Experimentelle Physik 2

Seminar Festkörperphysik (CMP Seminar)

Aktuelle Probleme der Festkörperphysik für Studenten und Mitarbeiter
020236 Kolloquium/Seminar WS 24/25
Vorlesungszeit: 10.10.2024 – 17.04.2025

Thursday, 16.01.2025
12:10 - P1-02-110

Real-time quantum measurements: Understanding electron dynamics in a single-photon emitter

Martin Geller

Faculty of Physics and Cenide, University of Duisburg-Essen, 47048 Duisburg, Germany.
Email: martin.geller@uni-due.de

The Zeeman-split spin states of a single self-assembled quantum dot, together with its optical trion transitions, form a spin-photon interface [1], which allows the coupling of a stationary quantum bit (spin) with a flying quantum bit (photon). In addition to a long coherence time of the spin state itself, the limiting decoherence mechanisms of the trion states are of key importance. Previous results have shown spin and charge noise to be the main dephasing mechanisms [2], while the influence of electron-electron and electron-photon scattering, such as the non-radiative Auger effect, the radiative Auger effect [3], or the internal photo-effect, are still under investigation.

We use time-resolved resonance fluorescence to observe the Auger and photo-effect in the non-equilibrium charge dynamics of a single self-assembled quantum dot. Real-time measurements of each individual quantum event provide the maximum information about the dynamical properties of the quantum dot coupled to an electron reservoir and driven by resonant optical excitation [4]. The obtained time traces can be used in a statistical analysis to gain a deep understanding of the underlying physical mechanisms, such as Auger recombination. The resulting telegraph signal is evaluated by full counting statistics, using factorial cumulants as a very sensitive statistical tool to reduce the influence of statistical and systematic errors [5]. We show that factorial cumulants, together with optical excitation push the limits of detection and analysis of random telegraph data to measure the possible dephasing mechanisms of electron-electron and electron-photon scattering.

[1] S. T. Yılmaz, P. Fallahi, and A. Imamoğlu, Phys. Rev. Lett. **105**, 033601 (2010).
[2] A. V. Kuhlmann, J. Houel, A. Ludwig, L. Greuter, D. Reuter, A. D. Wieck, M. Poggio, R. J. Warburton, Nature Phys. **9**, 570 (2013).
[3] A. Kurzmann, A. Ludwig, A. D. Wieck, A. Lorke, and M. Geller, Nano Lett. **16**, 3367 (2016).
[4] A. Kurzmann, P. Stegmann, J. Kerski, R. Schott, A. Ludwig, A. D. Wieck, J. König, A. Lorke, and M. Geller, Phys. Rev. Lett. **122**, 247403 (2019).
[5] E. Kleinherbers, P. Stegmann, A. Kurzmann, M. Geller, A. Lorke, and J. König, Phys. Rev. Lett. **128**, 087701 (2022); E. Kleinherbers, H. Mannel, J. Kerski, M. Geller, A. Lorke, and J. König, Phys. Rev. Research **5**, 043103 (2023).