Universität Basel

Research Project

Single spin imaging of strongly correlated electron systems

Third-party funded project

Project title Single spin imaging of strongly correlated electron systems
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Strongly correlated electron systems form a vibrant research field at the heart of condensed matter physics. They are of fundamental interest and highly promising for a broad range of applications from high temperature superconductivity to novel solid-state memory devices. However, despite significant efforts, full understanding of these fascinating materials remains an outstanding challenge. A central bottleneck for further progress is the lack of suitable tools to directly assess microscopic origins and manifestations of electronic correlations down to the level of single electrons. Here, I propose to apply a completely novel approach based on quantum-coherent sensing technologies to explore strongly correlated electron systems on the nanoscale and thereby promote our understanding of quantum matter to a new level. My group will engineer and apply an ultralow temperature scanning probe apparatus that uses single electrons as highly sensitive magnetometers. This approach combines nanometric imaging resolution, single electron spin sensitivity, and quantitative magnetic imaging - performance-characteristics that no existing method offers. My project focuses on the study of unexplored local magnetic phenomena, which emerge as Hallmarks of electronic correlations. Examples include spontaneous symmetry-breaking in quantum Hall states, fractional vortices in superconductors and magnetism in oxide interfaces. Our nanoscale studies of these phenomena will offer unprecedented insight into these complex states and my proposal thus has the potential to revolutionise our understanding of exotic quantum matter. This project combines key technological innovations with experiments of far-reaching scientific impact. It is highly interdisciplinary as it combines quantum-control and quantum-engineering with fundamental questions in condensed matter physics. This challenging project goes well beyond the state-of-the-art and could define the beginning of a new era in the field of quantum-sensing. I will thereby further strengthen Switzerland's position at the forefront of this vibrant research area. My project requires a several year commitment, significant investment in instrumentation and a team of two graduate students plus one postdoctoral fellow.

Keywords Magnetic imaging, Diamond, Nanofabrication, Spin physics, Scanning probe microscopy, Graphene, strongly correlated electron systems, LAO/STO, Sr2RuO4, Quantum optics, Quantum sensing, Solid state physics, Magnetism
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