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Coherent manipulation of quantum spin states in a single molecular nanomagnet

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The endeavour of quantum electronics is driven by one of the most ambitious technological goals of today's scientists: the realization of an operational quantum computer (http://qurope.eu). We started to address this goal by the new research field of molecular quantum spintronics. The building blocks are magnetic molecules, i.e. well-defined spin qubits. We will discuss this still largely unexplored field and present our first results: For example, using a molecular spin-transistor, we achieved the electronic read-out of the nuclear spin of an individual metal atom embedded in an SMM. We could show very long spin lifetimes (>10 s). Using the hyperfine Stark effect, which transforms electric fields into local effective magnetic fields, we could not only tune the resonance frequency by several MHz, but also perform coherent quantum manipulations on a single nuclear qubit faster than a μs by means of electrical fields only, establishing the individual addressability of identical nuclear qubits. Using three different microwave frequencies, we could implement a simple four-level Grover algorithm. S. Thiele, F. Balestro, R. Ballou, S. Klyatskaya, M. Ruben, W. Wernsdorfer, Science 344, 1135 (2014).