SYUK 2: United Kingdom as Guest of Honor II

Time: Wednesday 15:00–17:45 Location: H2

Invited Talk SYUK 2.1 Wed 15:00 H2

Hysteresis Design of Magnetic Materials for Efficient Energy Conversion — •Oliver Gutfleisch — TU Darmstadt, Material Science

High performance permanent magnets are key components of energy-related technologies, such as direct drive wind turbines and e-mobility. They are also important in robotics and automatization, sensors, actuators, and information technology. The magnetocaloric effect is the key for new and disruptive solid state-based refrigeration. Magnetic hysteresis and its inherent energy product - characterises the performance of all magnetic materials. Despite considerable progress in the modelling, characterisation and synthesis of magnetic materials, hysteresis is a long-studied phenomenon that is still far from being completely understood. Discrepancies between intrinsic and extrinsic magnetic properties remain an open challenge and magnets do not operate yet at their physical limits. Basic material requirements, figure of merits, demand and supply, criticality of strategic elements are explained for both permanent magnets and magnetocalorics referring to the benchmark materials NdFeB and LaFeSi. The search for perfect defects is driving the material design strategy.

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Invited Talk SYUK 2.2 Wed 15:30 H2

Non-equilibrium dynamics of many-body quantum systems versus quantum technologies — •Irene D'Amico — University of York, York, UK

Quantum technologies take advantage of properties developed by quantum systems when driven out of equilibrium. For example, quantum computation is based on an accurate, controlled driving of these systems to perform specific dynamics which produce entanglement, compute basic gates, and eventually leads to the completion of a numerical algorithm. Thermal fluctuations are often an enemy which spoils the controlled out-of-equilibrium dynamics. On the other side, quantum thermodynamics takes advantage of thermal - and quantum - fluctuations to create engines and refrigerators of sizes well below the thermodynamic limit and properties still under discussion. In this talk we will first focus on engineering robust properties for distributed quantum computing using spin-networks [1]: here the twist is *not* to drive the out-of-equilibrium dynamics, but let the system Hamiltonian do the job. We will then turn up the temperature, and consider a less-explored aspect of quantum thermodynamics, that is the effects and signatures of many-body interactions on few-electrons' quantum machines [2].

[1] L. Mortimer et al., Adv. Quantum Technologies 4, 2100013 (2021); A. H. Alsulami et al., arXiv:2202.02632

[2] K. Zawadzki et al., Phys. Rev. Research 2,033167 (2020); M. Herrera et al. Phys. Rev. Lett. 127, 030602 (2021); G. A. Canella et al., preprint (2022)

Invited Talk SYUK 2.3 Wed 16:00 H2

Quantum computing with trapped ions — •Ferdinand Schmidt-Kaler — QUANTUM, Uni Mainz

Quantum technologies allow for fully novel schemes of hybrid computing. We employ modern segmented ion traps. I will sketch architectures, the required trap technologies and fabrication methods, control electronics for quantum register reconfigurations, and recent improvements of qubit coherence and gate performance. Currently gate fidelities of 99.995% (single bit) and 99.8% (two bit) are reached. We are implementing a reconfigurable qubit register and have realized multi-qubit entanglement [1] and fault-tolerant syndrome readout [2] in view for topological quantum error correction [3], since current aim is to leave the noisy area of quantum computing. Complementary to gate tomography, we employ thermodynamically-inspired methods within the frameworks of global passivity and passivity deformation where system qubits undergoing unitary evolution but may optionally be coupled also to an unobserved environment qubit, resulting in a heat leak [4].

[1] Kaufmann er al, Phys. Rev. Lett. 119, 150503 (2017) [2] J. Hilder, et al., Phys. Rev. X.12.011032 (2022) [3] Bermudez, et al, Phys. Rev. X 7, 041061 (2017) [4] D. Pijn, et al., Phys. Rev. Lett. 128 110601 (2022)

15 min. break

Invited Talk SYUK 2.4 Wed 16:45 H2

Breaking the millikelvin barrier in cooling nanoelectronic devices — •Richard Haley — Physics Department, University of Lancaster, Lancaster LA1 4YB, UK

Over the last several years a number of groups across Europe have been developing techniques to cool the electrons in nano-fabricated devices to sub-mK temperatures. Cooling device electrons into the microkelvin regime, below the canonical limit of around 10 millikelvin, enhances sensitivity for observing known and new physical phenomena, and improves the performance of quantum technologies, sensors and metrological standards.

There are two main challenges. First, one must provide a technique which will deliver electron temperatures colder than a dilution refrigerator and which is relatively easy to implement. Currently the microkelvin regime is really only accessible in specially dedicated labs. Second, one must understand the thermal links between the microkelvin cooling platform and the electrons in the device of interest, bearing in mind that nanoscale systems are typically also more susceptible to nuisance heating than bulk materials. Progress has been made with three methods and combinations thereof: immersion cooling in liquid helium; demagnetisation cooling of electrical leads and contacts; and the demagnetisation of material deposited directly onto device chips.

Here we review the current state-of-the-art in cooling nanoelectronic devices, and ways to make the techniques easier to adapt and adopt.

Invited Talk SYUK 2.5 Wed 17:15 H2

Superconducting Quantum Interference Devices for applications at mK temperatures — •Sebastian Kempf — Institute of Micro- and Nanoelectronic Systems, Karlsruhe Institute of Technology, Hertzstraße 16, 76187 Karlsruhe, Germany.

Superconducting quantum interference devices (SQUIDs) are among the most sensitive wideband devices for measuring any quantity that can be naturally converted into magnetic flux. They are intrinsically compatible with Kelvin and sub-Kelvin operation temperatures, offer great sensitivity to even tiniest signals and often show a noise level close to the quantum limit. For this reason, SQUIDs are routinely used for various applications such as investigating magnetic nanoparticles, diagnostics in health care, "non-invasive" mineral deposit exploration, low-field magnetic resonance imaging, quantum information processing or the readout of low-impedance cryogenic particle detectors. However, SQUID based measurements are susceptible to suffer from parasitic Joule heating, often preventing to reach very low sub-K temperatures.

Using the example of cryogenic low-impedance detectors, we discuss strategies to minimize parasitic SQUID Joule heating to ultimately operate single-channel detectors as well as mid- and large-scale detector arrays at lowest mK temperatures. We particularly show that on-chip thermal decoupling of shunt resistors and sample environment or dispersive SQUID readout allow for performing SQUID based measurements down to very low temperatures. Moreover, we discuss a SQUID based multiplexer allowing for simultaneous readout of hundreds and thousands of signal sources with only several nW of power.