Spins in molecules: a versatile platform for quantum technologies

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A century after the birth of quantum mechanics, our understanding of matter has been profoundly transformed. The ability to harness fundamental quantum phenomena such as superposition and entanglement is now driving the so-called *second quantum revolution*. Alongside the impressive progress achieved with platforms such as superconducting circuits, cold atoms, Rydberg atoms, and photons, an important question emerges: Is there still room for alternative quantum platforms that could uniquely benefit from rational chemical design?

Spins—among the most elementary quantum systems—constitute the natural prototype of qubits, the building blocks of quantum computation. Their properties can be tuned through chemical design, making molecular spins particularly attractive platforms for quantum technologies. At the same time, spins also present challenges. Their weak coupling to the environment can lead to long coherence times, but it also makes single-spin manipulation and readout more demanding.

One promising route to overcome these limitations is the integration of spins with optical interfaces, as illustrated by the remarkable success of quantum technologies based on nitrogen-vacancy centers in diamond. Extending similar concepts to molecular systems requires new strategies that combine chemical design with advanced control schemes.

In this lecture, I will discuss our efforts to move in this direction by exploring a broader design space for molecular spin qubits, including photoactivated control mechanisms, spin–electric coupling, and the use of structural chirality for control and readout of molecular spins.