MON 22: Quantum Transport II

Time: Monday 16:30–17:45 Location: ZHG104

MON 22.1 Mon 16:30 ZHG104

Ultralow Lattice Thermal Conductivity and Colossal Thermoelectric Figure of Merit of the Room Temperature Antiferromagnet CsMnBi — •shubham Rakesh Singh[1], Nirpendra Singh[2], and Udo Schwingenschlögl[1] — [1]Physical Science and Engineering Division (PSE), King Abdullah University of Science and Technology (KAUST), Thuwal 23955-6900, Saudi Arabia — [2]Department of Physics, Khalifa University of Science and Technology, Abu Dhabi-127788, United Arab Emirates

We study the experimentally synthesized layered material CsMnBi using first-principles calculations and the linearized electron and phonon Boltzmann transport equations. CsMnBi is found to be a semiconductor with a indirect bandgap of 0.9 eV and to realize C-type antiferromagnetism, which is energetically favorable by 187 meV per formula unit over ferromagnetism. Energetical overlap between the acoustic and low-frequency optical phonon modes enhances the phonon-phonon scattering. Combined with low group velocities and high lattice anharmonicity this results in an ultralow lattice thermal conductivity of 0.07 $\mathrm{Wm^{-1}K^{-1}}$ at 300 K. A high thermoelectric figure of merit of 2.2 (1.7) is achieved at 300 K at a hole (electron) density of 6.0×10^{18} (1.0×10^{18}) $\mathrm{cm^{-3}}$.

MON 22.2 Mon 16:45 ZHG104

Transport characteristics of quantum dots for single-electron pumps — •Johannes C. Bayer, Thomas Gerster, Dario Maradan, Niels Ubbelohde, Klaus Pierz, Hans W. Schumacher, and Frank Hohls — Physikalisch-Technische Bundesanstalt, 38116 Braunschweig, Germany

An elegant and direct way to generate accurate currents is given by applying a periodic signal to a tunable barrier quantum dot. Such a device is called a single-electron pump (SEP) and emits a well defined number of n electrons per cycle of an external drive, resulting in a current of $I = nef$, with elementary charge e and driving frequency f. While individual SEPs can already achieve sub-ppm accuracy [1], the extension to systems operating multiple well-performing SEPs, e.g. in parallel to achieve larger currents, is still challenging. Our SEP devices are based on quantum dots formed electrostatically in a GaAs/AlGaAs two-dimensional electron gas. Based on multiple quantum dot devices, we characterize the DC transport properties and analyze relations to the dynamic SEP operation toward achieving robust, reproducible and scalable devices [2].

[1] F. Stein, et. al., Metrologia 54, S1-S8 (2017).
[2] T. Gerster, et. al., Metrologia 56, 014002 (2019)

MON 22.3 Mon 17:00 ZHG104

Quantum electrical current sources for metrological application based on silicon qubit technology — •Dustin Wittbrodt[1], Johannes C. Bayer[1], Janne S. Lehtinen[2], Lars R. Schreiber[3], Marcelo Jaime[1], and Frank Hohls[1] — [1]Physikalisch-Technische Bundesanstalt, Braunschweig, Deutschland — [2]SemiQon Technologies Oy, Espoo, Finnland — [3]3JARA Institute for Quantum Information, Forschungszentrum Juelich,Juelich, Germany

In 2019, the redefinition of the SI system of units introduced fixed values to fundamental constants such as the elementary charge (e) and the Planck constant (h). While the units Ohm and Volt are well established, the ampere has yet to reach the same level of accuracy. The most commonly used concept of Ampere realization has been the Single Electron Pumps (SEPs), which generate quantized currents in the fA-pA range with a precision of as low as 0.2 ppm. To increase the current level of such single electron-based quantum current standards into the nA range, parallelization of several SEPs is required. To explore this task a high level of reproducibility and scalability is necessary, which is available in industrial CMOS processes. As part of the EU-funded AQuanTEC project, different Si and Si-Compound Spin Qubit Technology platforms are being tested as SEPs focusing on their accuracy and pumping behavior. To benchmark their accuracy, AC modulated pumping experiments are conducted. The results of this effort are presented here, offering a perspective into the possible employment of Qubit technology for the broader usage as quantum metrological instruments.

MON 22.4 Mon 17:15 ZHG104

Influence of Electron Density on Giant Negative Magnetoresistance — •Lina Bockhorn[1], Christian Reichl[2], Werner Wegscheider[2], and Rolf J. Haug[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, Germany — [2]Laboratorium für Festkörperphysik, ETH Zürich, Switzerland

Ultra-high mobility two-dimensional electron gases often exhibit a remarkably robust negative magnetoresistance at zero magnetic field. Below 800 mK, this phenomenon divides into two distinct parts [1-4]: a temperature-independent narrow peak around $B = 0\,\mathrm{T}$, arising from the interplay of smooth disorder and elastic scattering at macroscopic defects [2, 3], and a temperature-dependent giant negative magnetoresistance (GNMR) at higher magnetic fields. The theoretical understanding of the GNMR remains an open question, as it involves several independent parameters in addition to electron-electron interaction, possibly leading to hydrodynamic transport effects. To gain insights into the nature of GNMR, we investigate this effect as a function of electron density at various temperatures and currents. Our results show a significant dependence of GNMR on electron density [4], suggesting that variations in scattering potentials [5] are not considered appropriately in theoretical models.

[1] L. Bockhorn et al., Phys. Rev. B 83, 113301 (2011).
[2] L. Bockhorn et al., Phys. Rev. B 90, 165434 (2014).
[3] L. Bockhorn et al., Appl. Phys. Lett. 108, 092103 (2016).
[4] L. Bockhorn et al., Phys. Rev. B 109, 205416 (2024).
[5] Y. Huang et al., Phys. Rev. Materials 6, L061001 (2022).

MON 22.5 Mon 17:30 ZHG104

Decoding undesired charge dynamics in gated GaAs quantum dots — •Lena Klar[1], Kai Hühn[1], Arne Ludwig[2], Andreas Wieck[2], Jens Hübner[1], and Michael Oestreich[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, Appelstraße 2, 30167 Hannover, Germany — [2]Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, 44780 Bochum, Germany

Single semiconductor quantum dots (QDs) exhibit high potential as single-photon sources and are promising candidates for solid state qubits [1,2]. However, fluctuations in their charge state and in the surrounding semiconductor matrix significantly affect their optical absorption and emission spectra, even for gated quantum dots. Using two-colour resonance fluorescence spectroscopy, we investigate these fluctuations in a gated GaAs/(AlGa)As-QD in dependence on the QD charge state, temperature, and laser intensity. The experiment reveals not only standard telegraph noise but also subtle noise contributions from the QD's environment, which deteriorate single photon QD sources. Calculations and numerical simulations based on light induced charge dynamics and an alternating occupation of charge traps surrounding the QD are in good agreement with the experimental results and show optimisation perspectives for GaAs QD single photon emitters.

[1] Y. Arakawa, M. J. Holmes, Appl. Phys. Rev. **7**, 021309 (2020).
[2] A. Chatterjee et al., Nat. Rev. Phys. **3**, 157-177 (2021).