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Prolonging the quantum coherence of semiconductor spins

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Powerful future technologies based on electronic spins in semiconductors require an unprecedented level of control over the spins. One of the greatest challenges in achieving this control is the decoherence induced by the environment, a problem which is particularly severe in the context of nanoscale quantum devices. In this talk, I will present recent progress in understanding quantitatively the primary sources of decoherence for spins in semiconductor nanostructures, namely the hyperfine interaction with nuclear spins and charge fluctuations. I will present new theoretical techniques that capture the effects of multiple noise sources on the evolution of the spin coherence and show how they can be used to develop new ways to characterize and mitigate noise. I will then describe a new general theory for combatting decoherence by driving the system in such a way that decoherence effects destructively interfere and cancel out, enabling precise and robust control of a broad range of coherent quantum systems.