Magnetic molecules promising platforms for quantum computer architecture

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The basic component of a quantum computer is the two level system or qubit that ideally can be prepared in long-lived superpositions. That is, this qubit has to be protected from environmental interactions while entanglement operations with other qubits are allowed. In our study, we investigate quantum gates based on magnetic rare-earth systems in nanoscale devices. The strong anisotropic and spin-orbit interactions of these rare-earth systems and tunability of coupling between their electronic and nuclear spins via external fields make them promising candidates for quantum computer architecture. In fact, we envision to embed these rare-earth magnetic systems in fullerene cages separating their electronic states into Kramers doublets (qubits) composed of two states with large magnetic moments pointing in opposite directions that are decoupled from environmental interactions. This shielding of high-spin electronic states combined with the natural stability of nuclear spin leads to qubits with long coherence times that could enable scaling with system size when an array of fullerenes is created. In addition, we investigate the likelihood of a) direct laser cooling of the highly magnetic rare-earth monoxide molecules and b) attachment of an optical cycling center to functionalized fullerenes.