# SYSD 1: Symposium SKM Dissertation-Prize 2015

Time: Monday 11:00–12:40 Location: HE 101

**Invited Talk** SYSD 1.1 Mon 11:00 HE 101

**Light-matter interaction in mesoscopic transport: The bright side of charge transfer through Josephson junctions** — •Vera Gramich, Björn Kubala, and Joachim Ankerhold — Institute for Complex Quantum Systems, University of Ulm, Ulm, Germany

Classical laws of macroscopic physics cannot describe electronic transport in nanoscale devices. Instead, one enters a world governed by fascinating quantum effects, where, to name just one basic example, electric current is constituted from quantized units of charge (e.g., Cooper pairs).

I will discuss a recently realized new type of superconducting circuit where current transport across a voltage-biased Josephson junction (JJ) is coupled to a microwave cavity via photonic energy transport allowing to detect photon radiation *and* charge flow. This setup sheds, in a literal sense, light on the interaction of single Cooper pairs with the electromagnetic cavity field: Thanks to its tunability, the JJ can be operated in different regimes of transport, where charge quantization (Coulomb blockade realm with low photon occupation in the cavity) or coherent transport with high photon occupancy dominates, resulting in a quantum-classical changeover from the JJ + resonator compound. A real benefit of the circuit is that radiated photons offer a new tool to investigate the creation of non-classical photon states in the cavity and to monitor charge flow, vice versa, current noise carries information about the nonlinear cavity dynamics, which allows to analyze quantum-classical boundaries.

**Invited Talk** SYSD 1.2 Mon 11:25 HE 101

**Dynamics of a Quantum Spin Liquid** — •Johannes Knolle — T.C.M. Group, Cavendish Laboratory, J. J. Thomson Avenue, Cambridge CB3 0HE, United Kingdom — Max Planck Institute for the Physics of Complex Systems, D-01187 Dresden, Germany

Topological states of matter present a wide variety of striking new phenomena, most prominently is the fractionalization of electrons. Their detection, however, is fundamentally complicated by the lack of any local order. While there are now several instances of candidate topological spin liquids, their identification remains challenging. Here, we address one of the key questions: How can a quantum spin liquid phase be diagnosed in experiments?

We find that the dynamical response can serve as a valuable tool for diagnosing quantum spin liquids. We provide a complete and rarely available exact theoretical study of the dynamical structure factor and the inelastic Raman scattering response of a two-dimensional quantum spin liquid in Abelian and non-Abelian phases. We show that there are salient signatures of the Majorana fermions and gauge fluxes emerging in Kitaev's honeycomb model. Our analysis identifies new varieties of the venerable X-ray edge problem and explores connections to the physics of quantum quenches.

A number of proposals suggest that some materials with strong spin-orbit coupling, e.g. $\{Na/Li\}_2IrO_3$ or $\alpha$-$RuCl_3$ compounds, realize some of the physics of the Kitaev model. We discuss the current experimental situation, recent measurements and explore more generally the effect of breaking the integrability on response functions of Kitaev spin liquids.

**Invited Talk** SYSD 1.3 Mon 11:50 HE 101

**Dynamics of Complex Autonomous Boolean Networks** — •David P. Rosin — Technische Universität Berlin, Germany — Duke University, NC, USA

Network science provides a powerful framework for analyzing coupled systems occurring in physics, biology, engineering, and society, such as for example the internet, food webs, and socio-economic networks, and are recently also used to develop novel computing approaches. One way of studying and harvesting network dynamics is to engineer networks in the laboratory, which is particularly difficult with established approaches. Here, I develop a new approach using microelectronic networks of connected Boolean logic elements (field-programmable gate arrays) with time-delay allowing for realization of large complex networks with arbitrary topology. I exploit the resulting chaotic and neural-like excitable dynamics to develop a hardware random number generation and a neuromorphic computer. The resulting network-based random number generator operates at an ultra-high bit rate of 12.8 Gbit/s of fundamentally unpredictable random numbers and is now tested in conjunction with a private company and the International Monetary Fund. The neuromorphic computer is based on the reservoir computing paradigm.

**Invited Talk** SYSD 1.4 Mon 12:15 HE 101

**Dynamical Bloch oscillations and terahertz high-harmonic generation in bulk semiconductors** — •Olaf Schubert[1], Matthias Hohenleutner[1], Fabian Langer[1], Benedikt Urbanek[1], Christoph Lange[1], Ulrich Huttner[2], Daniel Golde[2], Torsten Meier[3], Mackillo Kira[2], Stephan W. Koch[2], and Rupert Huber[1] — [1]University of Regensburg, Germany — [2]University of Marburg, Germany — [3]University of Paderborn, Germany

In 1934, Clarence Zener predicted that electrons in a crystalline solid should perform an oscillatory motion when a strong electric field is applied. Observing this counter-intuitive phenomenon in bulk solids has remained a challenge. Here, we control coherent charge transport in a semiconductor on femtosecond timescales via atomically strong multi-THz fields. The phase-locked waveforms off-resonantly drive coherent inter- and intraband excitations in the regime of dynamical Bloch oscillations, resulting in the emission of phase-stable high-order harmonics covering a frequency band of 12.7 optical octaves between 0.1 and 675 THz, a new bandwidth record for phase-stable femtosecond pulses. Interference of different excitation pathways allows for sensitive control of the generation process via the phase of the driving waveform. The experimental findings are well explained by a quantum many-body theory, identifying dynamical Bloch oscillations as the dominant source of high-harmonic generation. Demonstrating a novel crossover between optics and ultrafast transport, our experiments pave the way towards future electronics at optical clock rates.