Q 67: Photonics III

Time: Friday 16:30–18:30 Location: UDL HS3038

Q 67.1 Fri 16:30 UDL HS3038

Mueller matrix coherent measurement with non-separable classical light — •Falk Töppel[1,2], Andrea Aiello[1,2], Christoph Marquardt[1,2], Elisabeth Giacobino[3], and Gerd Leuchs[1,2] — [1]Max Planck Institute for the Science of Light, Erlangen, Germany — [2]Institute for Optics, Information and Photonics, Universität Erlangen-Nürnberg, Erlangen, Germany — [3]Laboratoire Kastler Brossel, Université Pierre et Marie Curie, Ecole Normale Supérieure, CNRS, Paris, France

Quantum information theory shows that coherent measurements can provide more information than incoherent ones. Coherent measurements are represented by operators whose eigenstates are entangled, allowing to test several quantities in parallel. However, not all features of quantum entanglement are needed: Most coherent measurements require entanglement, but not non-locality. Some classical systems show the remarkable feature of non-separability, i.e., classical entanglement between different degrees of freedom. Particular examples are optical beams with non-uniform polarization patterns, e.g., cylindrically polarized modes. In this work we demonstrate that classical entanglement in cylindrically polarized beams of light permits achieving coherent measurement of the Mueller matrix of an optical element affecting polarization. In principle, our method allows the Mueller matrix reconstruction from a single shot measurement, whereas conventionally four probe beams of different polarizations are required. This example furnishes a proof of principle that tasks requiring entanglement but not non-locality may be accomplished by using classical systems.

Q 67.2 Fri 16:45 UDL HS3038

Optical realisation of weak measurements with non-integer orbital angular momentum states — •Jörg Götte — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden, Deutschland

Weak measurements typically require two non-orthogonal states, which are not eigenstates of an observable. This is why weak values of the orbital angular momentum (OAM) operator seem counterintuitive in optics, as the corresponding eigenstates are the orthogonal modes with azimuthal quantum number ℓ. Most schemes therefore involve additional auxiliary observables, such as polarization of the light, or a change to the conjugate basis, the angular position. We show how the use of light beams with non-integer OAM circumvents these problems and how weak values can be rigorously related to the position of phase singularities in the optical field of the pointer. This establishes firmly the connection between singular optics and the enhancement techniques common for weak values.

Q 67.3 Fri 17:00 UDL HS3038

Optical Vortex Generation from Molecular Chromophore Arrays — •Matt Coles[1,2], Mathew Williams[2], Kamel Saadi[2], David Bradshaw[2], and David Andrews[2] — [1]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden, Deutschland — [2]School of Chemistry, University of East Anglia, Norwich NR4 7TJ, United Kingdom

Light endowed with orbital angular momentum, frequently termed optical vortex light, is commonly generated by passing a conventional beam through suitably constructed optical elements; for example, optical phase plates or bifurcated diffraction gratings. It emerges that the necessary phase structure for vortex propagation can be produced directly through the creation of twisted light from the vacuum. The mechanism is founded on optical emission from a family of chromophore nano-arrays that satisfy specific constraints, based on geometric and symmetry arguments. Each such array can support pairs of electronically delocalized excitons whose angular phase progression is responsible for the twisted wave-front of the emitted radiation. These pairs are equal in energy, however their decay leads to optical vortex light with opposing signs. The exciton symmetry dictates the maximum magnitude of the orbital angular momentum and an analysis reveals the conditions necessary to deliver optical vortices with arbitrary twist.

Q 67.4 Fri 17:15 UDL HS3038

Angle cut, birefrigent whispering gallery mode resonators — •Florian Sedlmeir[1,2,3], Martin Hauer[1], Josef Fürst[1], Gerd Leuchs[1,2], and Harald G. L. Schwefel[1,2] — [1]Max Planck Institute for the Science of Light, 91058 Erlangen, Germany — [2]Intitute for Optics, Information and Photonics, University of Erlangen-Nuremberg, Germany — [3]SAOT, School of Advanced Optical Technologies, University of Erlangen-Nuremberg, Germany

Crystalline whispering gallery mode (WGM) resonators are widely used for multiple applications as their high Q factors, compact size and comparably small modal volumes permit highly efficient nonlinear processes. Usually such WGM resonators are fabricated in the z-cut geometry, where the optic axis coincides with the symmetry axis. In such a cavity, phasematching is difficult to achieve. In general it is only possible in a very narrow bandwidth and therefore limiting the tunability of the device. Recently WGM resonators in the x-cut geometry were investigated: They provide phasematching over a huge wavelength regime as one modal family (the extraordinary one) experiences a varying index of reflection around the resonators equator. We studied an even more general geometry: an angle cut (neither x- nor z-cut) magnesium fluoride resonator. Here we present our results on the linear properties of the modes in terms of position dependent polarization, $Q \sim 10^8$ factors and coupling behaviour. It turns out that there are at least three modal families showing different, in general elliptical, polarization.

Q 67.5 Fri 17:30 UDL HS3038

Microcavity-enhanced Spectroscopy of Carbon Nanotubes — •T Hümmer[1,2], H Kaupp[1,2], M Mader[1,2], J Noe[2], M Hofmann[2], A Högele[2], TW Hänsch[1,2], and D Hunger[1,2] — [1]Max-Planck-Institut für Quantenoptik, Garching — [2]Ludwig-Maximilians-Universität, München

We use fiber-based Fabry-Perot optical microcavities [1] with mode volumes down to a few tens of wavelengths cubed and high quality factors up to 10^7 to study single-walled carbon nanotubes (SWCNTs). Harnessing the full tunability and open access of these cavities allows us to address a variety of nanotubes individually at different locations and wavelengths with.

We achieve high sensitivity for absorption spectroscopy, allowing to locate and characterize individual SWCNTs. Furthermore, we detect Raman scattering strongly enhanced by the Purcell effect. Since the spectral emission is increased on the order of the cavity Finesse, which can be as large as 10^5, this enables us to measure Raman spectra with high sensitivity and spectral resolution.

Recent progress in the growth of freestanding SWCNTs has demonstrated that this system can show exceptional fluorescence properties, including a strong optical dipole transition, single photon emission characteristics, and potentially Fourier limited linewidth [2]. This promises an extensive potential for cavity QED in the strong coupling regime and access to novel regimes of cavity optomechanics.

[1] Hunger et al., NJP 12, 065038 (2010) [2] Hofmann et al., Nature Nanotechnology, Vol. 8 (7) (2013)

Q 67.6 Fri 17:45 UDL HS3038

Nonlinear vortex propagation in discrete photonic structures — •Evgenij Travkin, Falko Diebel, Patrick Rose, Martin Boguslawski, and Cornelia Denz — Institut für Angewandte Physik and Center for Nonlinear Science (CeNoS), Westfälische Wilhelms-Universität Münster, 48149 Münster, Germany

A focal topic in the field of photorefractive optics is the investigation of light propagation in optically induced photonic structures. Since light propagating in such environments interacts with both the photonic potential as well as the photorefractive medium, this allows for in-depth experimental studies of a whole class of nonlinear systems.

We investigate complex refractive index modulations optically induced in photorefractive media. Such index distributions are non-permanent, they can be easily adapted and are highly customizable. Using nondiffracting beams, it is possible to induce single two-dimensional waveguides at exactly chosen positions, thus forming discrete photonic waveguide arrays. One particular class of beams whose propagation is investigated in these arrays is constituted by optical vortices. These are light fields where the phase circles around a singular point, giving rise to a variety of fascinating propagation effects, such as 'vortex switching' or the formation of vortex solitons.

In this contribution we present the creation of tailored photonic structures and analyze the propagation of photonic vortices therein. The discussion of our experimental results is supplemented by corresponding numerical simulations.

Q 67.7 Fri 18:00 UDL HS3038

Optimization of Photonic Crystal Fiber Based Supercontinuum Generation for Hyperspectral CARS Imaging — •Stefan Gomes da Costa, Gregor Hehl, and Andreas Volkmer — 3rd Institute of Physics, University of Stuttgart, Germany

Central to hyperspectral Coherent Anti-Stokes Raman Scattering (CARS) imaging is the use of broadband supercontinuum (SC) pulses covering a spectral Raman shift range of more than 4000 cm-1. Conventionally, a SC pulse generated in a highly nonlinear photonic crystal fibre (PCF) using a femtosecond seed pulse have been used together with a narrowband pump pulse in the CARS process. To optimize CARS, where the spectral width of the pump pulse corresponds to the bandwidth of the vibrational resonance of interest, matching the temporal widths of both the picosecond pump and Stokes-SC pulses is required. Here, we report on both the numerical simulation and the experimental characterization of vibrational bandwidth-matched picosecond SC-based hyperspectral CARS imaging using a single Ti:sapphire laser oscillator with near-transform-limited picosecond pulses. The spectral and temporal characteristics of both femto- and picosecond PCF-based SC generation have been investigated by means of XFROG-CARS experiments and compared with its respective SC pulse simulations. We found good agreement between experiment and theory, which allowed us to further optimize the generation of picosecond SC pulses for CARS. We will present exemplifying applications of label-free, hyperspectral 3D-CARS imaging to the noninvasive and quantitative analysis of a biological system.

Q 67.8 Fri 18:15 UDL HS3038

Ptychography in Energy-Time Space for Mössbauer Spectroscopy — •Johann Haber and Ralf Röhlsberger — Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, 22607 Hamburg

Ptychography is a phase retrieval method that has recently been the subject of much attention in the fields of x-ray microscopy and phase contrast imaging. The x-ray beam, called probe, scans a sample, called object, in discrete steps. At every position the diffraction pattern is recorded. The measured amplitudes and the knowledge of the position of the probe at the time of their measurement form the so-called amplitude and probe constraints. An iterative phase retrieval algorithm is then able to reconstruct from random initial guesses the object and probe amplitudes and phases. Here, we extend this principle to phase retrieval of signals in energy and temporal domains. The object is the response function of a sample containing ^{57}Fe. The response function of the sample is scanned in energy space by an analyzer foil. For each energy step, a temporal beat pattern is measured. This gives us amplitude constraints in both energy and temporal space and a probe constraint to apply in the algorithm, which should enhance its stability. We apply the algorithm to simulations and measurements and discuss its sensitivity to noise and incomplete sampling in the temporal domain.