HL 57: Photonic Crystals II

Time: Wednesday 12:00–13:15 Location: EW 202

HL 57.1 Wed 12:00 EW 202

Near-Field Coupling in Metamaterials — •Felix von Cube[1,2], Stephan Irsen[2], and Stefan Linden[1,3] — [1]Physikalisches Institut, Universität Bonn, 53113 Bonn, Germany — [2]Research center caesar, 53175 Bonn, Germany — [3]Institut für Nanotechnologie, Karlsruher Institut für Technologie (KIT), 76021 Karlsruhe, Germany

Metamaterials give rise to a variety of intriguing optical phenomena, e.g., a negative index of refraction, strong chirality and perfect lensing. The optical properties of a metamaterial can often be attributed to the excitation of localized plasmonic modes on the metallic substructures of the metamaterial. Electron energy-loss spectroscopy (EELS) in combination with scanning transmission electron microscopy (STEM) is a powerful tool to map the plasmon distributions on a nanometer scale with an energy resolution down to 0.15 eV.

Here, we investigate the near-field distributions of the interacting building blocks of a metamaterial. For these experiments, we have prepared a series of arrays in which we have successively increased the number of split-ring resonators. With STEM-EELS, we are able not only to map the optical bright modes, but also the optical dark modes. From the energy splitting of these modes, we get an indicator for the coupling strength of the metallic substructures in the metamaterial.

HL 57.2 Wed 12:15 EW 202

Analytically generated adaptive meshes for the Fourier Modal Method — •Jens Küchenmeister[1], Thomas Zebrowski[1], Sabine Essig[1], and Kurt Busch[2] — [1]Institut für Theoretische Festkörperphysik and DFG-Center for Functional Nanostructures, Karlsruhe Institute of Technology (KIT), 76128 Karlsruhe — [2]Humboldt-Universität zu Berlin, Institut für Physik, AG Theoretische Optik, Newtonstr. 15, 12489 Berlin, and Max-Born-Institut, Max-Born-Str. 2A, 12489 Berlin, Germany

The Fourier Modal Method is a versatile solver for Maxwell's equations for periodic systems which calculates transmittance and reflectance spectra by an expansion of the fields into eigenmodes. Problems appear for small structure features or large jumps in the permittivity distribution. These problems can be tackled using a mesh adapted to the structure: Firstly, coordinate lines are bent to match the structure's surface. Secondly, the density of coordinate lines along the surface is increased. In this contribution, we present how to build different types of analytical meshes and investigate their influence on the convergence behavior of the method. Especially, we address the influence of differentiability in adaptive meshing.

HL 57.3 Wed 12:30 EW 202

Advances of Modal Methods in the Simulation of Photonic Structures and Devices — •Thomas Zebrowski[1], Jens Küchenmeister[1], Michael Walz[1], and Kurt Busch[2] — [1]Institut für Theoretische Festkörperphysik, Karlsruher Institut für Technologie, 76128 Karlsruhe, Germany — [2]Humboldt-Universität zu Berlin, Institut für Physik, AG Theoretische Optik, Newtonstr. 15, 12489 Berlin, and Max-Born-Institut, Max-Born-Str. 2A, 12489 Berlin, Germany

Modal methods feature an elegant and efficient way for solving photonic scattering problems with the help of the s-matrix algorithm. In this contribution, we will first give an overview over our current developments in the traditionally used Fourier modal method and present recent results for periodic as well as aperiodic structures like woodpile photonic crystals and liquid crystal based fiber gratings. However, for some applications it seems reasonable to replace the plane wave basis with a localized polynomial basis. This leads us to the B-spline modal method whose basic principles and particularities will be introduced in the second part.

HL 57.4 Wed 12:45 EW 202

Light-Mediated Coupling of a Single QD Coupled to Strongly Interacting Planar Photonic Crystal Cavities — •Stefan Declair, Torsten Meier, and Jens Förstner — University of Paderborn, Department of Physics and CeOPP, Warburger Str. 100, D-33098 Paderborn, Germany

We numerically investigate the light-mediated coupling between a semiconductor heterostructure, a quantum dot (QD), and strongly interacting planar photonic crystal cavities (PhCCs) using a Finite-Difference Time-Domain method. The light-matter Hamiltonian is used to calculate the macroscopic polarization via dynamic equations of motion for the interband coherence and density of the QD [1].
The photonic system consists of two strongly interacting L3 cavities with an optimized Q-factor [2], exhibiting an asymmetric line splitting of >600 GHz [3]. Resonant coupling of a QD (phenomenological dephasing rate in the GHz regime) to one photonic eigenmode of the coupled PhCC system leads to emission of the QD on the other photonic eigenmode with a strong coupling signature (normal mode splitting).

[1] C. Dineen et al., Electromagnetic field structure and normal mode splitting in photonic crystal nanocavities, Optics Express 13, 4980 (2005).
[2] Y. Akahane et al., High-Q photonic nanocavity in a two-dimensional photonic crystal, Nature 425, 944 (2003).
[3] S. Declair et al., Numerical Analysis of Coupled Photonic Crystal Cavities, Photonics and Nanostructures: Fundamentals and Applications 9, 345-350 (2011).

HL 57.5 Wed 13:00 EW 202

High and Subharmonic Generation with a Semiconductor Quantum dot in a Photonic Crystal Cavity — •Matthias Reichelt[1], Andrea Walther[2], and Torsten Meier[1] — [1]Department of Physics and CeOPP, University of Paderborn, Warburger Str. 100, D-33098 Paderborn, Germany — [2]Institut für Mathematik, Universität Paderborn, Warburger Str. 100, D-33098 Paderborn, Germany

A semiconductor quantum dot modeled as two-level system can emit radiation at specific high harmonic frequencies if it is excited with an intense properly shaped laser pulse [1,2]. Here, we show that it is also possible to downconvert the emission below the fundamental frequency. This proves useful when a dot which is placed into a photonic crystal is capable of emitting into an off-resonant cavity mode in the photonic band gap. Numerical calculations are performed with an optimization algorithm [3] plus a FDTD-simulation.

[1] M. Reichelt, A. Walther, and T. Meier, J. Opt. Soc. Am. B, *accepted for publication.*
[2] D. Golde, T. Meier, and S.W. Koch, J. Opt. Soc. Am. B, **23**, 2559 (2006).
[3] M. Reichelt, A. Walther, and T. Meier, Photonics and Nanostructures - Fundamentals and Applications **9**, 328 (2011).