Q 39: Nano-Optics II

Time: Wednesday 14:30–16:30 Location: f342

Q 39.1 Wed 14:30 f342

Cavity-enhanced Raman Microscopy of Individual Carbon Nanotubes — •Thomas Hümmer[1,2], Matthias S. Hofmann[1], Jonathan Noe[1], Alexander Högele[1], Theodor W. Hänsch[1,2], and David Hunger[1,2] — [1]Ludwig-Maximilians-Universität München, Deutschland — [2]Max-Planck Institut für Quantenoptik, Garching, Deutschland

We use a tunable high-finesse optical microcavity[1] to demonstrate Purcell enhancement of Raman scattering in combination with high-resolution scanning-cavity imaging[2]. We detect cavity-enhanced Raman spectra[3] of individual single-walled carbon nanotubes and colocalize measurements with cavity-enhanced absorption microscopy. Direct comparison with confocal Raman microscopy yields a 1000-times enhanced collectable Raman scattering spectral density and a 20-fold enhancement of the integrated count rate for the same excitation intensity. We expand the technique to hyperspectral imaging, where we can deduce information such as the diameter and the metallic or semiconducting character of the nanotubes. The quantitative character, the inherent spectral filtering, and the absence of intrinsic background in cavity-vacuum stimulated Raman scattering renders our technique a promising tool for molecular imaging.

[1] Hunger et al., NJP 12, 065038 (2010) [2] Mader et al., Nat Commun 6, 7249 (2015) [3] Hümmer et al., arXiv:1508.06810 (2015)

Q 39.2 Wed 14:45 f342

Suppression of spontaneous Raman scattering for resolution improvement in label-free microscopy — •Steffen Rieger[1], Klaus-Jochen Boller[2], and Carsten Fallnich[1,2] — [1]Institute of Applied Physics, Westfälische Wilhelms-Universität Münster, Germany — [2]MESA+ Institute for Nanotechnology, University of Twente, Enschede, The Netherlands

The electronic excitation of a complex molecule with UV light can lead to a significant change of its vibrational behavior and therefore to a heavily altered Raman spectrum. This effect can be used for the suppression of Raman scattering, which is a prerequisite for a STED-like resolution improvement in label-free microscopy [1].

We present first experimental results from our Resonance Raman Spectroscopy, which show already a suppression of specific Raman lines by up to 50 % relative to the background – an effect that is strong enough to provide a resolution improvement by more than a factor of two.

To achieve this, we currently use a spontaneous Raman scattering spectrometer with an excitation wavelength of 355 nm and pulse powers of up to 10 μJ to perform Resonance Raman Spectroscopy on the metal complex Tris(bipyridine)ruthenium(II) in Acetonitrile, which is known for its excited state Raman resonances.

[1] C. Cleff et al., Phys. Rev. A **86**, 023825 (2012).

Q 39.3 Wed 15:00 f342

Fast and Precise Studying of Dynamical Processes on Live Cell Membranes Using Interferometric Scattering Microscopy (iSCAT) — •Mihail Petev[1,2], Richard W. Taylor[1], Hawzhin Hozhabrpour[1,2], Christian Riess[2], and Vahid Sandoghdar[1,2] — [1]Max Planck Institute for the Science of Light,D-91058 Erlangen, Germany — [2]Fredrich-Alexander-Universitat Erlangen-Nurnberg (FAU), D-91058 Erlangen, Germany

By monitoring the diffusion of single transmembrane proteins within the live cell membrane, one gains much important understanding of their subtle and nuanced function and interactions. To monitor all of the rich dynamics of such proteins requires very high spatial and temporal resolution that should be sustained over long duration. These requirements are simply inaccessible by conventional fluorescence microscopes. Using interferometric scattering imaging (iSCAT) and by labeling single transmembrane proteins in the live HeLa cell with a gold nanoparticle, we are able to overcome these limitations.

iSCAT microscopy exploits coherent interference between sample-scattered light and a homodyne reference to measure weakly scattered signals with improved signal-to-noise ratio. The interferometric nature of the imaging is thus sensitive to the fine three-dimensional motion of the gold nano-probe on the cell membrane, which we are able to track with nanometric precision at the fast microsecond time scale. An additional advantage of this approach is that one can also extend it to label-free cell membrane imaging, thus eliminating any marker related effects.

Q 39.4 Wed 15:15 f342

Tabletop extreme ultraviolet coherence tomography — •Johann Jakob Abel[1], Silvio Fuchs[1,2], Martin Wünsche[1], Julius Biedermann[1], Stefan Aull[1], Jan Bernert[1], Christian Rödel[1,2], Max Möller[1], and Gerhard G. Paulus[1,2] — [1]Institute of Optics and Quantum Electronics, Friedrich-Schiller University of Jena, Max-Wien-Platz 1, Jena — [2]Helmholtz Institute Jena, Helmholtzweg 4, Jena

We present a tabletop setup of a 3D nanometer imaging technique called XUV coherence tomography (XCT). Our XCT setup uses broadband extreme ultraviolet radiation from high harmonic generation (HHG).

Optical coherence tomography (OCT) reaches axial resolution on the order of the coherence length $l_c \propto \lambda_0^2/\Delta\lambda_{FWHM}$ which only depends on spectral properties of the light source [1,2]. By using short wavelenghts XCT extends OCT by improving the axial resolution from micrometers to nanometers. In contrast to optical coherence tomography the depth resolution of XCT is mainly limited by transmission windows of the investigated sample [3]. XCT was sucessfully demonstrated at synchrotron sources in the silicon (30-99 eV) and the water transmisson window (280-530 eV), before.

Here we show results using a tabletop XCT setup. We investigated different silicon based samples and achieved depth resolution of 27 nm.

[1] D. Huang et al., *Science* **254**, 1178-1181 (1991). [2] W. Drexler and J. G. Fujimoto , *Optical Coherence Tomography* (Springer Verlag, Berlin, 2008). [3] S. Fuchs et al., *Appl. Phys. B* **106**, 789-795 (2012).

Q 39.5 Wed 15:30 f342

Entanglement-free sub-shot noise microscopy — •Thomas Juffmann, Brannon Klopfer, and Mark Kasevich — Stanford University, California 94305, USA

We present a new technique for sub-shot noise and low damage microscopy based on repeated probe sample interactions. We show first results in absorption and polarization microscopy as well as design studies for a low damage electron microscope based on the same principle.

Q 39.6 Wed 15:45 f342

A segmented printed-circuit-board trap for macroscopic particles — •Joachim Zoll, Heather Partner, Alexander Kuhlicke, and Oliver Benson — AG Nanooptik, Institut für Physik, Humboldt-Universität zu Berlin, Newtonstraße 15, 12489 Berlin, Germany

In this presentation, a linear Paul trap for the investigation of levitating macroscopic particles such as diamonds with nitrogen-vacancy-defects [1] is introduced. The trap consists of two printed-circuit-boards (PCB), which are easy and fast to fabricate. For a rapid characterization of many different particles, the trap is separated in 12 segments, to establish loading, storing and subsequent analysis. Good optical access is ensured through a window in the side of the PCB. This is important for the detection of low optical signals. I will present a finite-element-simulation of the pseudo-potential for different particles, which have been stabilized in the PCB-trap. The stability of the trap was tested with microspheres (SiO_2) and various diamonds under atmospheric pressure.

[1] A. Kuhlicke, A. Schell, J. Zoll, and O. Benson, Applied Physics Letters 105, 073101 (2014)

Q 39.7 Wed 16:00 f342

Fibre optic surface plasmon resonance sensor for smartphones — •Kort Bremer[1], Johanna Walter[2], and Bernhard Roth[1] — [1]Hanover Centre for Optical Technologies (HOT), Leibniz University Hannover, Nienburger Straße 17, 30167 Hannover, Germany — [2]Institute of Technical Chemistry (TCI), Leibniz University Hannover, Callinstrasse 5, 30167 Hannover, Germany

We have demonstrated a low-cost fibre optic surface plasmon resonance sensor designed for smartphones [1] which might be applied for the monitoring of biologically relevant molecules, personalized health care or environmental sensing in the future. For the sensor, the LED

and the camera at the back side of a smartphone are used as light source and detector, respectively, and no external electrical components are required for the operation. In a first application example the sensor was realized by using a plastic cladded silica glass fibre and an easy-to-implement silver coating technique. Light from the smartphone is coupled in and out of the optical fiber by using 45° fibre end-faces. A diffraction grating is applied in front of the camera to disperse the light into a line spectrum. In a proof of principle experiment the performance of the sensor was successfully evaluated by using different volume concentrations of glycerol solutions and a sensitivity of $5.96{\cdot}10^{-4}$ refractive index units (RIU)/pixel for a RI values between 1.33 and 1.36 was obtained. In the talk we present our latest work towards higher sensitivity and functionalization of the sensor system.

[1] K. Bremer and B. Roth, Opt. Express 2015, 23 (13), 17179-17184

Q 39.8 Wed 16:15 f342

Einzel-Ionen Mikroskopie — •Karin Groot-Berning[1,2], Georg Jacob[1], Sebastian Wolf[1], Ferdinand Schmidt-Kaler[1] und Kilian Singer[2] — [1]QUANTUM, Institut für Physik, Universität Mainz, Staudingerweg 7, 55128 Mainz, Germany — [2]Experimental Physik, Universität Kassel, Heinrich-Plett-Straße 40, 34132 Kassel, Germany

Wir berichten über ein neuartiges Transmissionsmikroskop auf der Grundlage einer linearen Paul-Falle. Dabei werden einzelne $^{40}Ca^{+}$ Ionen lasergekühlt und anschließend deterministisch extrahiert [1]. Dieses Verfahren kann zur Bildgebung verwendet werden und zeichnet sich zusätzlich durch eine äußerst geringe Aufladung oder Beschädigung der Probe aus. Dabei wird eine räumliche Auflösung von besser als 10nm erreicht [2]. Gegenüber herkömmlichen Quellen mit Poissonscher Teilchenzahlstatistik erlaubt unser deterministischer Ansatz ein verbessertes Signal-zu-Rausch Verhältnis. Als eine praktische Anwendung stellen wir mikroskopische Abbildungen von photonischen Strukturen in einem Diamantfilm vor.

Um den Informationsgewinn bei jeder Extraktion zu maximieren, nutzen wir die "Bayes experimental design" Methode. Damit bestimmen wir nm-genau die Position von Markierungen auf Diamant Proben, was für viele Anwendungen von Nutzen sein kann, wie z.B. für die Implantation einzelner Ionen bezüglich photonischer Strukturen oder Kontrollelektroden auf einer Probe.

[1] W. Schnitzler et al., Phys. Rev. Lett. 102, 070501 (2009).
[2] G. Jacob et al., arxiv.org:1405.6480 (2014).