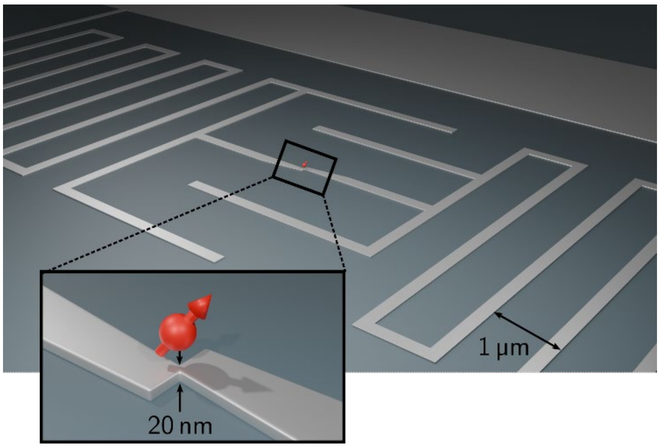
Hybrid Quantum Architecture for Single Spin Readout with a Superconducting Qubit

Project description

Why is universal quantum computing still out of reach – despite its revolutionizing potential e.g. in chemistry, medicine and cryptography? So far, no qubit architecture can implement all key requirements like scalability, coherence, read-out, and manipulation. Hybrid quantum architectures seek to leverage the strength of two qubit platforms to outperform each individual system. Therefore, they could be a gamechanger in the quest for universal quantum computing. The aim of this project is to develop a hybrid quantum architecture by achieving strong coupling between a superconducting qubit and a single molecule magnet.



Single molecule magnets shine with outstanding coherence in the minutes range, orders of magnitude ahead of most other quantum platforms. They consist of a magnetic core (e.g. a rare earth ion), surrounded by a shell of organic ligands which can be engineered to protect the spin from its environment. While single molecule magnets can be reproducibly synthesized in billions of identical copies, their inherent isolation from environmental degrees of freedom, renders it difficult to address the spin state of a single entity [3].

We will utilize the unparalleled versatility in the circuit design of superconducting qubits to overcome this challenge and to couple to a magnetic molecule on the nanoscale. For this purpose, we will take advantage of a novel superconducting qubit architecture [1] that is sensitive to a nanoscopic length scale. Moreover, this qubit promises resilience to magnetic fields of several 100mT, crucial to operate the magnetic molecules. The exceptional degree of control over superconducting hardware [2] opens a window of opportunity for a hybrid quantum architecture: The combination of fast, high-fidelity read-out and manipulation with excellent coherence!

In this project you will use an optimized, fast dilution refrigerator, fabricate samples in our in-house cleanroom facility, characterize superconducting qubits and optimize the coupling to the single molecule magnets (provided by our collaborators). Sound knowledge on superconducting qubits is a requirement.

References:

[1] Rieger & Günzler et al., Granular aluminium nanojunction fluxonium qubit, Nature Materials **22**, 194–199 (2023)

[2] Spiecker et al., Two-level system hyperpolarization using a quantum Szilard engine, Nature Physics **19**, 1320–1325 (2023)

[3] Thiele et al.,Electrically driven nuclear spin resonance in single-molecule magnets, Science **344**, 1135-1138 (2014)

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Interdisciplinary Network for Cutting-Edge Research

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Keywords
Hybrid quantum architecture
Single molecule magnets
Superconducting qubit
Quantum computing
Spin qubit

Entry requirements
Master degree in Physics

Location
Institute for Quantum Materials and Technologies (IQMT), Karlsruhe Institute of Technology (KIT), Karlsruhe

Starting date
As soon as possible

Funding

Four years of funding (3+1, three years with the possibility to extend for one year)

How to apply

Please apply via the HFA application portal.

The Hector Fellows will arrange interviews (via skype or if feasible in-person) with the most promising applicants. The final candidates will be invited for an online presentation on June 20, 2024. The final decisions will be announced in July 2024.

Application Deadline

March 31, 2024

Enquiries
For questions related to making your application, please contact Hector Fellow Academy Office: application@hector-fellow-academy.de or www.hector-fellow-academy.de

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