HL 21: Focus Session: Quantum Sensing with Solid State Spin defects II (joint session TT/HL/MA)

Time: Wednesday 9:30–10:30 Location: HSZ/0101

HL 21.1 Wed 9:30 HSZ/0101

Locally Imaging the Insulator to Metal Transition of Ca_2RuO_4 with Single Spin Magnetometry — •Hayden Binger[1], Cissy Suen[2], Young-Gwan Choi[1], Yejin Lee[1], Haolin Jin[1], Max Krautloher[2], Yuchen Zhao[1], Luke Turnbull[1], Elina Zhakina[1], Jeffrey Neethirajan[1], Lotte Boer[1], Berit Goodge[1], Piotr Surówka[3], Roderich Moessner[4], Bernhard Keimer[2], Claire Donnelly[1], and Uri Vool[1] — [1]MPI CPfS, Dresden, Germany — [2]MPI FKF, Stuttgart, Germany — [3]Wrocław University of Science and Technology, Wrocław, Poland — [4]MPI PKS, Dresden, Germany

The current-driven insulator to metal transition (IMT) in Ca_2RuO_4 is a fascinating phenomenon where increasing current driven across a sample causes a smaller voltage difference to develop. We have created devices of size 10-20 um by 10-20 um and 100 nm thick using Focused Ion Beam (FIB) milling. Through the utilization of Nitrogen Vacancies (NV), optically addressable spin-1 defects acting as a qubit at room temperature, we probe the local magnetic field at the defect via the Zeeman interaction. We are thusly able to image the local character of the insulator to metal transition in Ca_2RuO_4. At low currents we image the formation of a singular conducting channel at the edge of the device, which gradually grows throughout the entire device as more current is applied until eventually current flows evenly across the device. We explore reasons why local current channels nucleate at the edge, such as strain, defects, and crystalline lattice orientation.

HL 21.2 Wed 9:45 HSZ/0101

Topological Ambiguity in Stray Field Magnetometry — •Shirsopratim Chattopadhyay[1,2] and Aparajita Singha[1,2] — [1]IFMP, TU Dresden, Germany — [2]Würzburg-Dresden Cluster of Excellence (ct.qmat)

Inferring magnetic topology from stray field measurements is central to characterizing skyrmions, vortices, and other topological textures. Yet, the uniqueness of such reconstructions remains poorly characterized. We present a computational framework to systematically generate pairs of magnetization configurations with distinct topological charges ($|\Delta Q|$ = q, where q can be set by the user) that produce nearly identical stray fields (Normalized Root Mean Square Error ~ 0.8-4 percent). Our approach uses constrained optimization with a physics informed loss to jointly evolve magnetization pairs towards field degeneracy while preserving topological distinction. Across 200 randomized trials with varied initializations, we demonstrate rapid and reliable generation of adversarial pairs spanning skyrmions, merons, fractional defects and uniform domain textures. We theoretically analyse the relation between topological charge and stray field and construct an explicit example of near identical stray field from distinct topologies. Our adversarial dataset enables rigorous assessment of magnetization reconstruction algorithms and guides the design of measurement strategies capable of resolving topological ambiguity.

HL 21.3 Wed 10:00 HSZ/0101

Towards Cryogenic Scanning Nitrogen Vacancy Magnetometry — •Lotte Boer[1], Kilian Srowik[1], Hayden Binger[1], Young-Gwan Choi[1], Ahmet Ünal[1], Edouard Lesne[1], Matheus Barbosa[2], Bernd Büchner[2], Alexey Popov[2], and Uri Vool[1] — [1]MPI CPfS, Dresden, Germany — [2]IFW Dresden, Germany

In scanning nitrogen vacancy (NV) magnetometry, an atomic force microscopy tip is replaced with a diamond pillar containing a single NV center, which acts as a highly sensitive magnetic field sensor. Scanning over a sample then allows to map the magnetic stray field. This method has been widely used at room temperature to investigate, for example, magnetic textures in thin films or local current flow patterns. However, a wide range of interesting material properties, such as emergent magnetic phases and superconductivity only occur at lower temperatures. As the NV center retains its ability to sense magnetic fields at low temperatures, we are developing a variable temperature cryogenic scanning NV system. This will not only allow for the imaging of materials at low temperatures, but also allow for the unique opportunity of mapping magnetic phase transitions in quantum materials.

Building a cryogenic NV setup presents several challenges, as the NV requires optical access for readout and microwave pulses for control, all within tight spatial confines and while preventing sample heating. In this talk, we will discuss our setup, which is in its final stages of development, and show preliminary measurement results at few Kelvin temperatures.

HL 21.4 Wed 10:15 HSZ/0101

CISS from Vibrationally Assisted Tunneling in Chiral Molecules — •Fedor Baranov, Virginia Gali, and Maxim Breitkreiz — Dahlem Center for Complex Quantum Systems, Freie Universitat Berlin, Arnimallee 14, 14195 Berlin, Germany

Chiral-induced spin selectivity (CISS) remains a puzzling phenomenon, despite extensive experimental evidence. A possible explanation emerges when recognizing that charge transport through chiral insulating molecules occurs in the tunneling regime, where even small spin-orbit coupling becomes crucial inside the barrier. This enhancement leads to a spin-dependent potential that gives different tunneling probabilities for different spin orientations. Because this tunneling alone produces extremely small currents, one has to take into account the vibrational degrees of freedom of the system that in the static limit increases the current while preserving the spin splitting nature. Together, these ingredients offer a transparent physical mechanism underlying the CISS effect.