Q 20: Nano-Optics II

Time: Tuesday 11:00–13:00 Location: P 11

Q 20.1 Tue 11:00 P 11

Color centers in pyramidal single crystal diamond scanning probes — •Richard Nelz[1], Philipp Fuchs[1], Oliver Opaluch[1], Selda Sonusen[1], Natalia Savenko[2], Vitali Podgursky[3], and Elke Neu[1] — [1]Universität des Saarlandes, Fakultät NT - Fachrichtung Physik, Campus E2.6, 66123 Saarbrücken — [2]Artech Carbon OÜ, Jõe 5, 10151 Tallinn, Estonia — [3]Tallinn University of Technology, Department of Materials Engineering, Ehitajate tee 5, 19086, Tallinn, Estonia

Nitrogen vacancy (NV) color centers in diamond are highly suitable as nanoscale quantum sensors e.g. for optical near fields and magnetic fields; the latter due to their coherent, optically addressable electronic spin [1]. To harness the NV centers' full potential for nanoscale imaging, scannable nanostructures (scanning probes) are required that simultaneously enable efficient extraction of color center fluorescence. However, fabricating such structures in top-down approaches requires extensive efforts in nanofabrication. In contrast, bottom-up approaches can form nanostructures during diamond growth. We here investigate in-situ created color centers in such commercially available single-crystal pyramidal diamond scanning probes and their usability as magnetic field sensors [2]. We summarize our results on fluorescence spectroscopy, spin characterization and numerical investigation of the photonic properties.

[1] L. Rondin et al., Rep. Prog. Phys. **77** 056503 (2014)
[2] R. Nelz et al., Appl. Phys. Lett. **109** 193105 (2016)

Q 20.2 Tue 11:15 P 11

Widefield Microwave Imaging using NV Centres — •Andrew Horsley[1], Janik Wolters[1], Patrick Appel[1], James Wood[1], Jocelyn Achard[2], Alexandre Tallaire[2], Patrick Maletinsky[1], and Philipp Treutlein[1] — [1]University of Basel, Switzerland — [2]LSPM, Universite Paris 13, France

We present a microscope for widefield electromagnetic field imaging using NV centres in diamond. We expect to realise $> 1\,\mathrm{mm}^2$ field of view and sub-ms temporal resolution, exceeding the state-of-the-art for widefield NV imaging. The microscope provides $5\,\mu$m spatial resolution, given by the thickness of the near-uniaxial NV layer, and our current sensitivity is hundreds of $\mathrm{nT\,Hz}^{-1/2}$, which we expect to improve.

We use the microscope for microwave near-field imaging, which we are pursuing in the context of microwave device characterisation [2-4]. Such devices form the backbone of many scientific and technological applications, from quantum devices (atom chips, ion traps, atomic clocks, qubits...) to telecommunications (wifi, mobile phones...). Our technique promises to transform device development, characterisation, and debugging. Our high-resolution NV microscope may also be of interest for medical microwave sensing and imaging, particularly in skin-cancer screening.

[1] Steinert et al., Rev. Sci. Instr. 81, 043705 (2010)
[2] Horsley and Treutlein, APL 108, 211102 (2016)
[3] Horsley, Du, and Treutlein, NJP (FTC), 17(11), 112002, (2015)
[4] Appel et al., NJP (FTC), 17(11), 112001, (2015)

Q 20.3 Tue 11:30 P 11

Kerker Condition based Antenna for Collimation of Single NV Fluorescence — •Niko Nikolay[1], Stefan Fasold[2], Günter Kewes[1], Isabelle Staude[2], and Oliver Benson[1] — [1]Humboldt Universität zu Berlin, Germany — [2]Friedrich-Schiller-University Jena, Germany

The main advantage of plasmonics compared to dielectric structures is their small size - typically in the subwavelength regime [1]. In combination with the concentration of the electromagnetic field in plasmonic antennae, a significant improvement of nanophotonic devices is expected. When high directivities are desired, these advantages however may vanish: Metallic collimating antennas, such as bull's eye or spiral antennas have sizes that are typically significantly larger than the operating wavelength [2]. With increasing size, also losses will become more prominent. When it comes to dielectric nanostructures the Kerker condition can be employed, as such structures can also support magnetic modes [3].

In this contribution we will introduce a dielectric antenna with a subwavelength size and discuss the coupling to the nitrogen vacancy center in nano diamond. Experimental results will be complemented by full numerical calculations.

[1] Schietinger, S. et al.,Nano letters, 9(4), 1694-1698.
[2] Lezec, H. J. et al., Science 297(5582), 820-822.
[3] Kerker, M. et al., JOSA, 73(6), 765-767.

Q 20.4 Tue 11:45 P 11

Radiative heat transfer between spatial nonlocal dielectric sphere and plate — •Robin Schmidt and Stefan Scheel — Institut für Physik, Universität Rostock, Albert-Einstein-Straße 23, D-18059 Rostock, Germany

With the advances in modern nanophotonics and nanooptics, ever smaller metallic and dielectric structures become feasible. The strongly confined evanescent fields are associated with enormous field enhancements, thus providing heat transfer rates orders of magnitudes larger than feasible in the conventional far-field limit [1]. At nanoscale separation, the thermal heat transfer rate is predicted to diverge for ever smaller separation distances. To overcome this unphysical behaviour, the spatial nonlocal properties of the media under consideration must be taken into account [2,3]. Here, we compute the energy flux between a spatially nonlocal sphere and a plate separated by a vacuum interface. The thermal sources are correlated according to the fluctuation-dissipation theorem. In this linear response regime, spill-out effects can be neglected. Therefore, we employ the Huygens principle and the extinction theorem together with Maxwell boundary conditions [4].

[1] E. Rousseau, *et al.*, Nat. Phot. **3**, 514 (2009).
[2] A. Kittel, W. Müller-Hirsch, J. Parisi, S.-A. Biehs, D. Reddig, and M. Holthaus, Phys. Rev. Lett. **95**, 224301 (2005).
[3] C. Henkel and K. Joulain, Appl. Phys. B **84**, 61 (2006).
[4] R. Schmidt and S. Scheel, Phys. Rev. A **93**, 033804 (2016).

Q 20.5 Tue 12:00 P 11

Universal systematic polarization-dependent errors at the wavelength-scale for position measurements in super-resolution microscopy — •Stefan Walser, Jürgen Volz, and Arno Rauschenbeutel — Atominstitut TU Wien

Super-resolution microscopy is a fast evolving field that revolutionized traditional optical microscopy. Using different techniques, these approaches enhance the precision of optical microscopy significantly beyond the standard resolution limit of $\frac{\lambda}{NA}$ and routinely reach resolutions of a few nanometers. Here we show experimentally that, depending on the polarization of the light emitted by the observed particle, systematic wavelength-scale errors can occur when determining the particle's position using centroid fitting techniques. Surprisingly the observed shifts are universal, i.e., they are independent of the numerical aperture NA or magnification of the imaging optics. We demonstrate this effect by imaging a single gold nano-particle with an optical microscope. We observe a shift of the particle's apparent position of up to 0.3λ when varying the polarization of the light ($wavelength : \lambda = 685nm$) emitted by the nano-particle.

Q 20.6 Tue 12:15 P 11

Three-dimensional XUV Coherence Tomography with nanometer resolution using a supercontinuum HHG source — •Jan Nathanael[1,2], Silvio Fuchs[1,2], Martin Wünsche[1,2], Johann Jakob Abel[1], Julius Reinhard[1], Stefan Aull[1], Max Möller[1,2], Christian Rödel[1,3], and Gerhard G Paulus[1,2] — [1]IOQ, Friedrich-Schiller-University Jena, Germany — [2]Helmholtz Institute Jena, Germany — [3]SLAC Nat. Accelerator Laboratory, USA

We report on recent achievements in the development of XUV Coherence Tomography (XCT), which is based upon the principle of OCT. XCT is a method to resolve multilayer samples at nanometer resolution in axial direction and was proven at synchrotron radiation sources [1]. A suitable lab-scaled XUV source for XCT is a table-top femtosecond laser in combination with a tunable optical parametric amplifier (OPA) as a driver for high-harmonic generation (HHG) due to its spectral broadness. With slightly varying the fundamental frequencies the resulting harmonic combs are shifted. By averaging over these spectra within a few seconds a continuous XUV spectrum is generated in the range of 30 to 200 eV [2]. With this XUV source that features a photon flux up to $3{\times}10^8$ photons per eV's XCT can provide non-destructive volumetric three-dimensional measurements with a resolution of about 30 nm axially and 20 micrometer laterally on a lab-scaled HHG setup. Moreover, layers with thicknesses even lower than the achieved axial resolution of XCT can be revealed qualitatively. [1] S. Fuchs et al., Scientific Reports 6, 20658 (2016) [2] M. Wünsche et al., Optics Express, submitted (2016)

Q 20.7 Tue 12:30 P 11

Measuring the Polarizability of Individual Nanoparticles — •Matthias Mader[1,2], Theodor W. Hänsch[1,2], and David Hunger[1,2,3] — [1]Ludwig-Maximilians-Universität München, Schellingstraße 4, 80799 München — [2]Max-Planck-Insitut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching — [3]KIT, Physikalisches Institut, Wolfgang-Gaede-Straße 1, 76131 Karlsruhe

Optical characterisation of individual nanosystems gives deep insight into their chemical and physical structure. Getting spectroscopy signals beyond flourescence on a single particle level is very demanding. Here we present a method to quantitatively retrieve the full polarizability tensor of an individual nanosystem within a single measurement using a Fabry-Perot microcavity. [1].

The cavity is built of a micro-machined and high-reflective coated end facet of a single mode optical fibre and a macroscopic plane mirror. By scanning it with respect to the fibre tip, the cavity mode is used as an ultra-sensitive spatially resolving probe for the optical properties of a sample placed on top of the plane mirror. We measure differential frequency shifts as well as the linewidth of several cavity modes to simultaneously infer the sample extinction and dispersion. Combining extinction and dispersion measurements allow for reconstruction of the polarizability tensor of individual paricles.

[1] D. Hunger, T. Steinmetz, Y. Colombe, C. Deutsch, T. W. Hänsch, J. Reichel, New J. Phys. 12, 065038 (2010)

[2] M. Mader, J. Reichel, T. W. Hänsch, D. Hunger, Nature Commun. 6 7249 (2015)

Q 20.8 Tue 12:45 P 11

Progress on quantum-inspired sensing of optically trapped microparticles — •Stefan Berg-Johansen[1,2], Martin Neugebauer[1,2], Peter Banzer[1,2], Andrea Aiello[1,2], Gerd Leuchs[1,2,3], and Christoph Marquardt[1,2] — [1]Max Planck Institute for the Science of Light, Staudstr. 2, D-91058 Erlangen, Germany — [2]Institute of Optics, Information and Photonics, University of Erlangen-Nuremberg, Staudtstr. 7/B2, D-91058 Erlangen, Germany — [3]Department of Physics, University of Ottawa, 25 Templeton, Ottawa, Ontario, K1N 6N5 Canada

We experimentally demonstrate optical trapping and simultaneous kinematic tracking in three dimensions of a dielectric microparticle using only a single beam. Our approach is based on the nonseparability of polarization and transverse spatial degrees of freedom in cylindrically polarized modes [1,2].

[1] R. J. C. Spreeuw, Phys. Rev. A **63**, 062302 (2001).

[2] S. Berg-Johansen, F. Töppel *et al.*, Optica **2**(10), 864 (2015).