Building blocks for a scalable quantum computer

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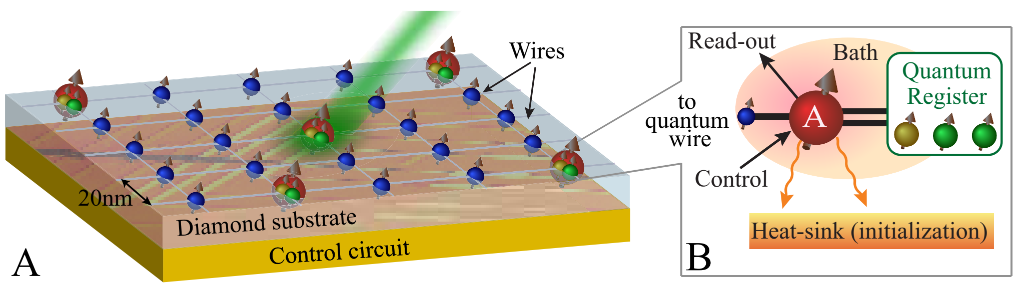
Quantum control of radiation-matter interactions at the nano-scale could yield significant improvements in fields ranging from atomic physics to magnetic resonance and chemistry. The most prominent application would be quantum computation. Although small quantum systems can be manipulated with high precision, there is still no clear path to build scalable quantum devices. We address this challenge with a bottom-up approach, where small quantum registers are assembled in a larger modular architecture.

After briefly describing an implementation of quantum registers based on Nitrogen-Vacancy centers in diamond [1], in this talk I will focus on a key element of this proposal, quantum spin wires that connect the registers and transmit information among them. I will present recent results on quantum information transport in spin wire networks, in particular protocols that permit perfect transfer in far more relaxed conditions that previously thought, thus opening the possibility of a practical implementation [2-5]. I will then show the first experimental study of these quantum information transport protocols in a unique, quasi-1D solid-state spin system [6-7]. These results can be extended to other physical implementations and pave the way toward a scalable quantum computer.



Diamond-based quantum computing architecture: A) The NV center (actuator) in each register is addressed optically. Nitrogen spins qubit wires connect the registers. The diamond rests atop a nano-fabricated circuit that provides static magnetic fields and microwave control. B) Quantum registers comprise an actuator and nearby nuclear spins that are strongly coupled to the actuator but interact weakly with the bath, thus providing long coherence times.

References

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