SYQS 1: Quantum Sensing and Decoherence in Solid-State and Photonics Systems

Time: Monday 10:45–12:45 Location: ZHG105

Invited Talk SYQS 1.1 Mon 10:45 ZHG105

Quantum Technologies for Sensing and Imaging in the Life Sciences — •Martin B Plenio — Institute of Theoretical Physics, Ulm University, 89081 Ulm, Germany

Nuclear Magnetic Resonance (NMR), one of the most widely used spectroscopic techniques in biology and the life sciences, is inherently limited by its low sensitivity. This limitation stems from the weak nuclear spin nuclear spin polarisation in thermal equilibrium, which typically amounts to just a few parts per million, as well as the constraints of inductive NMR signal detection.

In this talk, I will discuss control techniques and signal processing methods for colour centers in diamond that enable NMR at the micron- and nanoscale. Despite these advances, enhancing the signal from the target via nuclear spin hyperpolarisation would be highly beneficial. I will explore how this enhancement might be achieved using NV centers and demonstrate that these control techniques can be transferred to parahydrogen induced polarisation, where they result in unprecedented levels if concentration and polarisation product. Interestingly, beyond the practical importance of these developments, this approach also opens up opportunities to explore chaotic dynamics and non-linear quantum physics, which hold interest for fundamental physics.

Invited Talk SYQS 1.2 Mon 11:15 ZHG105

Quantum technologies with semiconductor color centers in integrated photonics — •Jelena Vuckovic — Ginzton Laboratory, Stanford University, Stanford, CA 94305-4088, USA

Optically interfaced spin qubits based on diamond and silicon carbide color centers are considered promising candidates for scalable quantum networks and sensors. However, they can also be used to build chip-scale quantum many body systems with tunable all to all interactions between qubits enabled by photonics - useful for quantum simulation and possibly computing.

Our recent efforts have focused on tin-vacancy (SnV) color center in diamond where we have shown high fidelity microwave control of an electron-spin at 1.7K temperature, high fidelity single shot (optical) readout of an electron spin, high quality quantum photonic interface, and even heterogeneous integration with lithium niobate for frequency conversion, making this color center very interesting candidate for implementation of quantum networks. Moreover, our recent demonstration of coherent and controlled interactions of multiple qubits (silicon vacancy - VSi color centers) inside a single silicon carbide resonator has established these systems as promising candidates for other quantum technologies, including quantum simulation and possibly even quantum computing.

We also show how chip-scale Ti:sapphire laser can replace commercial tabletop lasers in our quantum optics experiments without any loss in performance, leading to truly scalable quantum systems on chip.

Invited Talk SYQS 1.3 Mon 11:45 ZHG105

Towards spin-based quantum sensing in hybrid nanomechanical systems based on silicon carbide — •Eva Weig — Technical University of Munich, Germany

Silicon carbide (SiC) has extraordinary material properties, combining some of the most favorable properties of diamond and silicon. It hosts spin-carrying color centers and exhibits high mechanical quality factors. It is thus ideally suited for the realization of advanced hybrid nano-mechanical devices incorporating atomic-scale defects. In addition, SiC crystalizes in a variety of polytypes which entails different routes towards realizing high Q mechanical resonators. Cubic 3C-SiC enables thin-film epitaxial growth on silicon. Strong tensile pre-stress is incorporated when grown on a silicon substrate oriented along the (111) direction, leading to high Q from dissipation dilution. On the other hand, hexagonal 4H-SiC is a well-established material in nanophotonics and known for its highly coherent color centers. Recently, high intrinsic Q factors exceeding 100,000 have been demonstrated in monolithic 4H-SiC. Here I will compare nanomechanical resonators made of both 3C-SiC and 4H-SiC and describe the realization of optomechanical crystals. I will discuss how to generate color centers by means of He-ion implantation, and outline the prospects of both materials for spin-mechanical and spin-optomechanical sensing.

Invited Talk SYQS 1.4 Mon 12:15 ZHG105

Quantum Sensing of Quantum Matter — •Amir Yacoby — Harvard University, Cambridge, USA

Major scientific discoveries are often enabled by new measurement capabilities that provide novel perspectives into complex physical problems. Recent advances and discoveries made on quantum materials have challenged experimentalists to come up with new ways to probe their intrinsic properties. In this talk Yacoby will discuss some of the recent work he has worked on to develop a variety of new local quantum sensing techniques and discuss how they can assist us in exploring quantum matter.