DS 5: Nanophotonics - Theory of Nanophotonic Devices I

Time: Monday 11:15–12:30 Location: GER 38

Topical Talk DS 5.1 Mon 11:15 GER 38

Quantum modelling of nanophotonic laser devices — •Christina Bückers[1], Stephan W. Koch[1], Angela Thränhardt[2], Jörg Hader[3,4], and Jerome V. Moloney[3,4] — [1]Fachbereich Physik und Wissenschaftliches Zentrum für Materialwissenschaften, Philipps-Universität Marburg, Renthof 5, 35032 Marburg, Germany — [2]Fakultät für Naturwissenschaften, Technische Universität Chemnitz, 09107 Chemnitz, Germany — [3]Optical Sciences Center, University of Arizona, Tucson, AZ 85721, USA — [4]Nonlinear Control Strategies Inc., 3542 N. Geronimo Ave., Tucson, AZ 85705, USA

A microscopic theory is used to model the optical properties of semiconductor laser materials and modern devices. Typically, these devices are structured on the nanoscale such that any quantitative modelling requires a consistent quantum mechanical theory. In this talk, we show how such a many-particle approach can be used to compute the laser gain, absorption, photoluminescence as well as the radiative and Auger recombination processes. The predictive power of this modelling is demonstrated by detailed comparisons to quantitative experiments. In particular, so-called VECSEL (Vertical External Cavity Surface Emitting Laser) systems are analysed. It is shown that systematic design studies allow for device optimisation for a wide variety of different application conditions, such as high output power, emission at a particular wavelength, or low threshold.

Topical Talk DS 5.2 Mon 11:45 GER 38

Photon statistics and time evolution of photon correlations in semiconductor microcavity lasers — •Jan Wiersig[1], Christopher Gies[2], and Frank Jahnke[2] — [1]Institut für Theoretische Physik, Universität Magdeburg, 39016 Magdeburg — [2]Institut für Theoretische Physik, Universität Bremen, 28334 Bremen

Nanophotonic devices made of semiconductor quantum dots coupled to microcavities have a variety of potential applications including ultra-low threshold lasers and single-photon sources. In this talk we discuss a microscopic theory for the photon correlation functions $g^{(1)}(\tau)$ and $g^{(2)}(\tau)$ describing the first and second-order coherence of semiconductor quantum-dot-based microcavity lasers [1,2]. Our theory predicts interesting and unexpected decay properties of the correlation functions. We explain these findings and compare them to recent experiments [3-5].

[1] C. Gies, J. Wiersig, M. Lorke, and F. Jahnke, Phys. Rev. A **75**, 013803 (2007).

[2] C. Gies, J. Wiersig, and F. Jahnke, Phys. Rev. Lett. **101**, 067401 (2008).

[3] S.M. Ulrich *et al.*, Phys. Rev. Lett. **98**, 043906 (2007).

[4] S. Ates *et al.*, Phys. Rev. B **78**, 155319 (2008).

[5] J. Wiersig *et al.*, submitted (2008).

DS 5.3 Mon 12:15 GER 38

Sensitivity of Quantum-Dot Lasers to Optical Feedback — •Christian Otto, Kathy Lüdge, Ermin Malić, and Eckehard Schöll — Institut für Theoretische Physik, Sekr. EW 7-1, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin

Low sensitivity of a laser to back reflected light, a property needed for industrial device application, is predicted for semiconductor quantum dot (QD) lasers. In this work we investigate the complex dynamics of QD lasers subjected to weak external optical feedback from a distant mirror. The system is modeled with a modified Lang-Kobayashi equation for the electric field combined with microscopically based rate equations for the carriers in the quantum dots and surrounding wetting layer.

By varying the feedback strength we obtain complex bifurcation scenarios. For large linewidth enhancement factors ($\alpha>3$) we find a bifurcation cascade leading to chaotic regions alternating with short regions of stable cw operation. This resembles the behaviour found in quantum well lasers. However, for low α-factors around $\alpha=1$, typical for QD devices, the laser exhibits a reduced feedback sensitivity and performs stable cw operation over a wide range of increasing feedback strength.