# SYSD 1: Presentations of the Finalists for the 2021 SKM Dissertation Prize

The divisions belonging to the Condensed Matter Section (SKM) of the DPG award annually the SKM Dissertation Prize. The prize acknowledges outstanding research during the PhD work in the research areas of SKM completed between 1 October 2018 bis 30 September 2020, and its excellent oral presentation. Based on nominations a jury formed by the chairpersons of all SKM divisions has selected five finalists for the award to present their work in this symposium. The winner will be selected after the symposium and publicly announced Wednesday, September 29th, in the afternoon during the ceremonial session.

Time: Monday 10:00–12:15 Location: Audimax 2

**Invited Talk** SYSD 1.1 Mon 10:00 Audimax 2
**Avoided quasiparticle decay from strong quantum interactions** — •Ruben Verresen[1,2,3], Roderich Moessner[2], and Frank Pollmann[3] — [1]Harvard University, Cambridge, USA — [2]Max-Planck-Institut für Physik komplexer Systeme, Dresden, Germany — [3]Technische Universität München, Munich, Germany

The emergent phenomenon of quasiparticles is key to understanding the properties of quantum states of matter. Known to be long lived at the lowest energies, quasiparticles are expected to become unstable when encountering the inevitable continuum of many-particle excited states at high energies, where decay is kinematically allowed. In this talk, I will show that although this expectation is correct for weak interactions, quasiparticles are generically stabilized by strong interactions pushing them out of the continuum. This general mechanism of avoided decay is straightforwardly illustrated in an exactly solvable model. Moreover, we develop a state-of-the-art numerical tool based on tensor networks which allows us to observe avoided decay in the spin-1/2 triangular-lattice Heisenberg antiferromagnet (TLHAF). This is surprising given the expectation of magnon decay in this paradigmatic frustrated magnet. Turning to existing experimental data, we identify the detailed phenomenology of avoided decay in the TLHAF material $Ba_3CoSb_2O_9$ and even in liquid helium. This mechanism provides a new window into quantum matter in the strongly interacting regime. Moreover, our numerical algorithm gives access to spectral functions for general 2D quantum magnets, providing a direct link between theory and experimental inelastic neutron scattering data.

**Invited Talk** SYSD 1.2 Mon 10:25 Audimax 2
**Co-evaporated Hybrid Metal-Halide Perovskite Thin-Films for Optoelectronic Applications** — •Juliane Borchert — Cavendish Laboratory, University of Cambridge — AMOLF Institut, Amsterdam — Clarendon Laboratory, University of Oxford

Perovskite materials are a highly promising material class for the realisation of the next generation of thin, lightweight, bendable solar cells. Here I focus on co-evaporation of perovskites which is a versatile method to deposit thin films. Co-evaporated films are exceptionally smooth and uniform and, due to the additive nature of the technique, can be deposited onto solvent-sensitive substrates. This is crucial for the fabrication of flexible substrates or when building a multilayer stack for tandem solar cells. In my dissertation research, I realised the first reported co-evaporation of formamidinium lead triiodide ($FAPbI_3$) solar cells which achieved high efficiencies. Subsequently, I studied the impact of impurities on the co-evaporation of methylammonium lead triiodide ($MAPbI_3$) and gained crucial insights to improve the process control and reproducibility of the co-evaporation of perovskite thin films. Finally, the experience and knowledge gained from these two studies were combined to fabricate co-evaporated patterned $FAPbI_3$ thin films for applications in semi-transparent solar cells and micro-lasers. These results are important contributions towards the deeper understanding of organic-inorganic halide perovskites and their properties as well as towards the development of stable, efficient, large-scale perovskites solar cells.

### 5-Minute Break

**Invited Talk** SYSD 1.3 Mon 10:55 Audimax 2
**Attosecond-fast electron dynamics in graphene and graphene-based interfaces** — •Christian Heide — Friedrich-Alexander Universität Erlangen-Nürnberg, 91058 Erlangen

Graphene, a two-dimensional material, is an ideal material to coherently drive electrons in a conducting material using strong light fields. In the band structure, when the electron is driven near the Dirac point - the point where the conduction and valence bands touch - the wave function of the electron can split into a superposition of the two band states. After half an optical cycle of about 1.3 femtoseconds (1 fs = $10^{-15}$s), these parts of the wave function meet again and interfere, producing a current flow within one femtosecond. Its amplitude and phase are not only sensitive to the waveform of the laser field, but also to the band structure and its topology, which makes this process interesting for ultrafast electronics and the study of solid-state properties.

Furthermore, graphene attached to a semiconductor forms a functional Schottky junction. We have shown that charge transfer across the interface occurs within 0.3 fs - the fastest known charge transfer between two solids. The reason for the short charge transfer time is the combination of the materials used: the atomically thin graphene with excited electrons directly at the interface and the extended semiconductor, which is ideally suited to receive the excited electrons.

Both results, the coherent control of electrons in an electrical conductor and the attosecond-fast charge transfer, are important steps towards light-field driven electronics, i.e. another direct link between photonics and electronics.

**Invited Talk** SYSD 1.4 Mon 11:20 Audimax 2
**The thermodynamics of stochastic systems with time delay** — •Sarah A.M. Loos — ICTP, International Centre for Theoretical Physics, Strada Costiera, 11, 34151 Trieste TS, Italien

Recently, the field of stochastic thermodynamics has greatly advanced our understanding of biological, physical, and artificial microscopic systems, which fluctuate strongly due to thermal noise and often operate far from thermal equilibrium. Far less is known, however, when, in addition to noise, time-delayed forces act on the system, which may originate from feedback loops or may stem from communication delays between individual living or artificial-intelligent components. In this talk, I discuss technical challenges and uncover unexpected physical phenomena that arise from time delays. For example, an external time-delayed force may cool a stochastic system[1], in sharp contrast to non-delayed forces that always heat it up. When reversed in time, the history-dependence of a delay process transforms into a dependence on its own future, entailing acausality; which has nontrivial consequences for the thermodynamic arrow of time. In particular, the total entropy production is composed not only of the usual contributions of heat release and Shannon entropy change, but also of an information-theoretic term[2]. We discuss this information-term and show relations between time-delayed stochastic process and the famous Maxwell demon thought experiment.

[1] Loos, Klapp, Sci.Rep. 9,11 (2019). Loos, Hermann, Klapp, Entropy 23, 696 (2021). [2] Loos, Klapp, NJP 22, 123051 (2020).

### 5-Minute Break

**Invited Talk** SYSD 1.5 Mon 11:50 Audimax 2
**First Results on Atomically Resolved Spin-Wave Spectroscopy by TEM** — •Benjamin Zingsem — Uni Duisburg

Spin-wave spectroscopy methods, such as electron-spin-resonance (ESR), and ferromagnetic resonance (FMR), are vital tools for materials characterization and chemical monitoring. Magnetic data storage, such as MRAM and hard-disk drives, but also magnetic materials for efficient and sustainable energy conversion in magnetic motors and turbines hinge on the precise knowledge of magnetic material parameters. These parameters can be extracted with the highest accuracy using FMR. On the other hand, ESR can determine the spin states of unpaired electrons in chemical compounds and during catalytic reactions, providing fundamental insight into the electron configuration. Together with momentum-sensitive techniques, such as Brillouin light scattering, both techniques are also central to spintronics experiments and the design of spintronic and magnonic devices. Here, we demonstrate a new technique to spatially resolve spin-resonances on the single nanometer scale with the potential for atomic resolution by transmission electron microscopy (TEM). The precessional torque of a spin excitation is coupled to a highly coherent electron beam, which reveals localized resonant spin excitations in transmission electron microscopy. This technique can be applied in-situ and in-operando on its own and together with conventional spectroscopy methods. As a model system, we present first results of magnonic networks comprising ferromagnetic nanoparticles and observe the spatial distributions of various spin-resonance modes.