeld[1], David Zuber[1,2], Jose Mapa[1], and Uwe Morgner[1,2,3] — [1]Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover, Germany — [2]Cluster of Excellence PhoenixD (Photonics, Optics, and Engineering-Innovation Across Disciplines) 30167 Hannover, Germany — [3]Laser Zentrum Hannover e.V., Hollerithallee 8, 30419 Hannover, Germany

Due to the high efficiency, good scalability to high pulse energies and compactness multipass cells (MPCs) for post compression of laser pulses, are currently of high interest. In particular, gas-filled MPCs enable the compression of pulses with high pulse energies and simultaneously high average powers with efficiencies higher than 90%.

The compression of picosecond pulses to the few cycle regime is beyond the limits of a single MPC. To find the best way simulations based on the unidirectional pulse propagation equation (UPPE) in cylindrical coordinates are performed, leading to a two stage setup. In the first cell, a high compression ratio is achieved in order to exploit the high reflectivity of broadband dielectric mirrors. The high compression factor is achieved by using molecular gases as a nonlinear medium at comparatively low gas pressure and low cost. Gires-Tournois Interferometers (GTIs) are being used to compress the pulse before the second cell, which is operated in an atomic noble gas using silver mirrors.

To verify the functionality of the cell, the spectral, temporal and spatial characteristics of the output are measured and compared with the simulation results.

Q 7.5 Mon 16:30 Empore Lichthof

Low order harmonic generation in laser induced borosilicate glass plasma and CdTe quantum dots — •Victor Kärcher[1], Tobias Reika[1], Pedro F. G. M. da Costa[2], Andrea S.S. de Camargo[2], and Helmut Zacharias[1] — [1]Center for Soft Nanoscience, Busso-Peus Str. 10, 48149 Münster — [2]Sao Carlos Institute of Physics, University of Sao Paulo, Brazil

An investigation of the size dependent influence of CdTe quantum dots on the generation of low order harmonics up to the fifth order in laser induced plasma (LIP) of borosilicate glass for a fundamental wavelength of $\lambda=1030$\,nm and a pulse duration of $\tau=40$\,fs is presented. The aqueous soluble CdTe quantum dots are generated by seed-mediated growth approach. The CdTe nano particles are spin coated with different thicknesses on the surface. Laser intensities above ionization threshold are used to generate the plasma by laser induced optical breakdown. Electrons are accelerated in the electric field emitting harmonics after subsequent recombination. The resulting third harmonic is characterized by blue shifts originating from Raman and phonon lines of the targets. Applying CdTe quantum dots on the targets surface spectral shaping with different sizes and different coating thicknesses is observed. Peak amplification factors between 10 an 17 for small and large particles respectively are reached for the third harmonic while no size dependency of the power density is observed. The fifth harmonic is unaffected by Raman and phonon lines and no spectral shaping is observed as for the third. Amplification factors between 25 and 20 for small and large particle sizes respectively are observed.

Q 7.6 Mon 16:30 Empore Lichthof

Light-field control of electrons in graphene heterojunctions — •Tobias Boolakee[1], Christian Heide[1], Antonio Garzón-Ramírez[2], Heiko B. Weber[1], Ignacio Franco[2,3], and Peter Hommelhoff[1] — [1]Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), 91058 Erlangen — [2]Department of Chemistry, University of Rochester, Rochester, New York, USA — [3]Department of Physics, University of Rochester, Rochester, New York, USA

Ultrashort and intense laser pulses enable the observation and control of electronic processes in a wide variety of systems ranging from atomic and molecular processes to the microscopic motion of electrons inside solids. The time scale of this motion is set by the oscillation period of light, i.e., a few femtoseconds, and thus limits a potential bandwidth of emerging electric currents up to the petahertz range. Here we discuss strong-field physics in graphene, an electric conductor, and therefore, an ideal platform to drive and probe currents induced by the shape of the laser electric field. We can distinguish and take advantage of two types of charge carriers: Real carriers, persisting after their excitation, and virtual carriers, existing during the light-matter interaction only. We show that in a gold-graphene-gold heterostructure, the two types of carriers can be disentangled in their photocurrent response, as they are susceptible to the carrier-envelope phase of incident few-cycle laser pulses. These insights now enable us to design and demonstrate a proof-of-concept of an ultrafast logic gate.

Q 7.7 Mon 16:30 Empore Lichthof

Design and construction of a multi-hit-capable electron spectrometer for ultrafast photoemission experiments — •Jonathan Pölloth, Jonas Heimerl, and Peter Hommelhoff — Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), 91058 Erlangen.

The investigation of electron photoemission from metallic needle tips by femtosecond laser pulses allows to gain insights into ultrafast light-matter interaction processes. An important observable is the energy spectrum of the emitted electrons. Two typical features of such strong field spectra are the multiphoton peaks and the plateau due to rescattering. So far, mostly one-electron spectra have been considered, only recently first experiments on multi-electron emission were realised [1,2]. The energy-resolved simultaneous detection of more than one electron from one laser pulse is challenging. Here, we demonstrate a multi-hit-capable electron spectrometer for measuring electron energy spectra emitted from a tungsten needle tip. We use an electrostatic cylindrical deflector analyser that provides spatial separation of different electron energies. The spectrometer is designed and optimized using a commercial finite element solver. Our simulations show that an energy resolution below 0.25 eV at a central electron energy of 100 eV is feasible. This resolution not only allows us to observe strong field effects in the spectrum, but also to distinguish between different multiphoton order peaks.

[1] S. Meier, J. Heimerl and P. Hommelhoff, arXiv:2209.11806 (2022)
[2] R. Haindl et al., arXiv:2209.12300, (2022)

Q 7.8 Mon 16:30 Empore Lichthof

Guided acceleration in dielectric laser accelerators — •Leon Brückner, Tomás Chlouba, Johannes Illmer, Stefanie Kraus, Julian Litzel, Roy Shiloh, and Peter Hommelhoff — Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), 91058 Erlangen

Dielectric laser accelerators (DLA) are a highly promising technology that could enable the miniaturiziation of accelerators to tabletop or even microchip size. A DLA consists of a silicon nanostructure that is illuminated with a pulsed laser. This creates an evanescent near-field that accelerates electrons entering the channel of the structure. To reach high energies, it is necessary to extend this interaction from micrometer length to millimeters or more. This is challenging as the electrons also experience deflecting forces and are eventually lost. To counteract this, we have employed an alternating phase focusing scheme: the electrons experience alternating transversal focusing and defocusing forces, guiding them through the structure. We could guide a 28.4 keV electron beam through the 225 nm wide channel of a 77 μm long nanostructure [1]. To accelerate with this scheme, it is also necessary to continuously change the grating periodicity (tapering) to conserve phase-matching between the particles and the accelerating field. We have developed and fabricated structures with lengths of several hundred micrometers that combine particle guiding with tapering. These structures will enable acceleration over much longer distances than previously possible. We will report the current state of the experiment. [1] R. Shiloh et al., Nature 597, 498-502 (2021)

Q 7.9 Mon 16:30 Empore Lichthof

Selective intracavity control of interlaced femtosecond soliton combs — •Julia A. Lang[1], Luca Nimmesgern[1], Sarah R. Hutter[2], Alfred Leitenstorfer[2], and Georg Herink[1] — [1]Universität Bayreuth, Deutschland — [2]Universität Konstanz, Deutschland

Complex sequences of multiple solitons are observed in almost all ultrafast mode-locked laser, but their dynamics remain difficult to access, control, or eventually apply. In this contribution, we present deterministic control of relative soliton motion between two interlaced harmonic mode-locked frequency combs. We implement intra-cavity control by acousto-optic modulation allowing us to selectively address pulses in a 40 MHz Er:fiber laser. The soliton trajectories following the external stimulus are rapid, tuneable and deterministic. As shown in [1], intracavity feedback plays an important role in the formation of stable soliton molecules. In this work, we experimentally resolve and analyse the dynamics in the frame of soliton interaction with an effective binding potential. As a proof-of-concept, we demonstrate first steps towards the use of tuneable intracavity soliton motions for ultrafast pump-probe spectroscopy.

[1] Nimmesgern, Luca et al. Soliton molecules in femtosecond fiber lasers: universal binding mechanism and direct electronic control. Optica 8, 10 (2021).

Q 7.10 Mon 16:30 Empore Lichthof

Bi-chromatic current excitation in 2D-materials with complex laser fields — •Simon Wittigschlager[1], Tobias Boolakee[1], Christian Heide[2], and Peter Hommelhoff[1] — [1]Department Physik, Friedrich-Alexander-Universität Erlangen (FAU), Erlangen-Nürnberg, Germany — [2]Stanford PULSE Institute, SLAC National Accelerator Laboratory, Menlo Park, California, USA

We present a highly versatile and stable scheme to drive ultrafast light field-induced currents in solids using bi-chromatic laser fields (1550 nm and 775 nm) with full control over the polarisation states of both colours to form complex sum fields. We use these laser fields to steer electrons inside 2D-materials on trajectories, tailored to probe specific characteristics of their underlying band structure. In particular, if the field waveform is asymmetric with respect to time inversion, a momentum imbalance of excited electrons may occur, resulting in a measurable photocurrent. Importantly, while such schemes are usually realized as a Michelson interferometer with both colours separated spatially, our collinear approach grants superior stability with 2.99 mrad long-term phase jitter without the use of active stabilization techniques. We expect this highly stable setup to form the basis for probing electronic phenomena in solids, such as spin polarisation, Berry curvature and topological states, with unprecedented resolution at ultrafast timescales.

Q 7.11 Mon 16:30 Empore Lichthof

Pseudo Thermal Light Source in the XUV for Diffraction Imaging — •Jonas Musall[1], Chris Sträche[1], Philip Mosel[1], Sven Fröhlich[1], David Theidel[2], Hamed Merdji[2], Uwe Morgner[1], and Milutin Kovacev[1] — [1]Institute of Quantum Optics, Cluster of Excellecnce PhoenixD and Quantum Frontiers, Leibniz University Hanover, Welfengarten 1, 30167 Hanover, Germany — [2]LOA, ENSTA ParisTech, CNRS, Ecole Polytechnique, UMR 7639, 828 Boulevard des Maréchaux, 91120 Palaiseau, France

Coherent diffraction imaging (CDI) is a widely-used approach for nanoscale imaging. Besides its frequent use at synchrotron facilities, developments in laser-driven high harmonic sources have made it available on a smaller scale. A less explored possibility is the use of incoherent radiation for diffraction imaging as presented just recently [1]. This would allow a large number of compact sources in the X-ray range to be used for diffraction imaging. We are developing a method to control the degree of coherence in harmonics at 13 nm to investigate the transfer from coherent to incoherent imaging. To achieve this, the harmonic beam is scattered on different densities and sizes of nanoparticles. Additionally, the generated incoherent light can yield useful information on the initial coherent light source, such as the spot size and temporal pulse width [2].

[1] Classen, Anton et al. in: Physical Review Letters 119 (2017), Issue 5 [2] Tamasaku, Kenji et al. in: Journal of Synchrotron Radiation 26 (2019), No. 6

Q 7.12 Mon 16:30 Empore Lichthof

Potential Hazards and Mitigation of X-Ray Radiation Generated by Laser-Induced Plasma from Research-Grade Laser Systems — •Philip Mosel[1], Sven Fröhlich[1], Jose Mapa[1], Sven Kleinert[1], David Zuber[1], Jan Düsing[2], Thomas Püster[2], Günther Dittmar[3], Uwe Morgner[1], and Milutin Kovacev[1] — [1]Institute of Quantum Optics, Cluster of Excellence PhoenixD and Quantum Frontiers, Leibniz Universität Hannover, Hannover, 30167 — [2]Laser Zentrum Hannover e.V., Hannover, 30419 — [3]Ingenieur-Büro Prof. Dr.-Ing. G. Dittmar, Aalen, 73433

Ultra-short pulses and high laser intensities are used in a variety of laser-matter applications in laboratories and industry. Such processes can lead to unwanted generation of X-rays, which are a dangerous radiation factor [1]. We present an analysis of the radiation dose rate and the emitted X-ray spectrum during ablation of a rotating copper cylinder as a function of different laser parameters [2]. Furthermore, we studied the X-ray emission from commonly used metals, alloys and ceramics for ultrafast laser processing [3]. The results show that focused sub-picosecond pulses with intensity higher than 10^{13} W/cm^2 can exceed the annual irradiation limit even in one hour, making adequate shielding a necessity for researchers' safety.

[1] Legall, Herbert, et al., Applied Physics A 125.8 (2019): 1-8.
[2] Mosel, Philip, et al., Optics Express 30.20 (2022): 37038-37050.
[3] Mosel, Philip, et al., Materials 14.16 (2021): 4397.

Q 7.13 Mon 16:30 Empore Lichthof

Coherent imaging using a high-harmonic source — •Chris Sträche, Jonas Musall, Philip Mosel, Sven Fröhlich, Uwe Morgner, and Milutin Kovacev — Leibniz Universität Hannover, Deutschland, Welfengarten 1, 30167 Hanover

With increasingly smaller structures in the semiconductor industry and biological samples in the nanometer range imaging is becoming a challenging task. According to recently published results a resolution around 16 nm can be achieved using coherent diffraction imaging (CDI) [1]. To enhance the resolution limit higher photon energies, scanning the sample with a well-defined beam and overlapping probe positions (Ptychography) can be used. Here we present diffraction imaging using 13 nm based on high-harmonic generation in a semiinfinite gas cell. A variety of samples ranging from basic resolution targets up to biological samples and electronic circuits are to be characterized. With this setup a resolution below 50 nm is expected to be achieved. Keywords: lensless imaging, high-harmonic generation, coherent diffraction imaging, Pytchography Quellen: [1] Eschen, Wilhelm, et al. "Material-specific high-resolution table-top extreme ultraviolet microscopy." Light: Science & Applications 11.1 (2022): 1-10.

Q 7.14 Mon 16:30 Empore Lichthof

Pulse Characterization by Frequency-Resolved Optical Gating (FROG) for Extreme-Ultraviolet (XUV) Frequency Comb Generation — •Fiona Sieber[1], Lennart Guth[1], Jan-Hendrik Oelmann[1], Tobias Heldt[1], Simon Angstenberger[1], Stepan Kokh[1], Janko Nauta[1,2], Nick Lackmann[1], Nele Griesbach[1], Thomas Pfeifer[1], and José R. Crespo López-Urrutia[1] — [1]Max-Planck-Institut for Nuclear Physics, Heidelberg, Germany — [2]Department of Physics, Swansea University, Singleton Park, SA2, United Kingdom

The characterization of femtosecond pulses, which play a major role in precision spectroscopy, is challenging due to the lack of an accurate time reference on the ultrafast scale. Therefore the pulse has to be referenced by itself. In the scope of transferring a near-infrared frequency comb with 100 MHz repetition rate to the XUV-regime via high harmonic generation (HHG), 80 W femtosecond pulses are characterized in the time and frequency domain before the HHG stage using a FROG set-up. [1] The pulse is overlapped with a delayed copy of itself in a nonlinear crystal and the generated second harmonic is detected by a Czerny-Turner spectrometer. The shape, duration and power spectral density of the laser pulse are retrieved from the recorded FROG traces (intensities dependent of frequency and delay) using a noise removal protocol and the ePIE algorithm [2].

[1] J. Nauta et al., Optics Express, Vol. 29, No. 2, 2624 (2018)
[2] P. Sidorenko et al., Optica, Vol. 3, No. 12, 1320 (2016)

Q 7.15 Mon 16:30 Empore Lichthof

A hard X-Ray Split-and-Delay Unit for the HED Instrument at the European XFEL — •Dennis Eckermann[1], Sebastian Roling[1], Matthias Rollnik[1], Peter Gawlitza[2], Karen Appel[3], Liuba Samoylova[3], Harald Sinn[3], Frank Siewert[4], Thomas Tschentscher[3], Frank Wahlert[1], Ulf Zastrau[3] und Helmut Zacharias[1] — [1]Westfälische Wilhelms Universität, Münster, Deutschland — [2]Frauenhofer Institut IWS, Dresden, Deutschland — [3]European XFEL GmbH, Hamburg, Deutschland — [4]HZB, Berlin, Deutschland

A concept of a Split-and-Delay Unit which is capable of doing hard X-Ray pump-probe Experiments.

Q 7.16 Mon 16:30 Empore Lichthof

Simulations of magnetic field amplification and electric field suppression in ultrashort optical laser pulses — •Lorenz Grünewald[1,2], Rodrigo Martín-Hernández[3], Elizaveta Gangrskaia[4], Valentina Shumakova[4], Carlos Hernández-García[3], and Sebastian Mai[1] — [1]Institute for Theoretical Chemistry, Faculty of Chemistry, University of Vienna, Währinger Str. 17, 1090 Vienna, Austria — [2]Vienna Doctoral School in Chemistry (DoSChem), University of Vienna, Währinger Str. 42, 1090 Vienna, Austria — [3]Grupo de Investigación en Aplicaciones del Láser y Fotónica (ALF-USAL), Dpt. Fisica Aplicada, Universidad de Salamanca, Pl. La Merced sn., E37008 Salamanca, Spain — [4]Institute for Photonics, Faculty of Electrical Engineering and Information Technology, TU Wien, Gußhausstr. 27-29, 1040 Vienna, Austria

We present particle-in-cell simulations of the electromagnetic fields of an ultrashort azimuthally polarized laser beam (APB), and demonstrate that they exhibit a region close to the beam axis with strong oscillating magnetic field and vanishing electric field. Upon focusing the APB on a small metal iris, a so-called aperture, fast oscillating ring currents are induced around the aperture circumference, which in turn generates an additional magnetic field (MF) contribution that strongly increases the MF strength at the beam center [3]. Improved experimental setups with different aperture geometries, which yield further enhancements, are suggested, enabling a MF-only spectroscopy. [1] DOI: 10.1016/j.ccr.2015.02.015, [2] DOI: 10.1364/JOSAB.32.000345, [3] DOI: 10.1021/acsphotonics.8b01312

Q 7.17 Mon 16:30 Empore Lichthof

Transportable Laser System Employing Fourier Limited Picosecond Pulses for Laser Cooling of Relativistic Ion Beams — •Benedikt Langfeld[1,2], Sebastian Klammes[3], and Thomas Walther[1,2] — [1]Technische Universität Darmstadt — [2]HFHF Darmstadt — [3]GSI Helmholtzzentrum für Schwerionenforschung GmbH

Laser cooling of relativistic ion beams has been shown to be a promising technique to generate cold ion beams with a small velocity distribution. To strongly reduce intrabeam scattering, a well-known problematic effect for high-intensity ion beams which broadens the velocity distribution, pulsed laser systems with broad bandwidths can be employed.

In this work, we present our tunable high repetition rate UV laser system. We have developed a transportable master-oscillator-power-amplifier system, supplying Fourier transform limited pulses with a continuously adjustable pulse length between 50 and 735 ps and repetition rate of 1 to 10 MHz. With two SHG stages, the desired wavelength of 257 nm with up to 4 W average power can be achieved. The combination of the tunable seed laser (3 nm @ IR seed wavelength) and the large Doppler shift allows to easily match the output wavelength to the cooling transition of the ions.

Q 7.18 Mon 16:30 Empore Lichthof

Coherent beam recombination of intense femtosecond beams/pulses after controllable beam break-up and spectral broadening by using optical vortex lattices — •Lyubomir Stoyanov[1,2], Alexander Dreischuh[2], and Gerhard Paulus[1,3] — [1]Institute of Optics and Quantum Electronics, Friedrich Schiller University, Max-Wien-Platz 1, 07743 Jena, Germany — [2]Department of Quantum Electronics, Faculty of Physics, Sofia University, 5 J. Bourchier Blvd., 1164 Sofia, Bulgaria — [3]Helmholtz Institute Jena, Helmholtzweg 4, 07743 Jena, Germany

Ultra-short laser pulse generation, as well as extreme nonlinear processes like high-harmonic generation, are extensively studied and still actively developing fields of modern photonics. Ever since their discovery, researchers are dealing with problems like spectral broadening, filamentation, pulse/beam diagnostics, pulse amplification, and coherent beam recombination. On the other hand, singular optics is another rapidly developing field in which subject of interest is the sculpting of a laser beam by nesting phase singularities in it.

At high beam/pulse intensities, the beams are prone to instabilities, which could be suppressed by controllable splitting of the beam into sub-beams. This makes sense only if there is a reliable way to coherently recombine the sub-beams after their spectral broadening for pulse compression prior entering the laser-matter interaction zone. Some novel approaches towards these unsolved problems in nonlinear optics, based on previous studies on laser beams carrying phase singularities, will be presented and discussed.

Q 7.19 Mon 16:30 Empore Lichthof

Higher-order mean-field theory of chiral waveguide QED — •Kasper Jan Kusmierek[1], Sahand Mahmoodian[1,2], Martin Cordier[3], Jakob Hinney[4], Arno Rauschenbeutel[3,4], Max Schemmer[3], Philipp Schneeweiss[3,4], Jürgen Volz[3,4], and Klemens Hammerer[1] — [1]Institut für theoretische Phyisk, Leiniz University Hannover, Hannover, Germany — [2]Centre for Engineered Quantum Systems, School of Physics, University of Sydney, Sydney, Australia — [3]Departement of Physics, Humboldt-Universität zu Berlin, Berlin, Germany — [4]Vienna Center for QuantumScience and Technology, Vienna, Austria

Waveguide QED with cold atoms provides a potent platform for the study of non-equi-librium, many-body, and open-system quantum dynamics. Here we apply an improved mean-field theory based on higher-order cumulant expansions to describe the experimentally relevant, but theoretically elusive, regime of weak coupling and strong driving of large ensembles. We determine the transmitted power, squeezing spectra and the degree of second-order coherence, and systematically check the convergence of the results by comparing expansions that truncate cumulants of few-particle correlations at increasing order. This reveals the important role of many-body and long-range correlations between atoms in steady state. Our approach allows to quantify the trade-off between anti-bunching and output power in previously inaccessible parameter regimes. Calculated squeezing spectra show good agreement with measured data, as we present here.

Q 7.20 Mon 16:30 Empore Lichthof

Collective radiative effects in nanofiber-coupled atomic ensembles: From timed Dicke states to full inversion — •Christian Liedl, Felix Tebbenjohanns, Constanze Bach, Sebastian Pucher, Arno Rauschenbeutel, and Philipp Schneeweiss — Department of Physics, Humboldt-Universität zu Berlin, 10099 Berlin, Germany

Dicke superradiance is a hallmark effect in quantum optics. There, an ensemble of initially excited atoms can emit a burst of light due to spontaneous phase locking of the atomic dipoles during their decay. In order to observe this phenomenon, the atoms are typically placed in close vicinity of each other. In contrast, here, we study superradiance using macroscopically separated atoms. Each atom is almost unidirectionally coupled to the nanofiber-guided mode, allowing us to describe the dynamics using a cascaded interaction model. In our experiment, we coherently invert up to 1000 atoms and study their decay dynamics. We analyze the role of coherent forward scattering over the whole parameter regime, from weak excitation to almost full inversion. We observe superradiant burst dynamics and find a characteristic threshold behavior. Finally, we find that the superradiant burst has a random phase with respect to the excitation laser. This confirms that the build-up of coherence during the decay indeed stems from spontaneous phase locking of the atoms, which lies at the heart of superradiant.

Q 7.21 Mon 16:30 Empore Lichthof

Ultrafast excitation exchange in multimode cavities — •Oliver Diekmann, Dmitry O. Krimer, and Stefan Rotter — Institute for Theoretical Physics, Vienna University of Technology (TU Wien), Vienna A-1040, Austria

The single-mode Jaynes-Cummings model has been of paramount importance in the development of quantum optics. Recently, also the strong coupling to more than a single mode of an electromagnetic resonator has drawn considerable interest. We investigate how this *superstrong* coupling regime can be harnessed to coherently control quantum systems. In particular, we show that elliptical cavities and Maxwell-Fish-Eye lenses can be used to implement a pulsed excitation-exchange between two quantum emitters. This periodic exchange is mediated by single photon pulses and can be extended to a photon-exchange between two atomic ensembles, for which the coupling strength is enhanced collectively. Our study illustrates how ideas from classical optics can be used in the realm of multimode strong coupling for applications in quantum technology.

Q 7.22 Mon 16:30 Empore Lichthof

Properties of few level atomic systems possessing a permanent dipole moment. — •Alexandra Mirzac — Insitute of Applied Physics, Academiei str.5, MD-2028, Chisinau, Moldova

The quantum optical properties of two- and three-level atomic systems interacting with electromagnetic field is an area of research directed to solve applied problems emerging in laser science, fluorescent spectroscopy, nano-imaging and quantum information theory.

Dipolar two-level atomic systems are widely researched to detect novel multiphoton features and terahertz emission properties. Three level atomic systems with permanent dipole moment include both the properties of a two- and three- level system simultaneously. One can switch between these properties as function of tunable Rabi frequency. Also, three-level system exhibit many coherent interference effects, which can serve as application for testing quantum protocols and information storage. For this reason, few level atomic dipolar systems are perspective setups for generation of tunable electromagnetic waves such as terahertz domain. Consequently, detection of effective terahertz radiation is an emerging task both for applied and theoretical quantum optics. Additionally, non-resonant multiphoton conversion from optical to microwave region is a feasible quantum technology, where few level dipolar systems can be used for solution development.

Thus, the permanent non-zero dipole moment improves the quantum optical properties of few level atomic system in comparison to the similar ones yet in the absence of the permanent dipole moment.

Q 7.23 Mon 16:30 Empore Lichthof

Cavity-enhanced spectroscopy of molecular quantum emitters — •Evgenij Vasilenko, Weizhe Li, Senthil Kuppusamy, Mario Ruben, and David Hunger — Institute for Quantum Materials and Technologies, Karlsruhe Institute of Technology (KIT)

Rare earth ions in solid-state hosts are a promising candidate for optically addressable spin qubits, owing to their excellent optical and spin coherence times. Recently, also rare earth ion-based molecular complexes have shown excellent optical coherence properties [1]. Due to the long optical lifetime of the optical transition $^5D_0$-$^7F_0$, an efficient spin-photon interface for quantum information processing requires the coupling of single ions to a microcavity. Open-access Fabry-Pérot fiber cavities have been demonstrated to achieve high quality factors and low mode volumes, while simultaneously offering large tunability and efficient collection of the cavity mode [2]. Since the used molecular quantum emitters require a cryogenic environment, the demands on mechanical stability of the cavity setup have a high priority. To tackle these challenges, we report on the development of a monolithic type of cavity assembly, sacrificing some lateral scanning ability for the purpose of significantly increasing the passive stability. We integrate molecules into the cavity in the form of a crystalline thin film on a macroscopic mirror and identify a sub-nanometer local surface roughness, sufficient to avoid excessive scattering loss. We report on first studies of cavity-enhanced emission spectroscopy.

[1] Serrano et al., Nature, 603, 241-246 (2022)
[2] Hunger et al., New J. Phys 12, 065038 (2010)

Q 7.24 Mon 16:30 Empore Lichthof

Spectral Theory of Non-Markovian Dissipative Phase Transitions — •Baptiste Debecker, John Martin, and Francois Damanet — Universite de Liege, Liege, Belgique

The generation of phase transitions in quantum systems by coupling to engineered reservoirs provides a powerful way of accessing otherwise inaccessible non-equilibrium properties. However, until now, the theory of dissipative phase transitions (DPTs) has only been well established for quantum systems coupled to idealised Markovian environments, where Liouvillian gap closing is a hallmark. Here we extend the well-known Markovian formalism to general non-Markovian quantum systems. Furthermore, we illustrate our approach by showing how it can be used to reveal DPTs in standard quantum optical models, where the Lindblad description fails to capture them.

Our theory paves the way for exploring the dissipative control of phase transitions beyond the limiting Markovian regime, which is particularly important for understanding real materials or various other experimental platforms such as in the solid state, cold atoms, or cavity and circuit QED.

Q 7.25 Mon 16:30 Empore Lichthof

Optical Microcavity with Coupled Single SiV^- Centers in a Nanodiamond for a Quantum Repeater Platform — •Selene Sachero[1], Robert Berghaus[1], Gregor Bayer[1], Andrea B Filipovski[1], Lukas Antoniuk[1], Niklas Lettner[1], Richard Waltrich[1], Marco Klotz[1], Patrick Maier[1], and Viatcheslav Agafonov[2] — [1]Institute for Quantum Optics, Ulm University, Germany — [2]Tours University, France

A quantum repeater node requires a long-lived memory that can be addressed coherently. Additionally, efficient writing and reading of quantum states with high rates are crucial. optical cavities can be used as spin-photon platforms to accomplish such requirements. By coupling silicon vacancy defect centers (SiV^-) in a nanodiamond to an open Fabry-Pérot cavity, our work paves the way for a light-matter interface with efficient coherent control. Our fully tunable cavity formed by two Bragg mirrors allows short cavity lengths down to $\approx 1\mu$m, and provides efficient coupling of the quantum emitter at liquid helium temperatures.

Here, we perform photoluminescence measurements of SiV^- centers and power-dependent photoluminescence excitation of single SiV^- centers by collecting the cavity modulated sideband. We observe spectrally stable emitters and measure a linewidth close to the Fourier limit below $\Delta\nu = 200$ MHz. With the Purcell-enhanced cavity signal we demonstrate coherent optical driving and access the electron spin all-optical in a strong external magnetic field.

Q 7.26 Mon 16:30 Empore Lichthof

Enhanced photon emission from hBN defects centers inside a tunable fiber-cavity — •Florian Feuchtmayr[1], Gregor Bayer[1], Stefan Häussler[1,2], Richard Waltrich[1], Noah Mendelson[3], Chi Li[3], David Hunger[4], Igor Aharonovich[3,5], and Alexander Kubanek[1,2] — [1]Inst. f. Quantenoptik, Uni Ulm, D — [2]Center f. Integ. Q. Science and Techn. (IQst), D — [3]School of Math./ Phys. Sciences, Univ. of Tech. Sydney, AUS — [4]Phys. Institut, Karlsruhe Inst. of Tech., D — [5]ARC Centre of Exc. f. Transf. Meta-Optical Systems, Univ. of Tech. Sydney, AUS

Coupling single quantum emitters to the mode of optical resonators is essential for the realization of quantum photonic devices. We present a hybrid system consisting of defect centers in a few-layer hexagonal boron nitride (hBN) sheet and a fiber-based Fabry-Pérot cavity. The smooth surface of the chemical vapor deposition grown hBN layers enables efficient integration into the cavity. This hybrid platform is operated over a broad spectral range of more than 30 nm. Owing to cavity funneling, large cavity-assisted signal enhancement up to 50-fold and strongly narrowed linewidths are demonstrated, a record for hBN-cavity systems. On top, we implement an excitation and readout scheme for resonant excitation, allowing to establish cavity-assisted photoluminescence excitation spectroscopy. In total, we reach a milestone for the deployment of 2D materials to fiber-based cavities in practical quantum technologies.

Q 7.27 Mon 16:30 Empore Lichthof

Onset of atomic selforganization in optical cavities: from quantum to thermal momentum distributions — •Tarek Moussa, Simon B. Jäger, Imke Schneider, and Sebastian Eggert — Physics Department and Research Center OPTIMAS, Technische Universität Kaiserslautern, D-67663, Kaiserslautern, Germany

We theoretically study the dynamics of transversally driven atoms coupled to a single-mode optical cavity. The atoms spontaneously form a structured pattern above a critical driving strength. This pattern formation is known as atomic selforganization and results in a Bragg grating of the atoms which supports constructive interference of scattered laser photons. We study this threshold using a mean-field treatment and as a function of the initial temperature of the atomic cloud. Below threshold, we analyze the response of the atomic gas which we find to be fundamentally different in the low and high temperature regimes. For thermal energies much lower than the photon recoil energy we find long-lived coherent oscillations. Instead, for thermal energies well above the recoil energy we find that all fluctuations are strongly damped. Using this insight, we explore the importance of thermal fluctuations regarding resonant parametric amplification realized by a time-periodic modulation of the driving strength.

Q 7.28 Mon 16:30 Empore Lichthof

Coupling and dissipation in a system of Yb atoms interacting with a cavity on a narrow line — •Dmitriy Sholokhov, Saran Shaju, Ke Li, and Jürgen Eschner — University of Saarland, Saarbrücken, Germany

^{174}Yb atoms are trapped in a MOT, using the 182 kHz narrow $^1S_0$ - $^3P_1$ (556 nm) transition, residing inside a high-finesse cavity (length 5 cm, finesse 45 000). The trap light also acts as side-pump creating strong atom-cavity interaction. We present a comprehensive investigation of the cavity output spectra for variable trap/pump light detuning, cavity detuning, and atom number. We compare the properties of the cavity light with free-space scattered light (fluorescence) in order to identify the coupling mechanisms and dissipation channels of the coupled system.

Q 7.29 Mon 16:30 Empore Lichthof

Collective atom-cavity coupling and non-linear dynamics with atoms with multilevel ground states — •Elmer Suarez[1], Federico Carollo[2], Igor Lesanovsky[2,3], Beatriz Olmos[2,3], Philippe W. Courteille[4], and Sebastian Slama[1] — [1]Center for Quantum Science and Physikalisches Institut, Eberhard-Karls Universität Tübingen, Auf der Morgenstelle 14, 72076 Tübingen, Germany — [2]Institut für Theoretische Physik, Universität Tübingen, Auf der Morgenstelle 14, 72076 Tübingen, Germany — [3]3School of Physics and Astronomy and Centre for the Mathematics and Theoretical Physics of Quantum Non-Equilibrium Systems, The University of Nottingham, Nottingham, NG7 2RD, United Kingdom — [4]Instituto de Física de São Carlos, Centro de pesquisa em óptica é fotônica, Universidade de São Paulo, Brazil

We investigate experimentally and theoretically the collective coupling between atoms with multilevel ground state manifolds and an optical cavity mode. The ensuing dynamics can be conveniently described by means of an effective dynamical atom-cavity coupling strength that depends on the occupation of the individual states and their coupling strengths with the cavity mode. This leads to a dynamical backaction of the atomic populations on the atom-cavity coupling strength. Our results show that the multilevel structure of electronic ground states can significantly alter the relaxation behavior in atom-cavity settings as compared to ensembles of two-level atoms.

Q 7.30 Mon 16:30 Empore Lichthof

Quantum entanglement of atoms in presence of dipole-dipole interaction — •Sergiu Bazgan, Nicolae Enaki, and Tatiana Paslari — Institute of Applied Physics, State University of Moldova, Chisinau, Moldova, Republic of

It is studied the interaction between the single-mode cavity field and the pair of indistinguishable two-level atoms. The proposed model takes into account the dipole-dipole interaction between two-level atoms. In good cavity limits, the analytical solution for the Schrodinger equation, in the presence of detuning between the cavity field and the atomic transition was obtained. With the help of this solution, the quantum-statistical properties of the system are investigated. Much attention is devoted to the entanglement between atoms. The influence of dipole-dipole interaction and detuning on the resonance on the formation of entanglement is investigated.

Q 7.31 Mon 16:30 Empore Lichthof

Bath Induced synchronization — •Sayan Roy and Giovanna Morigi — Universität des Saarlandes

Synchronization is a collective phenomenon observed in nature at various scales[1]. An important question is what are the basic ingredients leading to synchronization in the microscopic domain[2,3]. In this work, we analyze the dynamics of two qubits coupled to a chain of linear oscillators acting as a reservoir. This model is amenable to an analytical treatment, which allows us to identify the conditions when the interaction with the phononic bath induces self-sustained oscillations of the two qubits. We then discuss when these dynamics can be understood as quantum synchronization.

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Q 7.32 Mon 16:30 Empore Lichthof

Network self-organization: the role of the activation function — •Frederic Folz[1], Kurt Mehlhorn[2], and Giovanna Morigi[1] — [1]Theoretische Physik, Universität des Saarlandes, 66123 Saarbrücken, Germany — [2]Algorithms and Complexity Group, Max-Planck-Institut für Informatik, Saarland Informatics Campus, 66123 Saarbrücken, Germany

The interplay of nonlinear dynamics and noise is at the basis of coherent phenomena, such as stochastic resonance, synchronization, and noise-induced phase transitions. In a recent work we analysed network dynamics in the presence of Gaussian noise when the activation function, governing the dynamics of the network connections, is a sigmoidal (Hill) function. In these settings we demonstrated the onset of network topologies that maximize the transport efficiency and behave as noise-induced resonances. In this work we systematically analyse this behavior for different classes of activation functions. We identify the activation function that yields the most robust network configuration at the the maximal convergence speed. We then discuss possible applications to neural networks in the quantum domain.