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Project SPINUS reaches milestones towards scalable solid-state quantum computing

Advancing scalable solid-state quantum computing from materials to quantum processors and simulators—this is the ambitious project goal of the joint European project SPINUS. During their annual meeting, which took place in February in Trento, Italy, the project partners gathered to assess their latest scientific achievements and to align on strategic objectives for the upcoming project phases. During two days of intensive discussions, including a quantum technologies networking session with external participants, the consortium showcased decisive milestones and lived up to SPINUS' role in advancing European quantum research.

The Horizon Europe project SPINUS tackles the challenge of building scalable quantum computing technologies with an innovative approach. Through the use of dipolar interactions between electron spins of nitrogen-vacancy (NV) color centers, solid-state qubits for quantum simulators and quantum computers are being developed. This technology requires miniscule NV-NV distances of several tens of nanometers. In addition to the technical challenge of arranging NV centers in a regular arrangement on such small length scales, readout of the quantum states is difficult because neighboring NV centers can no longer be resolved optically. The project SPINUS responds to these challenges by developing novel readout techniques and improved material syntheses.

The first twelve months of the four-year project already yield significant advances in the respective transdisciplinary fields that are part of the holistic project approach. During a project meeting held in Trento, Italy, the international consortium met to discuss their advancements and to pave their way towards realizing a solid-state-based quantum computer with more than 10 qubits as well as a solid-state quantum simulator with more than 50 qubits.
During the meeting, external stakeholders, and guest speakers from University of Trento, University of Turin, National Research Council of Italy (CNR), and TNO Netherlands Organization for Applied Scientific Research joined in, giving rise to fruitful transfer beyond the SPINUS consortium.

Project milestones and research highlights

The latest developments within the SPINUS project highlight significant advancements across various research areas, showcasing the consortium's commitment to pioneering research in quantum technologies. The international project team works hand in hand towards their common goal of advancing scalable solid-state quantum computing.

Researchers from FZJ as well as the universities of Ulm and Stuttgart made substantial progress in spin control and readout. This includes the successful implementation of controlled phase gates between two NVs and nitrogen-spin polarization using PulsePol techniques. The team also submitted the first technical deliverable on Polarization Sequences to the European Commission.

Significant strides in material synthesis were achieved, coordinated by Linköping University. This includes the growth of high-quality, isotopically pure Silicon Carbide layers with high surface smoothness, and growth of diamond sandwich structures with thin isotopically controlled layers.

Researchers from the universities in Delft, Stuttgart, and Ulm have successfully implemented optimal control sequences to initialize and program their quantum simulators. The teams made notable progress in controlling and measuring large nuclear spin networks of more than 40 spins and successfully demonstrated dissipative phase transitions using their quantum simulators.

The teams at Hasselt, Ulm, Stuttgart, and Delft continued to improve their color-center-based quantum computers. They developed dynamically decoupled radio-frequency entangling gates and demonstrated high-fidelity two-qubit gates in quantum registers of up to 7 qubits. In parallel, electrical readout techniques have been further developed at the university of Hasselt, the technical university of Denmark, Fondazione Bruno Kessler, and Quantum Brilliance.

These impressive experimental developments were complemented by improvements of classical simulation methods and quantum algorithms. Coordinated by Wigner RCP, the teams at FZJ, Stuttgart, Ulm, and Fraunhofer IAF improved methods to benchmark the performance of quantum computers and to simulate the dynamics of large spin networks. With all these developments, the SPINUS project continues to drive innovation and collaboration in the field of quantum technologies, positioning itself as an international leader in research and development in this field.

Roadmap ahead: what's on the Horizon (Europe)

The consortium set out to deepen their engagement with European quantum initiatives such as the European Quantum Industry Consortium (QuIC) and Project QUCATS - Quantum Flagship Coordination Action and Support. Thereby, synergies to further advance the research progress on an international scale will be identified and utilized at an early stage. Additionally, Quantum Pilot Lines within the Chips Joint Undertaking will be explored and integrated in the SPINUS roadmap where benefits arise. "Europe's research on quantum technologies is world class and can partake in the global race to develop large-scale quantum computers and to demonstrate quantum advantage. Within SPINUS, we combine and leverage the individual strengths of our partner institutions to advance solid-state quantum technologies," underpins Dr. Martin Koppenhoefer, project coordinator at Fraunhofer IAF.

To further foster collaboration within the European quantum ecosystem beyond quantum computing, SPINUS co-organized a quantum technologies networking event as part of their annual meeting in Trento, Italy. The event featured synergies between EU-funded projects and underscored the pivotal role of diamond-based quantum materials and devices for quantum computing, sensing, and communication.

About SPINUS

Project SPINUS is funded by the European Union's Horizon Europe research and innovation program (grant agreement No. 101135699) and runs for four years. Within SPINUS, the unique expertise of 12 partners from eight different countries is brought together. The consortium consists of: Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e.V. for their institute Fraunhofer IAF, University of Ulm, Danmarks Tekniske Universitet, University of Stuttgart, Forschungszentrum Jülich GmbH, Universiteit Hasselt, Linkopings Universitet, Technische Universiteit Delft, Wigner Fizikai Kutatokozpont, Fondazione Bruno Kessler, Quantum Brilliance GmbH and AMIRES.

For keeping up with the project updates, visit the SPINUS project website and follow our social media channels:

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