O 52: Focussed session: Coherence and coherent control in nanophotonics and plasmonics II

Time: Wednesday 16:45–19:15 Location: MA 005

Topical Talk O 52.1 Wed 16:45 MA 005

Spatio-temporal focusing of ultrashort pulses through scattering media — •Yaron Silberberg — Weizmann Institute of Science, Rehovot, Israel

When a short pulse is passed through an inhomogeneous medium, such as a biological tissue, it gets randomly scattered, resulting in a diffuse smeared-up light pattern in space and time. Scattering-induced distortions pose one of the major limitations in many applications, ranging from astronomy to microscopy. We have recently shown [1] that one can engineer an ultrashort optical pulse such that it will focus in both space and time inside a scattering medium. Moreover, we have discovered that one can correct both spatial and temporal distortions by manipulating only the spatial degrees of freedom of the incident wavefront using a spatial light modulator.

[1] O. Katz, E. Small, Y. Bromberg and Y. Silberberg, Nature Photonics 5, 372 (2011).

Topical Talk O 52.2 Wed 17:15 MA 005

Attosecond control of electrons laser-emitted from a nanoscale metal tip — •Peter Hommelhoff[1], Michael Krüger[1], Markus Schenk[1], Michael Förster[1], Georg Wachter[2], Christoph Lemell[2], and Joachim Burgdörfer[2] — [1]MPI of Quantum Optics, Garching, Germany — [2]Technical University of Vienna, Vienna, Austria

With carrier-envelope phase stable few-cycle laser pulses we demonstrate steering of electrons photo-emitted from a nanoscale metal tip with the optical electric field of the laser pulses. In spectrally resolved measurements we have observed strong-field effects such as peak shifting and peak suppression already at moderate laser intensities of less than 10^{12} W/cm^2, owing to field enhancement [1]. The formation of interference fringes in the photoelectron energy spectrum as function of the carrier-envelope phase points at electronic matter wave interference in the time-domain. We explain our results with the classical three-step model, including rescattering [2]. A detailed simulation based on time-dependent density functional theory corroborates our findings and can be used to determine the effective laser field at the metal tip [3]. Based on our experimental and theoretical findings we could show that we coherently control the dynamics of the liberated electronic matter wave with the laser field on sub-cycle, i.e., attosecond time scales.

[1] M. Schenk, M. Krüger, P. Hommelhoff, PRL 105, 257601 (2010)
[2] M. Krüger, M. Schenk, P. Hommelhoff, Nature 475, 78 (2011)
[3] G. Wachter, Chr. Lemell, J. Burgdörfer, M. Schenk, M. Krüger, P. Hommelhoff, to be published

Topical Talk O 52.3 Wed 17:45 MA 005

Theory of quantum control of semiconductor quantum dots in complex environments — Andreas Knorr, •Julia Kabuss, Alexander Carmele, Sverre Theuerholz, and Marten Richter — Institut für Theoretische Physik, Technische Universität Berlin

This talk is focused on the control of the statistics of coupled quantum fields (electrons, phonons and photons) in nanostructured materials, composed of quantum dots, cavities and metal nanoparticles. Addressing the full quantum statistics of the fields within a microscopic theory we discuss:
- the phonon statistics in acoustic cavities externally driven by a Raman process,
- the manipulation of the photon statistics in optical cavities by feedback control, and
- the Förster transfer processes between quantum dots in the presence of metal nanoparticles and the disentanglement of intrinsic interaction by local spectroscopy.

O 52.4 Wed 18:15 MA 005

Control of second-harmonic generation in metal nanoparticles and nanowires — •Giovanni Piredda[1], Zhimin Shi[2], Nina Rauhut[1], Regina de Vivie-Riedle[1], and Achim Hartschuh[1] — [1]Physikalische Chemie, Department Chemie, Ludwig-Maximilians-Universität München — [2]The Institute of Optics, University of Rochester, Rochester, NY 14620, USA

The goal of ultrafast nanooptics is shaping the electric field at the nanometer spatial scale and the femtosecond temporal scale through the controlled excitation of optical resonances in metallic nanostructures [1]. Experiments on nanoparticles and nanowires allow one to consider in a separate way two different types of resonances: localized resonances that are based on dipolar response and Fabry-Perot resonances that are based on propagation effects. Accordingly, we excite nanoparticles with chirped femtosecond pulses, and nanowires with pulse trains; we observe second-harmonic generation from the metal structures [2] as a function of pulse parameters in the two cases and demonstrate that the coherent control of harmonic generation reflects the characteristics of the resonance.

[1] M.I. Stockman, S.V. Faleev, and D.J. Bergman; Coherent control of femtosecond energy localization in nanosystems; Phys. Rev. Lett., **88**, 067402 (2002).
[2] M. Zavelani-Rossi et al.; Near-field second-harmonic generation in single gold nanoparticles; Appl. Phys. Lett., **92**, 093119 (2008).

O 52.5 Wed 18:30 MA 005

Classical Analog of Electromagnetically Induced Absorption in Plasmonics — •Richard Taubert[1], Mario Hentschel[1,2], Jürgen Kästel[3], and Harald Giessen[1] — [1]4th Physics Institute and Research Center SCoPE, University of Stuttgart, 70550 Stuttgart, Germany — [2]Max-Planck-Institut für Festkörperforschung, Heisenbergstraße 1, D-70569 Stuttgart, Germany — [3]Deutsches Zentrum für Luft- und Raumfahrt, Institut für Technische Physik, D-70569 Stuttgart, Germany

The ability to manipulate the phase shift between two coupled plasmonic resonances in a controlled fashion has been unavailable up to now. Here we present a strategy to overcome this limitation by employing the benefits of near-field coupling on the one hand and retardation effects due to far-field coupling on the other hand. We theoretically and experimentally demonstrate that in the intermediate regime the coupling of a broad dipolar to a narrow dark quadrupolar plasmon resonance is possible while simultaneously allowing for a retardation-induced phase shift. This leads to constructive interference and enhanced absorption. The observed phenomena can thus be termed classical analog of electromagnetically induced absorption.

O 52.6 Wed 18:45 MA 005

Hybridization of dark & bright modes leading to longlived plasmonic coherences on a corrugated silver surface — Martin Aeschlimann[1], Tobias Brixner[2], Alexander Fischer[1], Christian Kramer[2], Pascal Melchior[1], Walter Pfeiffer[3], Christian Schneider[1], •Christian Strüber[3], Philip Tuchscherer[2], and Dmitri V. Voronine[4] — [1]Technische Universität Kaiserslautern, Germany — [2]Universität Würzburg, Germany — [3]Universität Bielefeld, Germany — [4]Texas A&M University, College Station, USA

The hybridization of dark and bright plasmonic modes leads to Fano resonances and electronically induced transparency phenomena. So far these effects have been observed only in engineered nanostructures. Coherent 2D nanoscopy, a combination of coherent 2D spectroscopy and time-resolved photoemission electron microscopy (PEEM), reveals longlived plasmonic coherences and quantum beats on a randomly structured silver surface [1]. The unexpectedly long coherence lifetime of about 100 femtoseconds is explained by hybridization of dark and bright modes, formed by multiply scattered surface plasmon polaritons (SPPs) and localized SPPs, respectively. Fitting the measured spectra using either a two mode hybridization model or unconstrained parameters reveals sharp Fano-like resonances in the local response. The results emphasize that dark modes, i.e. modes coupled weakly to the radiation field, support longlived coherent states even in highly scattering environment.

[1] M. Aeschlimann et al., Science 333, 1723-1726 (2011)

O 52.7 Wed 19:00 MA 005

Strong field acceleration of attosecond electron pulses emitted by a nanometer-sized gold taper — •Björn Piglosiewicz, Slawa Schmidt, Doojae Park, and Christoph Lienau — Ultraschnelle Nano-Optik, Institut für Physik, Fakultät V, Universität Oldenburg, 26111 Oldenburg, Deutschland

When few-cycle near-IR femtosecond pulses in the range of 1 - 2 microns and with nJ energy are focused onto the nanometer-sized tip of a conical metallic taper, the strong laser field induces the tunneling of

electrons out of the very apex of this tip. The ejected electrons are then strongly accelerated within the field gradient near the tip apex and this acceleration results in unusual, plateau-like kinetic energy spectra of the ejected electrons. Here, we analyze for the first time the angle-resolved kinetic energy spectra generated by strong-field photoemission from single gold tips. We show that their dependence on dc-bias and laser wavelength allows us to deduced details of the light-driven electron dynamics on attosecond time and nanometer length scale. Our results might be interesting for electron microscopy with attosecond time resolution.