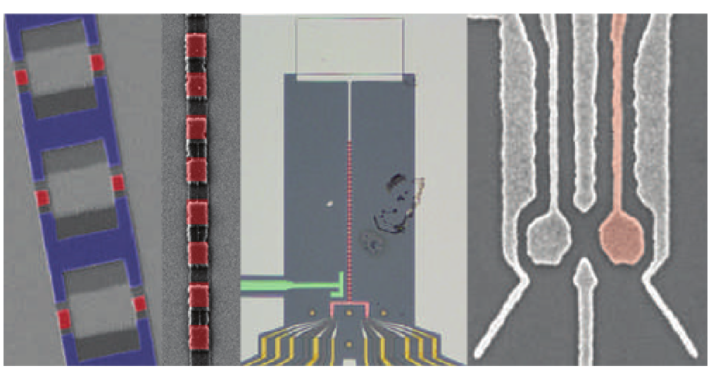
Quantum-Dot Qubits Kept Under Control

Two studies improve the status of artificial atoms—called quantum dots—as qubit candidates for quantum technologies.

By **Ryan Wilkinson**

Quantum dots are tiny semiconductor structures that can serve as qubits, with quantum information stored in the spin or charge states of confined electrons. But the limited coherence time of these qubits greatly restricts their potential applications. Now, Kha Tran at the US Naval Research Laboratory, Washington, DC, and his colleagues, and Pasquale Scarlino at the Swiss Federal Institute of Technology (ETH), Zurich, and his colleagues, have demonstrated ways to increase this coherence time [**1**, **2**].

Tran's team considered a spin-based qubit comprising a pair of coupled quantum dots. Previous work had suggested that the coherence time of such a qubit could be extended by operating the system at a particular electrical bias known as the "sweet spot." Tran and his colleagues used a quantum-optics technique called Ramsey interferometry to directly measure the qubit's coherence time at this sweet spot. They obtained a maximum value of 60 ns—more than 10 times higher than that of spin qubits formed by single quantum dots. The researchers found that away from the sweet spot, the coherence time was limited by electrical noise. With the right electrical bias, however, this noise was suppressed and the coherence time was mainly limited by nuclear spin fluctuations.



Credit: P. Scarlino *et al.* [**2**]

By contrast, Scarlino's team investigated a charge-based qubit, which also consisted of two quantum dots. For quantum information processing, it is useful to couple the electrons in such a qubit to the photons in a microwave resonator by establishing a strong electric-dipole moment across the qubit. However, this dipole moment also exposes the qubit to coherence-destroying electrical noise. Scarlino and his colleagues discovered a way to tune the strength of the dipole moment so that either the qubit-resonator coupling or the qubit coherence could be optimized according to the specific needs of the experiment. Minimizing the dipole-moment strength extended the qubit's coherence time to roughly 30 ns—at least 10 times higher than that usually observed for quantum-dot-based charge qubits. As a side benefit that is not directly related to the coherence of these qubits, maximizing the dipole-moment strength allowed the qubit-resonator system to be used as a platform to explore ultrastrong electron-photon interactions.

The results from these two studies improve our understanding of decoherence in quantum-dot qubits. Moreover, they could allow such qubits to be used in a wide range of quantum technologies—from quantum processors to single photon devices such as switches and transistors.

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REFERENCES

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