HL 21: Quantum Nanophotonics in Solid State Systems

Time: Tuesday 14:00–15:30 Location: H33

HL 21.1 Tue 14:00 H33

Single-spin-readout via spin-selective tunnelling aided by a microwave resonator — •Florian Ginzel, Maximilian Russ, and Guido Burkard — Department of Physics, University of Konstanz, D-78457 Konstanz, Germany

Recent implementations of the energy-selective schemes for single-spin-readout encountered limitations for its use in quantum information processing or sensing [1]. In this theoretical work an alternative detection method is proposed where a microwave resonator is used to read out the spin state through the state-dependent dispersive shift of the cavity frequency [2,3]. Using input-output-theory the expectation value and variance of the output field of the cavity are calculated from an idealised model. The cavity response to spin-dependent charge transitions distinguishes the initial spin-states of the electron with high fidelity. The feasibility of the cavity mediated spin-readout is discussed and the optimal operating regime is indicated.

[1] D.M. Zajac *et al.*, Science **359**, 439 (2018)
[2] K.D. Petersson *et al.*, Nature **490**, 380 (2012)
[3] G. Burkard, J.R. Petta, Phys. Rev. B **94**, 195305 (2016)

HL 21.2 Tue 14:15 H33

Quantum dot rapid adiabatic passage by ultrafast Stark tuning — Amlan Mukherjee[1], Alex Widhalm[1], •Björn Jonas[1], Sebastian Krehs[1], Nand Lal Sharma[1], Peter Kölling[2], Andreas Thiede[2], Jens Förstner[2], Dirk Reuter[1], and Artur Zrenner[1] — [1]Physics Department, University of Paderborn, Warburger Straße 100, Paderborn 33098, Germany — [2]Department of Electrical Engineering, University of Paderborn, Warburger Straße 100, Paderborn 33098, Germany

An exciton in a single quantum dot is an attractive implementation of a qubit, since it can be Rabi-flopped or coherently manipulated with pulsed laser fields. Robust methods of preparation have been demonstrated by the application of polarization tailored pulses [1] or chirped laser pulses, resulting in rapid adiabatic passage (RAP) [2,3]. Here we use unchirped laser pulses and an ultrafast transient Stark shift of the exciton energy to prepare an inversion via RAP. We use self-assembled InGaAs QDs embedded in a low capacitance Schottky-photodiode. An ultrafast BiCMOS chip that is closely connected to the photodiode generates transient Stark shifts as fast as 3.6 μeV/ps. It operates at low temperature and is synchronized to the laser excitation. By detecting the occupancy of the QD via photocurrent detection, we are able to observe the transition from the unchirped Rabi scenario to a RAP when the electric chirp is applied.

[1] D. Mantei et al., Sci. Rep. 5, S. 10313 (2015)
[2] Yanwen Wu et al., PRL 106, 067401 (2011)
[3] C.M. Simon et al., PRL 106, 166801 (2011)

HL 21.3 Tue 14:30 H33

Giant Rydberg excitons in the presence of an ultralow-density electron-hole plasma — Julian Heckötter[1], Martin Bergen[1], Marcel Freitag[1], Dietmar Fröhlich[1], Manfred Bayer[1], Peter Grünwald[2], Florian Schöne[2], Dirk Semkat[3], Heinrich Stolz[2], Stefan Scheel[2], and •Marc Assmann[1] — [1]Experimentelle Physik 2, TU Dortmund, 44221 Dortmund — [2]Institut für Physik, Universität Rostock, Albert-Einstein-Straße 23-24, 18059 Rostock — [3]Institut für Physik, Ernst-Moritz-Arndt-Universität Greifswald, Felix-Hausdorff-Straße 6, 17489 Greifswald

Giant Rydberg excitons in Cu_2O show a spatial extension up the micrometer range and huge interactions, which may result in intriguing blockade effects similar to the Rydberg blockade known from cold atom physics. We study the Rydberg exciton absorption spectrum in the presence of free carriers injected by above-bandgap illumination. Already at plasma densities below one hundredth electron-hole pair per μm^3, exciton lines are bleached, starting from the highest observed principal quantum number, while their energies remain constant. Also, the band gap decreases due to correlation effects with the plasma. An exciton line loses oscillator strength when the band gap approaches its energy, vanishing completely at the crossing point. Adapting a plasma-physics approach, we describe the observations by an effective Bohr radius that increases with plasma density, reflecting Coulomb interaction screening by the plasma. We distinguish plasma-induced bleaching from genuine Rydberg blockade and discuss the interplay between time-resolved blockade and Rydberg exciton population dynamics.

HL 21.4 Tue 14:45 H33

Coupling of Quantum Emitter Near-Infrared Radiation to Dielectric Mie Resonators — •Viktoriia Rutckaia[1], Joerg Schilling[1], Dominik Schulze[1], Mihail Petrov[2], Frank Heyroth[3], Vadim Talalaev[1], and Alexey Novikov[4] — [1]Martin-Luther University, Halle (Saale), Germany — [2]ITMO University, Saint-Petersburg, Russia — [3]CMAT, Halle (Saale), Germany — [4]IPAM RAS, Nizhny Novgorod, Russia

We demonstrate the possibility of the light control at the nanoscale by using Silicon nanodisks with embedded Ge quantum dots (QDs). Our experimental measurements of the microluminescence reshaping in such structures confirm that Ge QD emission is coupled to the localized Mie modes, and agree well with numerical modeling. We discuss the coupling mechanism and show both numerically and experimentally how the design of the resonators affects the radiative decay rate. For the first time, we demonstrate the Purcell effect in Si/Ge QDs structures from time-resolved microluminescence measurements and discuss how it can be further enhanced by exploiting collective Mie modes in oligomer structures. The work contributes to the development of the near-infrared (NIR) light sources for the telecommunication applications.

HL 21.5 Tue 15:00 H33

Quantization of open and dissipative cavities using quasinormal modes — •Sebastian Franke[1], Stephen Hughes[2], Mohsen Kamandar Dezfouli[2], Philip Trøst Kristensen[3], Kurt Busch[3,4], Andreas Knorr[1], and Marten Richter[1] — [1]Technische Universität Berlin, Institut für Theoretische Physik, Nichtlineare Optik und Quantenelektronik, Hardenbergstraße 36, 10623 Berlin, Germany — [2]Department of Physics, Engineering Physics and Astronomy, Queen's University, Kingston, Ontario, Canada K7L 3N6 — [3]Institut für Physik, Humboldt Universität zu Berlin, 12489 Berlin, Germany — [4]Max-Born-Institut, 12489 Berlin, Germany

In many cavity-QED platforms, photons are usually described by lossless normal modes, e.g., in the Jaynes-Cummings model. However, for metallic or open cavities, the so-called quasinormal modes[1] (QNMs) with complex eigenfrequencies are more appropriate, and are the natural modes to quantize. Here, we develop a powerful quantization scheme for these modes in absorptive and spatially inhomogeneous media, using a Green's function quantization method[2]. We derive the corresponding Fock state basis for symmetrized QNMs, leading to an intrinsic inter-mode coupling in the QNM master equation[3]. Applications of cavity-QED for metal resonators and hybridized plasmonic-photonic crystal cavities are derived and discussed.

[1]P. T. Leung *et al.*, *Phys. Rev. A* **49**, 3057, 1994
[2]T. Gruner, and D.-G. Welsch, *Phys. Rev. A* **53**, 1818, 1996
[3]S. Franke *et al.*, arXiv:1808.06392v2

HL 21.6 Tue 15:15 H33

Strain spectrally-tunable single photon source based on quantum dots in micropillar cavities — •Magdalena Moczała-Dusanowska[1], Łukasz Dusanowski[1], Stefan Gerhardt[1], Yu-Ming He[2], Marcus Reindl[3], Armando Rastelli[3], Rinaldo Trotta[3,4], Christain Schneider[1], and Sven Höfling[1,5] — [1]Technische Physik, Physikalisches Institut, Würzburg University, Germany — [2]Hefei National Laboratory for Physical Sciences, University of Science and Technology of China, Hefei, China — [3]Institute of Semiconductor and Solid State Physics, Johannes Kepler University, Linz, Austria — [4]Department of Physics, Sapienza University of Rome, Italy — [5]SUPA, School of Physics and Astronomy, University of St Andrews, UK

In this contribution we demonstrate results of emission tuning of QDs inserted in micropillar cavities. A sample containing an InAs/GaAs QDs embedded in a planar cavity based on Bragg reflectors has been integrated onto the PMN-PT piezo crystal. Subsequently micropillars have been fabricated by electron-beam lithography and reactive ion-etching. The application of an external stress produces roughly linear shifts of QDs emission which could be tuned into the resonance with fundamental cavity mode. Clear enhancement of QD emission have been observed and a Purcell factor as large as 4.43+/0.64 was extracted from time-resolved measurements based on strain tuning. Second-order autocorrelation histogram for pulsed resonant excitation with a π-pulse has been recorded, indicating high purity single-photon emission.