HL 49: Quantum dots: Devices

Time: Friday 9:30–11:45 Location: POT 151

HL 49.1 Fri 9:30 POT 151

Gate-based protocol simulations for quantum repeaters using quantum-dot molecules in switchable electric fields — •Steffen Wilksen, Frederik Lohof, and Christopher Gies — Institute for Theoretical Physics, University of Bremen, Bremen, Germany

Semiconductor quantum dots provide a promising platform for applications in quantum information technologies, such as quantum repeaters, which enable secure quantum communication over long distances. Two quantum dots, separated by a small tunnelling layer, form a so-called quantum dot molecule (QDM), which exhibits properties similar to classical molecules. Their energy levels can be tuned by applying an external electric field, thereby allowing to perform gate operations. We consider QDMs in switchable electric fields towards quantum-repeater realizations. The time dependence that arises from performing gate operations requires a careful treatment of the system-bath interaction. We treat the QDM as an open quantum system using an explicitly time-dependent Redfield master equation approach, accounting for the time dependence of the interaction rates beyond more simple Lindblad approaches. Based on our approach, we investigate the adiabatic and non-adiabatic behaviour of the system for different switching speeds and determine achievable execution times for gate operations with currently existing QDMs.

HL 49.2 Fri 9:45 POT 151

Heterogeneous integration of telecom c-band emitting quantum dots on silicon photonics platform by adhesive bonding — •Ponraj Vijayan, Fiona Braun, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen, Universität Stuttgart, Germany

Silicon photonics for telecommunications applications has garnered much attention recently. The optical transparency and the large refractive index contrast of silicon in the telecommunication wavelengths allow the implementation of high-density photonic integrated circuits. The drawback of silicon photonics is that there is no native light source due to the indirect band-gap nature of silicon. Integration of III-V material, which offers outstanding optical emission properties, on silicon provides a potential solution. The direct growth of III-V materials on silicon is the most desired approach because it is economically favourable. However, it is challenging because of large lattice mismatch between the III-V materials and silicon. An alternate approach for large-scale integration is through heterogeneous integration of thin III-V membrane using adhesive bonding technique. For such integration, it is crucial to have a robust bonding procedure which provides a uniform bonding layer with a desired thickness for efficient light coupling between III-V active layer and the silicon photonic platform. Our group has previously developed InAs QD/InGaAs MMB/GaAs substrate structures for long-distance optical fiber applications [3]. Here, we report on the route to integrate the telecom C-band emitting InAs QD on silicon photonic platform using adhesive bonding.

HL 49.3 Fri 10:00 POT 151

Investigation of optical properties of open-fiber cavities embedding semiconductor quantum dots emitting in the telcom O-band — •Nam Tran[1], Julian Maisch[1], Jonas Grammel[2], Julia Wecker[1], Thomas Herzog[1], Robert Sittig[1], Ponraj Vijayan[1], Michael Jetter[1], Simone L. Portalupi[1], David Hunger[2], and Peter Michler[1] — [1]Institut für Halbleiteroptik und Funktionelle Grenzflächen , Center for Integrated Quantum Science and Technology (IQ^{ST}) and SCoPE , University of Stuttgart, Stuttgart, Germany — [2]Physikalisches Institut , Karlsruher Institut für Technologie (KIT), Karlsruhe, Germany

Single photon sources operating at telecom wavelength play a central role in quantum information, in particular when long-distance implementations are targeted. Highly promising candidates are semiconductor quantum dots (QD). Cavity quantum electrodynamics is often used to tailor the emission properties and, in case of photon sources, enhance their performances. However, limiting factors like spatial and spectral mismatch can be detrimental to the cavity-emitter interaction. Using tunable fiber cavities can overcome these limitations. Additionally, since the fiber coupling is intrinsically given in these cavities the integration into the already existing fiber network is facilitated. Here, we made a thorough investigation of the optical properties of open fiber cavities embedding semiconductor QDs emitting in the telecom O-band. Moreover, deterministic positioning of individual QDs enables the comparison of the optical properties within and outside the cavity.

HL 49.4 Fri 10:15 POT 151

Higher order effective coefficients in Ge/Si core/shell nanowire devices — •Sebastian Miles[1,2], Piotr Rozek[1,2], Mert Bozkurt[1,2], Dániel Varjas[3], and Michael Wimmer[1,2] — [1]QuTech, Delft University of Technology, Delft 2600 GA, The Netherlands — [2]Kavli Institute of Nanoscience, Delft University of Technology, Delft 2600 GA, The Netherlands — [3]Max-Planck-Institut für Physik komplexer Systeme, 01187 Dresden, Germany

Germanium based nanowires are prominent platforms in mesoscopic physics because of their tunable spin-orbit interaction. This property makes them an interesting candidate for hole-qubit devices or as a platform for Majoranas. Hence, a good understanding of effective models for the relevant degrees of freedom in these devices is of great importance. We revisit the subject of effective Hamiltonians and effective coefficients for efficient nano-device control in Ge/Si core/shell semiconductor nanowires from a perturbation theory perspective. We elaborate on relevant terms and present numerical and semi-analytical results of Lowdin perturbation theory to second order. We discuss the consequences of higher order terms on the effective models of interest for device applications.

30 min. break

HL 49.5 Fri 11:00 POT 151

Interfacing Semiconductor Quantum Dots with Photonic Wire Bonds — •Marco De Gregorio[1], Shangxuan Yu[2,3], Donald Witt[2,3], Becky Lin[2,3], Matthew Mitchell[2], Tobias Huber-Loyola[1], Lukas Chrostowski[2,3], Jeff F. Young[2,4], Andreas Pfenning[1,2], and Sven Höfling[1] — [1]Lehrstuhl für Technische Physik, Julius-Maximilians-Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany — [2]Stewart Blusson Quantum Matter Institute, University of British Columbia, Vancouver, British Columbia V6T 1Z4, Canada — [3]Department of Electrical and Computer Engineering, University of British Columbia, Vancouver, British Columbia V6T 1Z4, Canada — [4]Department of Physics and Astronomy, University of British Columbia, Vancouver, British Columbia V6T 1Z1, Canada

We present first experimental results of an alternative extraction technique of single photons emitted by semiconductor quantum dots. For this purpose, a photonic wire bond is directly attached to the end facet of a waveguide containing In(Ga)As semiconductor quantum dots grown by molecular beam epitaxy and connected to a single-mode optical fiber. We perform above-band and optical resonant excitation of the quantum dot and find that in this configuration, cross-polarization filtering of the single photons can be avoided, while measuring a steady stream of single-photons in fiber. The coupling efficiency can be further improved by optimized mode matching between photonic wire bond and waveguide.

HL 49.6 Fri 11:15 POT 151

Deterministically fabricated InAs quantum dot based single-photon sources at telecom wavelengths — •Monica Pengerla[1], Alkaales Mohanad[2], Ranbir Kaur[2], Jan Donges[1], Lucas Bremer[1], Johannes Schall[1], Sven Rodt[1], Mohamed Benyoucef[2], and Stephan Reitzenstein[1] — [1]Institut für Festkörperphysik, Technische Universität Berlin, Hardenbergstraße 36, D-10623 Berlin, Germany — [2]Institute of Nanostructure Technologies and Analytics (INA), Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany

Quantum dot (QD) based single-photon sources are key elements of photonic quantum networks. Most interesting are sources emitting at telecom wavelengths to enable long distance fiber-based quantum communication. Here, we report on deterministically fabricated single-photon sources based on InAs QDs grown on InP substrate. Numerical simulations of such QD heterostructures with backside distributed

Bragg reflector reveal photon extraction efficiency exceeding 50% when QDs are integrated into mesa or circular Bragg grating structures. A state-of-the-art electron beam lithography (EBL) system with integrated low temperature cathode luminescence (CL) system allows us to perform in-situ EBL at telecom wavelengths. For noisy CL maps, an advanced approach for machine learning enhanced in-situ EBL to enhance the maps at telecom wavelengths for better integration of QDs into photonic structures is used. Micro-photoluminescence studies reveal the optical properties of the fabricated quantum devices.

HL 49.7 Fri 11:30 POT 151

GaSb Quantum Dots as Emitters of Telecom S-Band Single Photons — •Johannes Michl[1], Giora Peniakov[2], Andreas Pfenning[1], Joonas Hilska[2], Abhiroop Chellu[2], Teemu Hakkarainen[2], Tobias Huber-Loyola[1], Mircea Guina[2], and Sven Höfling[1] — [1]Technische Physik, Julius-Maximilians-Universität Würzburg, Germany — [2]Physics Unit / Photonics Faculty of Engineering and Natural Sciences, Tampere University, Finland

Over the last few years, several semiconductor quantum dot (QD) material platforms like In(Ga)As)/ GaAs and InAs/InP have emerged as resources for non-classical light and spin-photon interfaces in the telecom wavelength range. However, there is not much data on the optical and spin properties of GaSb QDs, despite it being a physically rich system. For example, it is possible to switch between direct and indirect bandgap by controlling the size of the quantum dots. Moreover, due to reduced strain, it is expected to have less quadrupole nuclear interaction resulting in enhanced spin dephasing times, similar to what was recently observed in GaAs QDs in AlGaAs. Here, we investigate the (quantum-) optical properties of GaSb quantum dots which are fabricated by filling droplet-etched nanoholes in an AlGaSb matrix and exhibit photoluminescence (PL) with a narrow linewidth in the telecom S-band. We perform polarization resolved magneto-PL studies to investigate charge complexes in our sample and perform correlation measurements to evaluate the use of GaSb quantum dots as a source of indistinguishable single photons.