SYSD 1: SKM Dissertation Prize

Time: Monday 10:15–12:15 Location: H2

Invited Talk SYSD 1.1 Mon 10:15 H2

Charge localisation in halide perovskites from bulk to nano for efficient optoelectronic applications — •Sascha Feldmann — Cavendish Laboratory, University of Cambridge, Cambridge, UK — Rowland Institute, Harvard University, Cambridge, USA

Halide perovskites have emerged as high-performance semiconductors for efficient optoelectronic devices like solar cells or LEDs. Yet, we still do not fully understand why these materials work so efficiently, given that we can process them crudely from solution, likely introducing many defects detrimental to devices based on conventional crystalline semiconductors like silicon. In this talk, I will give an overview of our recent work on understanding the high luminescence yields observed in i) bulk mixed-halide thin films and ii) atomically doped nanocrystals. We show that spatially varying energetic disorder in the electronic states of mixed-halide films causes local charge accumulation, which unearths a strategy for efficient charge extraction at low-light conditions for solar cells and for efficient light emission in LEDs operating at low currents. In doped perovskite nanocrystals, we find that the dopant-induced lattice periodicity breaking results in the transient localisation of charges with an increased overlap of electron and hole wavefunctions. This leads to increased radiative rates - a property that is typically intrinsic to a semiconductor and hard to change - together with reduced non-radiative losses, paving the way to highly efficient LEDs and quantum applications. Overall, these findings hint at energetic disorder in these materials not only being tolerated but potentially helpful in explaining their high performance.

Invited Talk SYSD 1.2 Mon 10:45 H2

Nonequilibrium Transport and Dynamics in Conventional and Topological Superconducting Junctions — •Raffael L. Klees — University of Konstanz, D-78457 Konstanz, Germany

In this talk, I will give a brief overview about the main content of my dissertation. Recently, it has been shown that multiterminal superconducting junctions (MSJs) provide an ideal platform to mimic topological systems in a controlled manner [1]. In the first part, we will construct deterministic model systems of MSJs based on quantum dots that show nontrivial Andreev bound states in terms of a nonzero first and second Chern number. We will also see how the underlying object of quantum geometry and topology, the quantum geometric tensor [2], can be accessed with the help of polarized microwave spectroscopy [3]. In the second part, I will report on the theory behind recent scanning tunneling microscope (STM) experiments between single superconducting Yu-Shiba-Rusinov (YSR) bound states that form in localized magnetic impuritites on superconducting substrates [4]. Motivated by these experiments, we study YSR-functionalized STM tips and present a detailed analysis of multiple Andreev reflection processes mediated by YSR states giving rise to a very complex subgap structure in the current-voltage characteristics [5]. [1] R.-P. Riwar *et al.*, Nat. Commun. **7**, 11167 (2016). [2] M. Kolodrubetz *et al.*, Phys. Rep. **697**, 1 (2017). [3] R. L. Klees *et al.*, Phys. Rev. Lett. **124**, 197002 (2020); Phys. Rev. B **103**, 014516 (2021); H. Weisbrich *et al.*, PRX Quantum **2**, 010310 (2021). [4] H. Huang *et al.*, Nat. Phys. **16**, 1227 (2020). [5] A. Villas *et al.*, Phys. Rev. B **103**, 155407 (2021).

Invited Talk SYSD 1.3 Mon 11:15 H2

Probing magnetostatic and magnetotransport properties of the antiferromagnetic iron oxide hematite — •Andrew Ross — Johannes Gutenberg Universität-Mainz, Mainz, Germany

With spin dynamics in the THz regime, a lack of stray fields and a high stability in external magnetic fields, antiferromagnets have several benefits over ferromagnets for spintronics applications. In this talk I will discuss two key steps towards functionalising antiferromagnetic insulators, focussing on the antiferromagnetic iron oxide, hematite, the main component of rust.

First, I will demonstrate how spin Hall magnetoresistance measurements can be used to extract the strengths of key antiferromagnetic anisotropies for both bulk and thin film samples responsible for the equilibrium orientation of the magnetic ordering.

Then, I will show how we can use antiferromagnetic insulators for information transport via quantised magnetic excitations, magnons. Polarised magnons are electrically excited by an interfacial spin-bias and carried over micrometres by the antiferromagnetic Neel order, facilitated by the relative orientation of the antiferromagnetic Neel vector and the low damping of hematite. By performing direct magnetic imaging of the domain structure, the strong attenuation of the magnon transport by a multi-domain structure is elucidated. Overall, the results I will present demonstrate the feasibility and promise of the prototypical antiferromagnet hematite for antiferromagnetic spintronic devices.

Invited Talk SYSD 1.4 Mon 11:45 H2

Quantum dot optomechanics with surface acoustic waves — •Matthias Weiss — Institut für Physik, Universität Augsburg — Physikalisches Institut, WWU Münster

Phonons, the quanta of mechanical vibrations, represent fundamental excitation in solid state materials and interact strongly with literally any other system. This universal coupling and their low susceptibility to dissipation makes phonons ideally suited to manipulate dissimilar systems and interface them in hybrid technologies.

In this talk, I show experiments of the interaction between the coherent phonon field of a surface acoustic wave and a single quantum emitter, a semiconductor quantum dot, employing resonant light scattering. This approach provides an ideal testbed to study electron-phonon interactions and to implement optomechanical control schemes. I show that the dynamic strain field of the acoustic wave modulates the dot's sharp optical transition at gigahertz frequencies enabling precisely triggered single photon emission and the generation of phononic sidebands in the optical spectrum. When combining two acoustic waves of different frequencies, spectral components are programmed by coherent wave mixing of photons and phonons by the quantum dot. I will discuss the experimental observations using a simple model of coupled phonon emission and absorption processes obeying well-defined phase matching conditions.