DY 14: Quantum Coherence (joint session TT/DY)

Time: Monday 16:15–18:00 Location: H 3025

Invited Talk DY 14.1 Mon 16:15 H 3025

Quantum thermodynamics and its statistical mechanics: Facts, debatable issues and still unsolved problems — •Peter Hänggi — 1 University of Augsburg, Dept. Physics, 86159 Augsburg, Germany

The present state of the art of this topic contains several subtleties, pitfalls, inconsistencies as well as still open issues. Those are present in both, classical and quantum settings. Even at manifest thermal equilibrium, these thermodynamic notions become surprisingly tricky when strong system-bath interactions matter. A particular intriguing difficulty comprises the notorious invasive character of quantum measurements; i.e., the role of quantum back-action. Fact is: If anything can be said at all, - it preferably should be stated most clearly (Ludwig Wittgenstein, 1889-1951).

[1] D. Castelvecchi, Nature 543 (2017) 597 ; Z. Merali, Nature 551 (2017) 20
[2] P. Hänggi and P. Talkner, Nature Physics 11 (2015) 108
[3] P. Talkner and P. Hänggi, Phys. Rev. E 93 (2016) 022131
[4] P. Talkner and P. Hänggi, Rev. Mod. Phys. 92 (2020) 041002.

DY 14.2 Mon 16:45 H 3025

Efficiency of pulsed electron spin resonance protocols for quantum state storage with phosphorus donors in silicon — •Patricia Oehrl[1,2], Nadezhda Kukharchyk[1,2,3], Kirill G. Fedorov[1,2,3], Rudolf Gross[1,2,3], and Hans Huebl[1,2,3] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]Technical University of Munich, TUM School of Natural Sciences, Garching, Germany — [3]Munich Center for Quantum Science and Technologies (MCQST), Munich, Germany

The storage of quantum states is considered to be a key element for the successful realization of a multimode quantum network [1]. Solid-state spin ensembles, such as phosphorus donors in silicon, offer exceptional coherence times and resonant transitions in the GHz range [2]. Therefore, they are promising candidates for the realization of quantum memories without frequency conversion techniques. Here, we present a hybrid system consisting of a superconducting lumped-element microwave resonator coupled to a phosphorus donor electron spin ensemble hosted in isotopically engineered silicon. We use continuous-wave spectroscopy complemented by pulsed excitation and time-domain detection techniques. To this end, we operate our hybrid system at millikelvin temperatures and moderate static magnetic fields. We investigate the performance of our hybrid system with regard to quantum memory applications by analyzing the storage efficiency based on various pulse shapes and sequences.

[1] M. Pompili et al., Science 372 (2021) 6539
[2] M. Steger et al., Science 336 (2012) 1280

DY 14.3 Mon 17:00 H 3025

Characterization of hyperfine transitions of rare-earth spin ensembles via broadband ESR spectroscopy at mK temperatures — •Ana Strinic[1,2,3], Patricia Oehrl[1,2,3], Owen Huisman[4], Hans Huebl[1,2,3], Rudolf Gross[1,2,3], and Nadezhda Kukharchyk[1,2,3] — [1]Walther-Meissner-Institute, Bavarian Academy of Sciences and Humanities, Garching, Germany — [2]School of Natural Sciences, Technical University of Munich, Garching, Germany — [3]Munich Center for Quantum Science and Technologies, Munich, Germany — [4]Delft University of Technology, Delft, The Netherlands

Hybrid quantum systems consisting of a superconducting quantum processor coupled to a quantum memory (QM) offer great potential for quantum computing [1]. For interfacing the two components, a microwave (mw) QM is advantageous, since losses due to frequency transduction can be avoided. A potential platform for mw QMs are rare-earth spin ensembles, due to their hyperfine transitions in the GHz regime, which exhibit long coherence times [2]. In this work, we study the hyperfine transitions in ^{167}Er:^{7}LiYF$_4$ using broadband microwave spectroscopy employing a coplanar waveguide. The high resolution ESR spectra obtained at 10 mK allow to quantify the parameters of the spin Hamiltonian, in particular the hyperfine and quadrupole coefficients. Moreover, this technique allows to directly address various hyperfine transitions at their zero first-order Zeeman points, which is key for the implementation of mw QM schemes.

[1] E. Gouzien, N. Sangouard, Phys. Rev. Lett. 127 (2021) 140503
[2] P.Y. Li et al., Phys. Rev. Appl. 13, 024080 (2020)

DY 14.4 Mon 17:15 H 3025

Dichroic cavity mode splitting and lifetimes from interactions with ferromagnetic metal — •Henning G. Hugdal, Eirik Jaccheri Høydalsvik, and Sol H. Jacobsen — Center for Quantum Spintronics, Department of Physics, NTNU, Norwegian University of Science and Technology, NO-7491 Trondheim, Norway

We study the effect of ferromagnetic metals (FM) on the circularly polarized modes of an electromagnetic cavity and show that broken time-reversal symmetry leads to a dichroic response of the cavity modes. In the simple model of only one spin split band, the Zeeman coupling between the FM electrons and cavity modes leads to an anticrossing for mode frequencies comparable to the spin splitting. However, this is only the case for one of the circularly polarized modes, while the other is unaffected by the FM. Hence, the cavity photons display a dichroic response to the presence of the FM, allowing for the determination of the spin-splitting of the FM using polarization-dependent transmission experiments. Moreover, using a spin-split two-band model, we show that also the lifetimes of the cavity modes display a polarization dependent response. The reduced lifetime of modes of only one polarization could potentially be used to engineer and control circularly polarized cavities.

DY 14.5 Mon 17:30 H 3025

Diagrammatic approach to quantum heat transport in the quantum Rabi model — •Luca Magazzu[1], Elisabetta Paladino[2,3], and Milena Grifoni[1] — [1]University of Regensburg — [2]Università di Catania, Italy — [3]INFN, Sez. Catania, Italy

A diagrammatic approach to quantum transport in Liouville space, valid for bosonic/fermionic environments, is applied to bosonic heat transport in the quantum Rabi model. Heat transport at weak interaction with the heat baths is controlled by the qubit-oscillator coupling g. Universality of the linear conductance versus the temperature is found below a coupling-dependent Kondo-like temperature.

At low temperature, coherent 4th-order processes dominate transport yielding a T^3 behavior for the thermal conductance κ. In the high-temperature regime, incoherent emission/absorption processes constitute the main transport mechanism, giving resonant peaks, at low g, when the qubit frequency matches the one of the oscillator. In these conditions, the spectrum of the Rabi model displays quasi-degeneracies that produce non-vanishing coherences at the steady state which, in turn, impact κ.

In moving from the weak to the ultrastrong qubit-oscillator coupling regime, the low-T conductance converges to the one of an effective two-level system. At high T, κ makes a transition from a resonant peak to a broad, zero-bias peak regime, a behavior that parallels the one found for the spin-boson model at strong qubit-bath coupling.

DY 14.6 Mon 17:45 H 3025

An on-demand source of energy-entangled electrons using Levitons — Bruno Bertin-Johannet, Laurent Raymond, •Flavio Ronetti, Jérôme Rech, Thibaut Jonckheere, Benoît Grémaud, and Thierry Martin — Aix-Marseille Univ, Université de Toulon, CNRS, CPT, Marseille, France

The on-demand generation of single- and few-electron states in mesoscopic systems has opened the way to the fascinating field of electron quantum optics (EQO), where individual fermionic quantum states are manipulated with methods borrowed from photonic quantum-optical experiments. In this framework, a train of Lorentzian voltage pulses represents one of the most reliable experimental protocol to inject coherent single-electronic states, known as Levitons, into ballistic channels of meso-scale devices. In this talk, we will discuss how the propagation of Levitons is affected by the presence of correlations between electrons and how these effects can be exploited in potential applications for quantum electronics and quantum information. We propose a device where EQO is combined with a BCS superconductor – a reservoir of Cooper pairs. With spin polarized wave guides, this version of the Cooper pair beam splitter is driven by an AC drive, and observables such as period-averaged noise are computed using a Keldysh-Nambu-Floquet formalism. This allows to propose an on-demand source of non-local energy-entangled states. By measuring current fluctuations we propose a way to observe the entangled nature of this state.