HL 89: Quantum Dots and Wires: Lasing

Time: Thursday 16:00–17:45 Location: H13

HL 89.1 Thu 16:00 H13

Sub- and Superradiance in Quantum-Dot Nanolasers — •Heinrich A.M. Leymann[1], Alexander Foerster[1], Christopher Gies[2], Marc Assmann[3], Christian Schneider[4], Martin Kamp[4], Sven Höfling[4], Manfred Bayer[3], Frank Jahnke[2], and Jan Wiersig[1] — [1]Otto-von-Guericke-Universität Magdeburg Postfach 4120 39016 Magdeburg — [2]Institut for Theoretical Physics University of Bremen P.O. Box 330 440 28334 Bremen, Germany — [3]Experimentelle Physik 2 Technische Universität Dortmund Otto-Hahn-Straße 4 D-44227 Dortmund Germany — [4]Technische Physik Am Hubland 97074 Würzburg

We investigate the influence of radiative coupling between emitters in quantum-dot (QD) nanolasers. For typical lasers with tens to hundreds of active QDs, a strong impact of sub- and superradiance (SR) on laser characteristics is demonstrated. It is shown that radiative coupling enhances spontaneous emission such that significantly fewer emitters are required to reach the lasing threshold [1]. The SR coupling can seemingly change the β-factor by an order of magnitude. Experimental results show a direct connection between superradiant pulse emission and distinctive changes in the photon correlation function which is in excellent agreement with the theoretical results. Calculations are based on a microscopic laser theory for the coupled multi-QD-cavity-photon system [2].

[1] Phys. Rev. Applied **4**, 044018 (2015).
[2] Phys. Rev. B **89**, 085308 (2014).

HL 89.2 Thu 16:15 H13

Imaging the lasing emission of semiconductor nanowires — •Walter Dickmann[1], Max Riediger[1], Robert Röder[1], Robert Buschlinger[2], Carsten Ronning[1], and Ulf Peschel[2] — [1]Institut für Festkörperphysik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena, Germany — [2]Institut für Festkörpertheorie und Optik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena, Germany

The forthcoming limitations of conventional on-chip electronic circuits make the development of miniaturized photonic circuits desirable, which should be driven by coherent nanoscale light sources. Semiconductor nanowires are very promising as such functional device, because they provide efficient waveguiding in sub-wavelength diameter scales as well as lasing above a material dependent threshold. The emission features of single ZnO NWs are investigated in a head-on setup, as they highly affect the coupling efficiency into envisaged photonic circuits. Direct imaging of the far-field emission allows the characterization of the transverse mode(s) as well as their polarization features. This is realized by calculating the Stokes parameters from Fourier mappings of the far field. The measured intensity distributions are unambiguously assigned to the respective transverse lasing modes in agreement with FDTD simulations: For NW diameters below 180 nm, only the fundamental mode HE11 lases, while in thicker NWs additionally the TE01 mode contributes significantly.

HL 89.3 Thu 16:30 H13

Strain induced tunable semiconductor nanowire lasers — •Maximilian Zapf[1], Lisa Schade[1], Robert Röder[1], Karl Winkler[2], Alois Lugstein[2], and Carsten Ronning[1] — [1]Institute of Solid State Physics, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena, Germany — [2]Institute of Solid State Electronics, TU Wien, Floragasse 7, A-1040 Vienna, Austria

Semiconductor nanowire (NW) lasers are a promising approach for the future miniaturization of optoelectronic devices. An emerging goal of research on nanoscale laser systems is the ability to tune the emission spectrally, which is achieved within semiconductor nanowires by inducing strain. Both the possibility of a strain induced bandgap modulation and laser oscillations in semiconductor NWs have been proven in several studies [Wei et al., Nano letters 12, 4595 (2012) ; Geburt et al., Nanotechnology 23, 365204 (2012)]. This has recently raised the idea of combining both efforts, aiming for lasing in strain tunable devices. Such devices were fabricated by placing NWs on a structured low refractive index substrate in a way that both NW ends are fixed, while the middle part is bridging a length tunable gap. Strain is applied by bending the sample macroscopically with a home built stage, which provides uniaxial strain to the gap area of the NW. Nanowire lasing measurements were conducted as a function of the applied strain, which lead to changes in the emission spectra as well as in the gain/loss ratio of the laser device. Furthermore, the device geometry enables the realization of strain switchable photonic waveguides.

15 min. Coffee Break

HL 89.4 Thu 17:00 H13

Lasing at arbitrary frequencies with atoms with broken inversion symmetry and an engineered electromagnetic environment — •Michael Marthaler[1], Martin Koppenhöfer[1], Karolina Słowik[1,2], and Carsten Rockstuhl[1] — [1]Karlsruhe Institute of Technology — [2]Instytut Fizyki, Uniwersytet Mikołaja Kopernika

We consider a two level system with both a transversal and longitudinal coupling to the electromagnetic field. If the longitudinal coupling is sufficiently, strong multi-photon transitions become possible. We assume that the electromagnetic environment has a spectrum with a single sharp resonance which serves as a lasing cavity. Additionally the electromagnetic environment should have a very broad peak at a frequency which differs form the sharp resonance. We use the polaron transformation, and derive a rate equation which can describe the dynamics of our system. Lasing at the frequency of the sharp mode is possible if the energy difference of the atomic transition is similar to the sum of the frequencies of both peaks in the spectral function. This allows for the creation of lasing over a large frequency range.

HL 89.5 Thu 17:15 H13

Pump-probe quantum state tomography in quantum-dot amplifiers: Theory and experiment — •Fabian Böhm[1], Nicolai B. Grosse[1], Nina Owschimikow[1], Roland Aust[2], Benjamin Lingnau[2], Mirco Kolarczik[1], Kathy Lüdge[2], and Ulrike Woggon[1] — [1]Institut für Optik und Atomare Physik, Technische Universität Berlin, Germany — [2]Institut für Theoretische Physik, Technische Universität Berlin, Germany

Optical quantum state tomography is a method which allows to reconstruct a quantum state by obtaining it's corresponding Wigner function. It can be used to infer the state's density matrix and thus the full quantum information such as the photon number distribution or correlation function can be obtained. We apply this technique to an In(Ga)As quantum-dot optical amplifier and investigate how the coherent state of an ultrashort probe pulse tuned to the quantum dot ground state is transformed by passing through the device. Combination with a probe pulse tuned to the excited state gives access to the dynamics of population inversion and device gain on a sub-picosecond scale as well as the amplified and spontaneous emission noise relative to the quantum noise limit in the amplifier. We experimentally study depletion and recovery mechanisms in the population inversion for varying pump currents and compare them with predictions from a theoretical model for semiconductor amplifiers.

HL 89.6 Thu 17:30 H13

Ultrafast optical pulse modulation in hybrid silicon nitride/colloidal quantum dot systems — •Christian Ulbrich[1], Bastian Herzog[1], Pieter Geiregat[2,3], Yunpeng Zhu[3], Yücel Kaptan[1], Mirco Kolarczik[1], Zeger Hens[2], Dries van Thourhout[3], Ulrike Woggon[1], and Nina Owschimikow[1] — [1]Institut für Optik und Atomare Physik, Technische Univeristät Berlin, Germany — [2]Physics and Chemistry of Nanostructures Group, Faculty of Science, Department of Inorganic and Physical Chemistry, Ghent Univeristy, Belgium — [3]Photonics Research Group, Faculty of Engineering and Architecture, Department of Information Technology, Ghent Univeristy, Belgium

To explore the prospects for the integration of quantum dots with silicon photonics, we investigate the effect of colloidal PbS quantum dots coated onto SiN waveguides on the optical properties of the waveguides. The quantum dots are coupled to the waveguide mode via the evanescent field. In heterodyne detected pump-probe experiments we study (cross)-amplitude and -phase modulation of a probe pulse induced by optical pumping of intra- and interband transitions of the quantum dots.