HL 53: Optical Properties I

Time: Wednesday 12:30–13:30 Location: POT 251

HL 53.1 Wed 12:30 POT 251

Microscopic theory of phonons in the semiconductor microcavity luminescence — •Christoph N. Böttge, Thomas Feldtmann, Mackillo Kira, and Stephan W. Koch — Department of Physics and Material Sciences Center, Philipps-University, Renthof 5, D-35032 Marburg, Germany

The strong interaction between electrons and longitudinal optical (LO) phonons in ZnO gives rise to pronounced phonon sidebands in the photoluminescence (PL) spectrum as strikingly shown in recent experiments and theoretical investigations. To develop a consistent microscopic theory of the sideband emission, we have generalized the semiconductor luminescence equations (SLE) by including phonon-assisted processes. This approach allows us to compute both spontaneous and stimulated emission at the excitonic resonance and its first phonon sideband. In addition, we have developed an analytic model to describe phonon-assisted luminescence in a cavity.

Because phonon-assisted emission and absorption take place on different sides of the excitonic resonance, we found that no normal-mode splitting occurs for the phonon sideband. This is in pronounced contrast to the usual case where the cavity mode coincides with the zero phonon line leading to strong qualitative changes in the spectra due to the normal-mode coupling. Our numerical and analytical results confirm that the sideband intensity is strongly enhanced when the reflectivity of the mirrors reaches a critical value. We show that also ZnO-based systems can reach normal-mode coupling for the zero-phonon line and strongly enhanced emission for the first phonon sideband.

HL 53.2 Wed 12:45 POT 251

Many-body effects in phonon-sideband luminescence — •Alexej Chernikov[1], Verena Bornwasser[1], Christoph N. Böttge[1], Thomas Feldtmann[1], Sangam Chatterjee[1], Martin Koch[1], Mackillo Kira[1], Stephan W. Koch[1], Thomas Wassner[2], Stefan Lautenschlaeger[2], Bruno K. Meyer[2], and Martin Eickhoff[2] — [1]Faculty of Physics and Material Sciences Center, Philipps-Universität Marburg, Renthof 5, D-35032 Marburg, Germany — [2]I. Physikalisches Institut,Justus-Liebig-Universität Giessen,Heinrich-Buff-Ring 16, D-35392 Giessen, Germany.

The photoluminescence spectra of high-quality intrinsic semiconductors with a direct bandgap are usually dominated by the excitonic resonance. The spectra may also feature one or more additional lines, commonly referred to as phonon sidebands (PSBs), traced back to the phonon-assisted recombination. In theory, PSB luminescence is traditionally treated using a perturbative approach with excitons coupled directly to LO-phonons via polar Froehlich interaction. However, the many-body properties of the interacting carrier system yield a more complex picture. Already the luminescence at the main excitonic resonance does not necessarily require excitonic population. In addition, the Froehlich coupling is expected to be suppressed in case of the exciton-phonon interaction. Here, we study the time-resolved PSB emission of direct polar semiconductors and apply a microscopic many-body approach to analyze the experimental observations. Our results show that excitonic population is not required for the observation of PSBs.

HL 53.3 Wed 13:00 POT 251

THz studies of strong-coupling microcavity systems — •Andrea C Klettke[1], Johannes T Steiner[1], Mackillo Kira[1], Stephan W Koch[1], and Yun-Shik Lee[2] — [1]Department of Physics and Material Sciences Center, Philipps-University Marburg, Renthof 5, D-35032 Marburg, Germany — [2]Department of Physics, Oregon State University, Corvallis, Oregon 97331, USA

We study semiconductor quantum wells inside a cavity assuming the simultaneous presence of optical and terahertz radiation. Light-matter coupling of semiconductor quantum wells inside Bragg-mirror microcavities leads in the linear regime to a polaritonic mixing of the excitonic quantum well resonance and the cavity mode. The resulting normal mode splitting into low (LEP) and high energy peak (HEP) provides a basis for the conversion of $1s \rightarrow 2p$ population via strong THz radiation.

We present a microscopic theory allowing us to quantitatively evaluate the combined influence of the optical and THz field and their interaction with the microcavity exciton resonance. We use the parameters appropriate to study the response of a system investigated experimentally in the group at Oregon State University. The major observation is that we can selectively switch off either the low or the high energy peak. Non-linear contributions will be discussed as well as multi-photon absorption and higher harmonics.

HL 53.4 Wed 13:15 POT 251

Quantum-optical correlations in dissipative quantum-dot systems — •Martin Mootz, Mackillo Kira, and Stephan W. Koch — Department of Physics and Material Sciences Center, Philipps-University Marburg, Renthof 5, D-35032 Marburg

Quantum-optical spectroscopy is based on a concept where the system interactions are controlled and characterized through the quantum fluctuations of the light. We apply this scheme to semiconductor systems which exhibit a complicated many-body problem dominated by the Coulomb interaction among electrons and holes and by coupling with the semiconductor environment. To gain insights on the quantum-optical spectroscopy, we model quantum-dot systems via the Jaynes-Cummings model coupled to a reservoir. We characterize the quantum features of the light source and the resonance fluorescence via the cluster-expansion transformation that yields a one-to-one mapping between correlated clusters and the traditional phase-space distributions. We investigate the transition from strong-to-weak coupling, which is typically considered to be the border between quantum-optical and classical studies. We show that quantum-optical spectroscopy can detect nonclassical features even in the weak-coupling regime where dephasing completely removes direct quantum-optical signatures such as revivals and quantum-Rabi flopping.