Q 65: Nano-Optics and Biophotonics

Time: Friday 10:30–12:15 Location: K 0.023

Q 65.1 Fri 10:30 K 0.023

High resolution isotropic particle localization with a monolithic 4π parabolic mirror — •Lucas Alber[1,2], Martin Fischer[1,2], Florian Loosen[1,2], Bharath Srivathsan[1], Johannes Stehr[2], Markus Sondermann[1,2], and Gerd Leuchs[1,2,3] — [1]Max-Planck-Institute for the Science of Light, Erlangen, Germany — [2]Institute of Optics, Information and Photonics (IOIP), Friedrich-Alexander University Erlangen-Nuremberg (FAU), Germany — [3]Department of Physics, University of Ottawa, Canada

3D localization of single emitters forms the basis for high resolution localization microscopy. Localization is commonly done by imaging the emitter with a high-NA microscopic setup. In our work, we present the experimental demonstration of tracking a single trapped ion incorporating a monolithic parabolic mirror as the primary collection optic spanning almost 4π solid angle. Instead of imaging the emitter, we record the wavefront aberrations that are induced by displacements of the ion from the focal point of the mirror. For the measurement, we use a home-made single-photon sensitive Shack-Hartmann sensor that is based on a EMCCD camera. By moving the ion-trap mounted on a 3D translation piezo-stage, we can determine the tracking accuracy that amounts to a few tens of nanometer. Since we incorporate a 4π parabolic mirror, we are able to demonstrate a nearly isotropic 3D tracking resolution while at the same time we collect more than half of the photons emitted by the ion. The high 3D resolution and collection efficiency enables more accurate tracking of weak emitters embedded in a three-dimensional specimen.

Q 65.2 Fri 10:45 K 0.023

Coherent 2D fluorescence micro-spectroscopy — •Donghai Li[1], Sebastian Götz[1], Tobias Brixner[1,4], Verena Kolb[2], and Jens Pflaum[2,3] — [1]Institute for Physical and Theoretical Chemistry, University of Würzburg, 97074 Würzburg — [2]Experimental Physics VI, University of Würzburg, 97074 Würzburg — [3]Bavarian Center for Applied Energy Research (ZAE Bayern), Magdalene-Schoch-Str. 3, 97074 Würzburg — [4]Center for Nanosystems Chemistry (CNC), Theodor-Boveri-Weg, 97074 Würzburg

It is important to explore the relation between the microscopic morphology of the materials and their intrinsic ultrafast energy transfer processes. However, traditional ultrafast spectroscopy techniques provide only spatially averaged optical information. In order to study ultrafast processes on nanoscale, we combine femtosecond 2D spectroscopy with high NA microscopy. These functionalities are implemented by pairing fluorescence microscopy with phase and amplitude pulse shaping of few-cycle NIR pulses. The pulse shaper enables us not only to use the iterative pulse-compression algorithm to achieve nearly transform-limited sub-10fs laser pulses at the focus position, but also to create delay- and phase-controllable pules trains for phase-cycling process in third order signal measurements. The designed microscope setup with high NA objective focuses the broadband beam to the diffraction limit with a FWHM of 300 nm. The capability of the setup is demonstrated by obtaining spatially resolved 2D electronic spectroscopy of laterally nanostructured fluorinated zinc phthalocyanine film.

Q 65.3 Fri 11:00 K 0.023

Artifact-free XUV Coherence Tomography by one-dimensional phase retrieval — •Julius Reinhard[1], Silvio Fuchs[1,2], Martin Wünsche[1,2], Jan Nathanael[1], Johann Jakob Abel[1], Felix Wiesner[1], Christian Rödel[2], and Gerhard Paulus[1,2] — [1]Institute of Optics and Quantumelectronics, Jena, Germany — [2]Helmholtz Institute Jena, Germany

We report on major advances of XUV Coherence Tomography (XCT), which enable artifact-free three-dimensional imaging of nanoscale objects. XCT is the XUV equivalent of Optical Coherence Tomography (OCT). By using the broad bandwidth of high harmonics of femtosecond laser pulses (HHG) the axial resolution of XCT can reach a few nanometers [1]. However the typically modulated HHG spectra need to be transformed into a continuous spectrum by averaging HHG spectra generated with slightly different fundamental frequencies [2]. A challenge for XCT is the reconstruction of the sample structure from the measured intensity reflectivity, as the backtransform without knowledge of the phase information leads to artifacts in the reconstructed image. This problem has recently been addressed by implementing a novel one-dimensional phase retrieval algorithm, which has ultimately led to the artifact-free reconstruction of three dimensional samples [3].

[1] S. Fuchs et al., Scientific Reports 6, 20658 (2016)
[2] M. Wünsche et al., Optics Express 25, 6936 (2017)
[3] S. Fuchs et al. Optica 4, 903 (2017)

Q 65.4 Fri 11:15 K 0.023

Structured illumination quantum correlation microscopy — •Anton Classen[1,2], Joachim von Zanthier[1,2], Marlan O. Scully[3,4,5], and Girish S. Agarwal[3] — [1]Institut für Optik, Information und Photonik and — [2]Erlangen Graduate School in Advanced Optical Technologies (SAOT), Universität Erlangen-Nürnberg, 91052 Erlangen — [3]Texas A&M University, College Station, Texas 77843, USA — [4]Princeton University, Princeton, New Jersey 08544, USA — [5]Baylor University, Waco, Texas 76798, USA

We propose to use intensity correlation microscopy in combination with structured illumination to image quantum emitters that exhibit antibunching with a resolution reaching far beyond the Rayleigh limit. Combining intensity measurements and intensity autocorrelations of order m creates an effective PSF with the FWHM shrunk by a factor of $\sqrt{m}$ [1,2]. Structured Illumination microscopy [3] on the other hand introduces a resolution improvement by a factor of 2 by the principle of moiré fringes. We show that for linear low-intensity excitation and linear optical detection the simultaneous use of both techniques leads to an in theory unlimited resolution power with the improvement scaling favorably as $m+\sqrt{m}$ [4]. This yields the technique to be of interest for microscopy including imaging of biological samples. We present the underlying theory and simulations that demonstrate the increased resolution power, and point out requirements for an experimental implementation. [1] T. Dertinger et al., PNAS 106, 22287 (2009); [2] O. Schwartz et al., PRA 85, 033812 (2012); [3] M. G. Gustafsson, J. Micr. 198, 82 (2000); [4] A. Classen et al., Optica 4, 580 (2017)

Q 65.5 Fri 11:30 K 0.023

Exploring protein structure with cryogenic optical localization in three dimensions — Daniel Boening, •Franz Ferdinand Wieser, and Vahid Sandoghdar — Max Planck Institute for the Science of Light, Erlangen, Germany

Super-resolution optical microscopy has considerably advanced the study of cellular processes, but optical access to the molecular structure of proteins and biomolecular assemblies remains very limited. We have recently exploited the enhanced photostability of fluorophores at cryogenic temperatures to increase the number of detected photons, thus reaching a significantly higher signal-to-noise ratio compared to room-temperature measurements. Using this approach, cryogenic optical localization in three dimensions (COLD) is capable of determining the positions of several fluorescent sites within a single protein at Angstrom resolution [1]. We present results on imaging DNA Origami, the four binding sites of streptavidin and the conformational state of the Per-ARNT-Sim domain of the histidine kinase CitA. With its high spatial resolution COLD opens new possibilities for obtaining quantitative structure information from small to medium sized biomolecules and for correlative measurements with established imaging methods.

[1] S. Weisenburger et al., Nature Methods 14, 141-144 (2017).

Q 65.6 Fri 11:45 K 0.023

Multi-pass (electron) microscopy for low damage imaging applications. — •Thomas Juffmann — Ecole Normale Superieure, Paris, France

Specimen damage is often a limiting factor when it comes to imaging biological specimens (e.g. in cryogenic electron microscopy or optical live-cell imaging). Improved sensitivity and spatial resolution can be obtained employing quantum measurement strategies. A technologically viable and quantum optimal approach to measuring small phase shifts is to pass each probe particle through the specimen multiple times. Employing self-imaging cavities, this idea can be applied to widefield microscopy. We show post-selected optical birefringence and absorption measurements beyond the single pass shot-noise limit and discuss the applicability of multi-pass microscopy to cryo-EM. Our EM simulations show that multi-pass TEM allows for a tenfold damage reduction in imaging small proteins.

Q 65.7 Fri 12:00 K 0.023

Femtosecond 3D printing of an entire mini-microscope for neurobiological applications — •Chenyang Zhang[1], Simon Thiele[2], Simon Ristok[1], Ksenia Weber[1], Alois Herkommer[2], and Harald Giessen[1] — [1]4th Physics Institute and Research Center SCoPE, University of Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany — [2]Institute of Technical Optics and Research Center SCoPE, University of Stuttgart, Pfaffenwaldring 9, 70569 Stuttgart, Germany

Using genetically modified mice, it is possible to observe the calcium ion transport in their brain cells. Green fluorescent protein with a peak luminescence at 510 nm indicates where the electric signals in the brain of mice flow after particular stimuli. Currently, a miniature microscope of the size in the range of centimeters is glued to the opened skull of the living mice. This allows for monitoring their thoughts. However, the size and weight of this microscope is hampering their motion and agility. Here, we demonstrate a 3D printed microscope imaging system including blue fluorescence excitation which allows for decent magnification and subsequent imaging. We utilize a femtosecond laser for printing. The size of the microscope is as small as a few mm, thus reducing the volume and the weight significantly.