Q 45: Photonics III

Time: Thursday 11:00–13:00 Location: A320

Q 45.1 Thu 11:00 A320

Probing nonlinear optical processes with free electrons — •Jan-Wilke Henke[1,2], Yujia Yang[3,4], F. Jasmin Kappert[1,2], Arslan S. Raja[3,4], Germaine Arend[1,2], Guanhao Huang[3,4], Armin Feist[1,2], Zheru Qiu[3,4], Rui Ning Wang[3,4], Aleksandr Tusnin[3,4], Alexey Tikan[3,4], Tobias J. Kippenberg[3,4], and Claus Ropers[1,2] — [1]Max Planck Institute for Multidisciplinary Sciences, Göttingen, Germany — [2]4th Physical Institute, University of Göttingen, Germany — [3]Institute of Physics, Swiss Federal Institute of Technology Lausanne (EPFL), Switzerland — [4]Center for Quantum Science and Engineering, Swiss Federal Institute of Technology Lausanne (EPFL), Switzerland

Integrated photonics has proven to facilitate the interaction of light with free electrons in electron microscopy by significantly boosting the coupling strength. This enables the exploration of quantum optics with free electrons as well as a probing of nonlinear optical effects inherent to integrated microresonators with electron spectroscopy.

Here, we harness the inelastic electron-light scattering to investigate the spatial and spectral properties of the electric field inside a high-Q silicon nitride microresonator. For increasing optical input powers, characteristic changes to the electron energy spectra that coincide with the formation of various nonlinear intracavity states including dissipative Kerr solitons are observed.

In the future, this enables new schemes in electron beam modulation and manipulation, while electron-based optical state probing may also be extended to different quantum states of light.

Q 45.2 Thu 11:15 A320

Incoherent diffractive imaging of (non)regular structures — •Sebastian Karl[1], Stefan Richter[1], Manuel Bojer[1], Fabian Trost[2], Kartik Ayyer[3], Henry Chapman[2], Ralf Röhlsberger[4], and Joachim von Zanthier[1] — [1]QOQI, FAU Erlangen Nürnberg, Germany — [2]Center for Free-Electron Laser Science CFEL, Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany — [3]Max Planck Institute for the Structure and Dynamics of Matter, Hamburg, Germany — [4]Helmholtz-Institut Jena, Germany

X-ray crystallography relies on coherent scattering for high resolution structure determination. However, often the predominant scattering mechanism is an incoherent process like fluorescence, introducing severe background in the coherent diffractogram. Incoherent diffractive imaging (IDI) aims to use this incoherently scattered light for structure determination by measuring second order correlations in the far field [1]. While in theory single shot 3d imaging would be possible using IDI, careful theoretical examinations place thresholds on its feasibility [2,3]. IDI has been implemented at the European XFEL using metal foils. After evaluations for regular structures have been performed [4], we discuss the evaluation progress for non-regular structures and comment on the possibility of ab initio phasing using third order correlations on this dataset [5].

[1] A. Classen et al, PRL 119, 053401, 2017 [2] F. Trost et al., New J. Phys. 22, 083070, 2020 [3] L. M. Lohse et al., Acta Cryst. A 77, 480-496, 2021 [4] F. Trost et al., to be published [5] N. Peard et al., arXiv:2210.03793

Q 45.3 Thu 11:30 A320

Optical Ramsey Spectroscopy on a Single Organic Molecule — •Yijun Wang[1], Vladislav Bushmakin[2], Guilherme Stein[2], Andreas Schell[1,3], and Ilja Gerhardt[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, Appelstraße 2, D-30167 Hannover, Germany — [2]3. Physikalisches Institut, Universität Stuttgart and Stuttgart Research Center of Photonic Engineering (SCoPE), Pfaffenwaldring 57, D-70569 Stuttgart, Germany — [3]Physikalisch-Technische Bundesanstalt, D-38116 Braunschweig, Germany

Single molecules are important players in quantum optics. Their coherence is of uttermost importance, since it influences the usage in quantum information processing, such as in quantum networking applications. We implement a pump-probe experiment in a Ramsey-type pulse sequence on a single 2.3,8.9-dibenzanthanthrene (DBATT) molecule to measure the optical coherence time and compare it with conventional methods [1]. The molecule is selected microscopically and spectroscopically at T=1.4 K. We also perform frequency-detuned excitation, gaining richer insights into the dephasing behavior of the molecule. The experiments exhibit that optical Ramsey spectroscopy is a promising tool for measuring the emitter's coherence properties.

[1] – Y. Wang, V. Bushmakin, G. Stein, A. Schell, and I. Gerhardt, *Optical Ramsey spectroscopy on a single molecule,* Optica **9**, 374-378 (2022).

Q 45.4 Thu 11:45 A320

Photoacoustic spectroscopy with a tunable narrowband infrared laser system — •Luca Schmid, Florent Kadriu, Sandro Kuppel, Tobias Steinle, and Harald Giessen — 4th Physics Institute and Research Center SCoPE, University of Stuttgart, Germany

We report on a photoacoustic setup with a narrowband picosecond ultrafast tunable laser system in the mid-infrared. The fingerprints of various atmospheric species such as humid ambient air and carbon dioxide overtones at 5000 cm^{-1} at 2000 ppm have been detected. The entire molecular overtone is scanned within a few seconds with a linewidth-limited resolution of 2 cm^{-1}. We quantify the signal-to-noise ratio and compare these data with theoretically calculated spectra from the HITRAN database. Even extremely weak resonances can be resolved owing to the excellent brilliance of the laser source with several hundreds of mW output power.

Q 45.5 Thu 12:00 A320

Thermodynamic control of stimulated Brillouin-Mandelstam scattering in liquid-core optical fiber — •Andreas Geilen[1,2], Alexandra Popp[1,2], Debayan Das[1,3], Saher Junaid[4,5], Christopher G. Poulton[6], Mario Chemnitz[7], Christoph Marquardt[1,2], Markus A. Schmidt[4,5], and Birgit Stiller[1,2] — [1]Max Planck Institute for the Science of Light, 91058 Erlangen, Germany — [2]Department of Physics, University of Erlangen-Nuremberg, 91058 Erlangen, Germany — [3]Université Bourgogne Franche-Comté, 25030 Besançon, France — [4]Leibniz Institute of Photonic Technology, 07745 Jena, Germany — [5]Otto Schott Institute of Materials Research, 07743 Jena, Germany — [6]School of Mathematical and Physical Sciences, University of Technology, Sydney, NSW 2007, Australia — [7]Centre Énergie Matériaux Télécommunications, Québec, J3X 1S2, Canada

We present temperature and pressure dependent Brillouin-Mandelstam scattering measurements inside a fully sealed, CS$_2$-filled liquid-core optical fiber. The confinement of the liquid inside the micrometer-size silica capillary allows us to control and investigate the thermodynamic behavior. Tuning the temperature from 5 °C to 135 °C we reach high pressure values above 1000 bar as well as substantial absolute negative pressure values below -300 bar. With this, the Brillouin frequency shift (BFS) can be tuned by 40%. Our platform offers a rich source for fundamental optoacoustic investigation of liquids in different thermodynamic states, maintaining all-fiber convenience, while the low BFS ($\approx$2.5 GHz) and a high temperature sensitivity of 7 MHz/°C are promising for sensing applications.

Q 45.6 Thu 12:15 A320

Optical solitons in curved spacetime — Felix Spengler[1], •Alessio Belenchia[1,2], Dennis Rätzel[3,4], and Daniel Braun[1] — [1]Institut für Theoretische Physik, Eberhard-Karls-Universität Tübingen, 72076 Tübingen, Germany — [2]Centre for Theoretical Atomic, Molecular, and Optical Physics, School of Mathematics and Physics, Queens University, Belfast BT7 1NN, United Kingdom — [3]ZARM, University of Bremen, Am Fallturm 2, 28359 Bremen, Germany — [4]Humboldt Universität zu Berlin, Institut für Physik, Newtonstraße 15, 12489 Berlin, Germany

From the seminal work of Plebanski in the '60s, we know that Maxwell equations in vacuum curved spacetime are equivalent to flat-spacetime Maxwell equations in the presence of a bi-anisotropic moving medium whose dielectric permittivity and magnetic permeability are determined entirely by the space-time metric. We will use this insight in order to describe light propagation in a non-linear stationary medium in curved spacetime. We will focus on the case of a weak gravitational field and, via a non-linear Schrödinger equation, describe the propagation of an optical pulse in an effective, gradient-index medium in flat spacetime, which encodes both the material properties and curved spacetime effects. Furthermore, in analyzing the special case of propagation in a 1D optical fiber, we will also include the effect of mechanical deformations and show it to be the dominant effect for a fiber oriented in the radial direction in Schwarzschild spacetime.

Q 45.7 Thu 12:30 A320

Optical control of one-dimensional topological end states via soliton formation — •Christina Jörg[1,2], Marius Jürgensen[2], Sebabrata Mukherjee[3], and Mikael C. Rechtsman[2] — [1]Physics Department and Research Center OPTIMAS, TU Kaiserslautern, D-67663 Kaiserslautern, Germany — [2]Department of Physics, The Pennsylvania State University, University Park, Pennsylvania 16802, USA — [3]Department of Physics, Indian Institute of Science, Bangalore 560012, India

Solitons are solutions of the nonlinear Schrödinger equation that maintain their shape during propagation. Here we show that soliton formation can be used to optically induce and control a linear topological end state in the bulk of a Su-Schrieffer-Heeger (SSH) lattice, using evanescently-coupled waveguide arrays. We observe an abrupt nonlinearly-induced transition above a certain power threshold due to an inversion symmetry-breaking nonlinear bifurcation of the soliton. We use a pump-probe framework such that the dynamics of the soliton is only coupled to the end state via the potential it induces, meaning that we may control the end state independently and all-optically. Specifically, we use orthogonal polarizations for the pump and probe: The pump induces the soliton and the probe experiences the potential induced by the soliton in which an end state appears as a result. In our case, the soliton acts as an all-optical switch to turn on and off the topological (linear) end state. Our results demonstrate all-optical active control of topological states.

Q 45.8 Thu 12:45 A320

From Berry phase to quantum skyrmions: a geometric loop tour in Physics — •Sinuhe Perea — Strand King's College London

In several physics systems the whole can be obtained as an exact copy of each of its parts, which facilitates the study of a complex system by looking carefully at its elements, separately. Reducionism offers simplified models which makes the problems easier, but “there's plenty of room...at the \emph{mesoscopic} scale”. Here we present a tour for two of its representants: Berry phase and skyrmions, studying some of its basic definitions and properties, and two cases in which both arise together, to finish constraining the scale for our mesoscopic system in the quest of quantum skyrmions, discovering which properties are conserved and which others may be destroyed. In several classical physics systems the whole can be obtained as an exact copy of each of its parts, which facilitates the study of a complex system by looking carefully at its elements, separately. Reducionism offers simplified models which makes the problems easier, but ”there's plenty of room...at the discrete scale”. Here we present a tour for two of its representants: Constant section fiber bundles and skyrmions, studying some of its basic definitions and properties, and an example where both arise together via domain wall analogy. We will finish constraining the scale for our mesoscopic system in the quest of quantum and photonic skyrmions from above via Hamiltonian local minimisation and for below via novel graphic re-writing evolution, discovering which properties are conserved and which others may be destroyed.