Q 30: Nano-optics

Time: Wednesday 11:00–13:00 Location: F442

Q 30.1 Wed 11:00 F442

A Novel Approach to Nanophotonic Black-Box Optimization Through Reinforcement Learning — •Marco Butz[1], Alexander Leifhelm[1], Marlon Becker[2], Benjamin Risse[2], and Carsten Schuck[1] — [1]Center for Soft Nanoscience, Münster, Germany — [2]Institute for Geoinformatics, University of Münster, Germany

After the use of Photonic integrated circuits (PICs) has led to a significant increase in the performance of devices employed in classical telecommunication schemes in the last years, complex quantum optics experiments have recently undergone a similar transition from free space setups to PICs. This development poses challenging requirements on the PICs' individual components in both footprint and performance and even raises the need for novel functionalities that are not accessible by conventional design methods. Recently, various design algorithms addressing this problem have been demonstrated. However, they all suffer from various drawbacks such as reliance on convex optimization methods in non-convex environments or the presence of gradient fields, which cannot always be accessed easily. Here, we show a novel inverse-design method based on reinforcement learning capable of producing pixel-discrete nanophotonic devices with arbitrary functionality and small footprints. Freely configurable design constraints can be realized through multiple interfaces enabling manipulation of the internal data flow. To demonstrate the capabilities of our method we show the fully automated design of a silicon-on-insulator waveguide-mode converter with $> 95\%$ conversion efficiency from scratch.

Q 30.2 Wed 11:15 F442

Reentrant delocalization transition in one-dimensional photonic quasicrystals — Sachin Vaidya[1], •Christina Jörg[1,2], Kyle Linn[2], Megan Goh[3], and Mikael C. Rechtsman[1] — [1]Department of Physics, The Pennsylvania State University, University Park, Pennsylvania 16802, USA — [2]Physics Department and Research Center OPTIMAS, TU Kaiserslautern, D- 67663 Kaiserslautern, Germany — [3]Department of Physics, Amherst College, Amherst, MA 01002, USA

Over the past few years, there has been significant interest in exploring the localization of waves propagating in disordered media, also known as Anderson localization. We experimentally demonstrate that the localization transition in certain one-dimensional photonic quasicrystals (PhQC) is followed by a surprising second delocalization transition upon further increasing quasiperiodic disorder strength - an example of a reentrant transition. We measure this localization and reentrant delocalization via the inhibition and complete recovery of transmission through an Aubry-André type PhQC for increasing quasiperiodic modulation. To further shed light on the observed reentrant transition, we also develop a tight-binding model inspired by the PhQCs that captures the essential localization physics of our system.

Q 30.3 Wed 11:30 F442

Nonlocal Soft Plasmonics: Ionic plasmon effects in planar homogeneous multi-layered systems — •Preethi Ramesh Narayan and Christin David — Institute of Condensed Matter Theory and Optics (IFTO), Abbe Center of Photonics, Friedrich-Schiller-University Jena (FSU Jena), Jena, Germany

Plasmonics is the study of resonant interactions between free electrons present in the conduction band of metals and incident electromagnetic radiation. These resonant interactions result in surface plasmon waves that propagate along the surface at the metal-dielectric interface. Apart from metals, such charge oscillations can also be found in soft matter as a charged ionic fluid in an impermeable lipid membrane. Such a system can be studied analogously from the behavior of metal nanosystems, with lower resonance frequencies in larger ionic systems. We study the ionic plasmon interactions in planar electrolyte systems. We also consider the nonlocal interactions between the charge carriers that happen due to strong spatial confinement on the microscale. The optical response of free positive and negative ions in an electrolyte is explained using a hydrodynamic, two-fluid model under the scope of nonlocality. These ions oscillate with different bulk plasmon frequencies based on their respective charge, mass, and concentration. This allows analyzing the nonlocal plasmonic effects through highly tunable system parameters. We develop this system further with the aim to understand energy transfer in nerve cells and electrolyte-solid interactions for photocatalysis.

Q 30.4 Wed 11:45 F442

Nonlinear response in nanostructured multilayers — •Navid Daryakar[1] and Christin David[2] — [1]Institute of Condensed Matter Theory and Optics, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena, Germany — [2]Institute of Condensed Matter Theory and Optics, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena, Germany

We studied the nonlinear optical response of composite nanostructured layers in terms of a self-phase-modulated, third-order Kerr nonlinearity. Theoretical modeling is considered through effective medium theories (Maxwell-Garnett, Bruggeman) to identify the behavior of the composite nanostructures in linear and nonlinear regimes. The optical response is modified and the dependence on various system parameters such as fill fraction, layer thickness and width, diffraction orders and laser intensity is studied. We thus show at which intensity transitioning to the nonlinear regime occurs, and how material response changes can be conveniently used as a signature of the transition. Our finding is general, and the method can be applied to any material mixture of thin films. As such, we expect our results to enable future studies aimed at predicting nonlinear optical response of composite nanostructures on the nanoscale. Nonlinear effective medium theory is used to describe low densities of gold nanoparticles embedded in an equally nonlinear host material. The fill fraction strongly influences the effective nonlinear susceptibility of the materials increasing it by orders of magnitude in case of gold due to localized surface plasmonic resonances.

Q 30.5 Wed 12:00 F442

Towards Cavity-Enhanced Spectroscopy of Single Europium Ions in Yttria Nanocrystals — Timon Eichhorn, •Nicholas Jobbitt, and David Hunger — Karlsruher Institut für Technologie

A promising approach for realizing scalable quantum registers lies in the efficient optical addressing of rare-earth ion spin qubits in a solid state host. We study Eu^{3+} ions doped into Y_2O_3 nanoparticles (NPs) as a coherent qubit material and work towards efficient single ion detection by coupling their emission to a high-finesse fiber-based Fabry-Pérot microcavity. A beneficial ratio of the narrow homogeneous line to the inhomogeneous broadening of the ion ensemble at temperatures below 10 K makes it possible to spectrally address and readout single ions. The coherent control of the single ion $^5D_0$ - $^7F_0$ transition then permits optically driven single qubit operations on the Europium nuclear spin states. A Rydberg-blockade mechanism between ions within the same nanocrystal permits the implementation of a two-qubit CNOT gate to entangle spin qubits and perform quantum logic operations. We observed fluorescence signals from small ensembles of Europium ions at cryogenic temperatures and measured cavity-enhanced optical lifetimes of half the free-space lifetime resulting in effective Purcell-factors of one. Considering the low branching ratio into the desired transition this amounts to a two-level Purcell-factor of 100. We will report on the progress towards single ion readout and control.

Q 30.6 Wed 12:15 F442

Improvements of the Timing Resolution of SNSPDs Using Enhanced Light Intensity — Roland Jaha[1,2], Wolfram Pernice[3], and •Simone Ferrari[3] — [1]Institute of Physics, Münster 48149, Germany — [2]Center for Soft Nanoscience, Münster 48149, Germany — [3]Kirchhoff-Institute of Physics, Heidelberg 69120, Germany

Superconducting nanowire single-photon detectors enable single-photon detection with low dark counts, count rates up to a few Gcps, and almost unitary detection efficiency which makes them a key element in many quantum and faint light experiments. During the last few years, much effort has been spent on the development of detectors with high temporal resolution. Such devices would allow for high-speed quantum communication and the realization of optical sampling with superior bandwidth.

Typical free-space coupled low-jitter detectors suffer from low detection efficiency because of their small active region. Our nanowires instead are placed on top of a photonic waveguide where photons can be absorbed along the detector length. Using this approach, we are able to probe the detector within a confined space thereby enhancing the temporal resolution without sacrificing its detection efficiency.

By adopting NbN SNSPDs atop SiN waveguides, we investigate the dependence of the temporal resolution and latency time on the photon illumination. At high photon flux, we observe an enhancement of the slew rate of the nanowire voltage response, leading to a sub-3 ps timing jitter and a reduction of the latency time of more than 100 ps compared to the single-photon level.

Q 30.7 Wed 12:30 F442

Extinction of plasmonic ellipsoidal core-shell nanoparticles — •Mathis Noell and Carsten Henkel — Institut für Physik und Astronomie, Potsdam, Germany

Plasmonic nanostructures provide an interesting platform for localized heating and field enhancement. If a nanoparticle is covert with a thin absorbing layer, theory predicts a resonance that is not seen in experimental extinction spectra. To understand this issue, we analyze the distribution of electric fields and energy dissipation in and around an ellipsoidal nanoparticle. Calculations are done for gold Nano particles covered with a few nm thick absorbing layer. At the spurious resonance the field is highly localized in this layer, suggesting that strong coupling to the molecular exciton is possible at the few-photon level. Treating the interface between the absorbing layer and the surrounding medium as a sharp interface is an assumption which is most likely not true. As a first step towards a model without a sharp layer-medium interface we modeled the layer as an effective medium (mixture of layer material and medium). Using the effective medium approach, we observe that the spurious resonance is suppressed for sufficiently diluted shells. Using a inhomogeneous but continuous permittivity profile one can formulate a model with no sharp layer-medium interface. We analyze the effective medium and continuous permittivity approaches and compare them with experimental data.

Q 30.8 Wed 12:45 F442

Tailoring Near-Field*Mediated Photon Electron Interactions with Light Polarization — •Fatemeh chahshouri and Nahid Talebi — Institute of Experimental and Applied Physics, Kiel University, 24098 Kiel, Germany

Inelastic interaction of free-electrons with optical near fields has recently attracted attention for manipulating and shaping free-electron wavepackets. Understanding the nature and the dependence of the inelastic cross section on the polarization of the optical near-field is important for both fundamental aspects and the development of new applications in quantum-sensitive measurements. Here, we investigate the effect of the polarization and the spatial profile of plasmonic near-field distributions on shaping free-electrons and controlling the energy transfer mechanisms, but also tailoring the electron recoil. We particularly show that polarization of the exciting light can be used as a control knop for disseminating the acceleration and deceleration path ways via the experienced electron recoil. We also demonstrate the possibility of tailoring the shape of the localized plasmons by incorporating specific arrangements of nanorods to enhance or hamper the transversal and longitudinal recoils of free-electrons. Our findings open up a route towards plasmonic near-fields-engineering for the coherent manipulation and control of slow electron beams for creating desired shapes of electron wavepackets.