Co-funded by the European Union

Gen-Q Generation Quantum

eucor The European Campus

Scientific Area	Developing quantum hardware
Topic title	Hybrid quantum architecture for single spin readout with a superconducting qubit
Main host institution	IQMT, KIT https://www.iqmt.kit.edu/
Supervisor/institution	Prof. Wolfgang Wernsdorfer https://www.phi.kit.edu/wernsdorfer.php
Co-Supervisor/institution	Prof. Ioan Pop https://www.phi.kit.edu/pop.php
Mentor[1]/institution	Nicolas Roch, Néel Institute, Grenoble, France http://perso.neel.cnrs.fr/nicolas.roch/
Secondment institution	Néel Institute, Grenoble, France: https://neel.cnrs.fr/en

Topic 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.

[1] Nature Materials 22, 194–199 (2023)
[2] Nature Physics 19, 1320–1325 (2023)
[3] Science 344, 1135-1138 (2014)

Recommended applicant's profile

[1] Mentor: The primary role of the mentors will be to identify and facilitate specific training objectives, advise on any problems faced by the DC, including career matters with an external perspective and provide mediation in the case of disputes.

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Master degree of physics with background in nanoscience, lithography, programing, quantum technologies. Proficiency in English isrequired.

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