CPP 22: Plasmonics I (joint session O/CPP)

Time: Tuesday 10:30–12:45 Location: H8

CPP 22.1 Tue 10:30 H8

Creating functional plasmonic fields with orbital angular momentum via meta structures — •Eva Prinz[1,2], Grisha Spektor[3], Michael Hartelt[1], Anna-Katharina Mahro[1], Meir Orenstein[3], and Martin Aeschlimann[1] — [1]Department of Physics and Research Center OPTIMAS, TU Kaiserslautern, Germany — [2]Graduate School Materials Science in Mainz, Staudingerweg 9, 55128 Mainz, Germany — [3]Department of Electrical Engineering, Technion - Israel Institute of Technology, Israel

Optical fields can carry spin angular momentum (SAM) in the form of circularly polarized light and orbital angular momentum (OAM) as helical wavefronts. In the field of plasmonics, surface plasmon polaritons (SPPs) can carry surface confined OAM in the form of plasmonic vortices. Controlling such vortices opens the door towards a variety of applications.

Plasmonic OAM can be generated by the use of plasmonic vortex lenses (PVLs), a type of coupling structure based on Archimedean spirals. We demonstrate both experimentally and in simulations a modular plasmonic lens assembling strategy for the sculpturing of functional plasmonic fields. This approach is based on meta structures and allows the creation of lenses with an effective chirality that depends on the illumination. The coupling structures are milled into a gold surface and the created SPPs are detected via time-resolved PEEM.

CPP 22.2 Tue 10:45 H8

Advanced optical programming of individual meta-atoms beyond the effective medium approach — •Andreas F. Hessler[1], Ann-Katrin U. Michel[1], Sebastian Meyer[1,2], Julian Pries[1], Yuan Yu[1], Martin Lewin[1], Tobias W. W. Mass[1], Matthias Wuttig[1], Dmitry N. Chigrin[1,2], and Thomas Taubner[1] — [1]Institute of Physics (IA), RWTH Aachen — [2]DWI - Leibniz Institute for Interactive Materials, Aachen

Despite their nanometer thickness, active metasurfaces (MSs) based on phase-change materials (PCMs) enable compact photonic components, offering adjustable functionality for the manipulation of light, such as polarization filtering, lensing and beam steering[1]. Commonly, they feature multiple operation states by switching the whole PCM fully between two states of drastically different optical properties[2]. Intermediate states of the PCM have also been exploited to obtain gradual resonance shifts which are usually uniform over the whole MS and described by effective medium theory. We now demonstrate simultaneous control of size, position and crystallization depth of the switched PCM volume within each meta-atom. By modifying the local optical properties, reflection amplitude and phase can be programmed at the meta-atom scale. This goes beyond previous effective medium concepts and should allow for multiple complex functionalities on the same MS or small adaptive corrections to external aberrations and fabrication errors.

[1] X. Yin et al., Light Sci Appl. 6, e17016 (2017).
[2] M. Wuttig et al., Nat. Photon. 11, 465 (2017).

CPP 22.3 Tue 11:00 H8

A Spin-Optical Nano Device — •Enno Krauss[1], Gary Razinskas[1], Dominik Köck[1], Swen Grossmann[1], and Bert Hecht[1,2] — [1]Nano-Optics and Biophotonics Group, Department of Experimental Physics 5, University of Würzburg, Würzburg, Germany — [2]Wilhelm-Conrad-Röntgen-Center for Complex Material Systems (RCCM), University of Würzburg, Würzburg, Germany

The photon spin is an important resource for quantum information processing as is the electron spin in spintronics. However, for subwavelength confined optical excitations, polarisation as a global property of a mode cannot be defined. Here, we show that any polarisation state of a plane-wave photon can reversibly be mapped to a pseudo-spin embodied by the two fundamental modes of a subwavelength plasmonic two-wire transmission line. We design a device in which this pseudo-spin evolves in a well-defined way throughout the device reminiscent of the evolution of photon polarisation in a birefringent medium and the behaviour of electron spins in the channel of a spin field-effect transistor. The significance of this pseudo spin is enriched by the fact that it is subject to spin-orbit locking. Combined with optically active materials to exert external control over the pseudo-spin precession, our findings could enable spin-optical transistors, i.e. the routing and processing of quantum information with light on a subwavelength scale.

CPP 22.4 Tue 11:15 H8

Magneto-optical thermal Hall effect — •Annika Ott[1], Philippe Ben-Abdallah[2], and Svend-Age Biehs[1] — [1]Institut für Physik, Carl von Ossietzky Universität, D-26111 Oldenburg, Germany — [2]Laboratoire Charles Fabry, UMR 8501, Institut d'Optique, CNRS, Université Paris-Sud 11, 2, Avenue Augustin Fresnel, 91127 Palaiseau Cedex, France

The control of heat flux at the nanoscale by means of external magnetic fields has attracted much attention, recently. It could be shown that the near-field heat transfer between two magneto-optical slabs can be tuned by the external field [1], and unexpected and very interesting effects like the thermal radiative Hall effect, persistent currents, and giant magneto-resistance [2, 3, 4, 5] have been highlighted. Here we discuss the existence of a circular heat flux [6] as the origin of the thermal radiative Hall effect.

References:
1. E. Moncada-Villa, V. Fernandez-Hurtado, F. J. Garcia-Vidal, A. Garcia-Martin, and J. C.Cuevas, Phys. Rev. B 92, 125418 (2015). 2. P. Ben-Abdallah, Phys. Rev. Lett. 116, 084301, (2016). 3. L. Zhu and S. Fan, Phys. Rev. Lett. 117, 134303 (2016). 4. I. Latella and P. Ben-Abdallah, Phys. Rev. Lett. 118, 173902, (2017). 5. R. M. Abraham Ekeroth, P. Ben-Abdallah, J.C. Cuevas and A. Garcia Martin, ACS Photonics, 5, 705-710, (2018). 6. A. Ott, P. Ben-Abdallah, S.-A. Biehs, Physical Review B, 97, 205414 (2018).

CPP 22.5 Tue 11:30 H8

Electroluminescence from transparent graphene nanojunctions — •Christian Ott, Martin Hauck, Sascha Korn, and Heiko B. Weber — Lehrstuhl für Angewandte Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Staudtstr. 7/Bau A3, D-91058 Erlangen, Germany

Electroluminescence (EL) emitted from metal-metal tunnel junctions has already been observed in STM experiments in the late 80s [1], nevertheless its origin is still under scientific discussion and is usually attributed either to plasmonic modes triggered by the granular nature of current [2] or to blackbody-like radiation of the injected hot electrons [3]. We report on EL emitted from graphene-graphene nanojunctions (GNJ) fabricated from epitaxial graphene on silicon carbide [4]. In stark contrast to STM experiments, GNJs provide a flat, accessible and transparent geometry, allowing an unobscured optical and electron-microscopic access. The observed EL shows a blackbody like spectrum with surprisingly high apparent temperatures well above the damage threshold of the material. Our findings are critically discussed in terms of differences and similarities to other reported experiments (especially STM) to highlight their contribution to the understanding of an elementary process of light-matter interaction.

[1] Schlittler et al., Z. Phys. B. 72, 497 - 501 (1988) [2] Peters et al., PRL 119, 066803 (2017) [3] Downes et al., Applied Physics Letters 81, 7 (2002) [4] Ullmann et al., Nano Letters 14, 5 (2015)

CPP 22.6 Tue 11:45 H8

Towards Niobium Plasmonics for Single Photon Detection — •Ahmed Farag, Monika Ubl, Annika Konzelmann, Mario Hentschel, and Harald Giessen — 4th Physics Institute, Center for Integrated Quantum Science and Technology IQST, and Research Center SCoPE, University of Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany

With the fast development in single photon based technologies such as quantum computing and quantum cryptography, conventional avalanche photodiodes as single photon detectors are not the optimum tools anymore. They are currently replaced by Superconducting Nanowire Single Photon Detectors (SNSPDs) based on the superconductivity of certain materials. The current challenge with SNSPDs lies in overcoming the trade-off between the detection efficiency and the recovery time. While a large active area will lead to high detection efficiency, the associated high kinetic inductance causes a long recovery time. Plasmonic nanoantennas can play an important role in the absorption enhancement of SNSPDs. These nanostructures provide a high absorption cross section at resonance, significantly larger than their geometric cross section. We present a plasmonic photon detector based on niobium, as one of the common superconductors with low kinetic inductance. Additionally, we are increasing the absorption of our nanostructures even further using the perfect absorber scheme. We fabricated a plasmonic perfect absorber SNSPD, investigated its response to external light at resonance, and proved the plasmonic-based working principle as evidenced by its polarization dependence.

CPP 22.7 Tue 12:00 H8

Probing surface plasmon with phase-shaped electron energy-loss spectroscopy — •Hugo Lourenco-Martins[1], Davy Gérard[2], Jo Verbeeck[3], Giulio Guzzinati[3], and Mathieu Kociak[1] — [1]Laboratoire de Physique des Solides, Université Paris-Saclay, France — [2]L2n, Université de Technologie de Troyes, France — [3]EMAT, University of Antwerp, Belgium

Electron energy loss spectroscopy (EELS) has attracted a large interest due to its efficiency in resolving plasmonic resonance at the nanometer scale. However, it remained intrinsically unable to detect plasmonic phase-related properties. Nevertheless, vortex electron states constitute a perfect candidate to overcome this limitation and measure optical dichroism in an electron microscope [1]. Moreover, it has been recently demonstrated that such probes can be created in an electron microscope by tailoring the phase of the beam [2]. In the present work [3], we developed a semiclassical formalism describing the interaction between an electron probe with an arbitrary phase profile and a plasmonic mode. We showed that the equation ruling this interaction takes the elegant form of a transition matrix between two electron states mediated by the eigenpotentials of the plasmon modes. In this contribution, we will present the theoretical formalism and a wide variety of numerical studies of interactions between different nano-structures and phase-shaped electron probes, with a special emphasis on the experimental feasibility of the proposed geometries. [1] Asenjo-Garcia et al. PRL 113 (2014) [2] Verbeeck et al, Nature 467 (2010) [3] Guzzinati et al., Nature Com. 8 (2017)

CPP 22.8 Tue 12:15 H8

Quantitative phase imaging of plasmonic metasurfaces — •Vlastimil Křápek[1], Petr Dvořák[1], Alexander Fassbender[2], Petr Bouchal[1], Martin Hrtoň[1], Jiří Babocký[1], Filip Ligmajer[1], Radim Chmelík[1], Stefan Linden[2], and Tomáš Šikola[1] — [1]Central European Institute of Technology, Brno University of Technology, Purkyňova 123, 612 00 Brno, Czech Republic — [2]Physikalisches Institut, Universität Bonn, Nussallee 12, 53115 Bonn, Germany

We report on wide-field quantitative phase imaging of plasmonic metasurfaces by coherence-controlled holographic microscopy [1] and 4th generation quantitative optical microscopy. Both resonant [2] and geometric phase [3,4] are retrieved for various metasurfaces including a lens and a vortex beam plate. Three-dimensional imaging, polarization sensitivity, and sensitivity down to single antenna is demonstrated.

[1] P. Kolman et al., Opt. Express 18, 21990 (2010).
[2] J. Babocký et al., ACS Photonics 4, 1389 (2017).
[3] A. Faßbender et al., APL Photonics 3, 110803 (2018).
[4] P. Bouchal et al., arXiv 1811.01561.

CPP 22.9 Tue 12:30 H8

Influence of laser parameters on spatially periodic heating of metals induced by surface plasmon polaritons — •Pavel N. Terekhin[1,2], Pascal D. Ndione[1], Sebastian T. Weber[1], and Baerbel Rethfeld[1] — [1]Department of Physics and Research Center Optimas, University of Kaiserslautern, Erwin-Schroedinger-Strasse 46, 67663 Kaiserslautern, Germany — [2]National Research Centre "Kurchatov Institute", Kurchatov Sq. 1, 123182 Moscow, Russia

We present a detailed investigation of periodic heating of metals and periodic structure formation on their surfaces induced by surface plasmon polaritons (SPPs) after irradiation with ultrashort laser pulses. The interference of the incident and the SPPs electromagnetic waves leads to an enhancement of the resulting field and, therefore, a spatial modulation of the deposited laser energy.

Our aim is to show the influence of laser parameters on the formation of surface structures. The two-temperature model (TTM) is used to calculate the evolution of electronic and lattice temperatures. A new source term in the TTM, which takes into account plasmonic subsystem, is derived. The results obtained indicate that the electronic temperature shows the same spatial oscillations as the source term. Further, these oscillations are still present in the lattice temperature when being heated to the melting point. That could cause the formation of the periodic structures on the surface of the solid. Therefore, the developed model allows calculating materials' heating after ultrashort laser irradiation and studying the fundamental mechanisms of laser energy absorption under controlled conditions.