Circuit QED with molecular spin qudits

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Achieving a quantum computational power that can solve practical problems is still very challenging, even for today's most successful platforms, on account of the need of correcting errors and the fact that this requires increasing the number of physical qubits. Artificial magnetic molecules can provide some competitive advantages for progressing towards large-scale quantum computation [1-3]. They are microscopic yet tuneable via chemical methods. Recent examples of molecular designs are able to integrate 2, 3, 4 and 6 qubits or, in general, *d*-dimensional qudits using their multiple electronic and nuclear spin states. Each of these molecules can, in principle, act as a universal quantum processor or even encode error-corrected qubits [3]. However, exploiting these possibilities calls for a solid-state platform to control, read-out and wire them up [3-5]. I'll discuss recent experiments aimed at achieving this goal via the coupling of molecular spin ensembles, mainly diluted in diamagnetic single crystals, to on-chip superconducting resonators. These experiments show that it is possible to achieve a high cooperativity coupling to electronic and even nuclear spin transitions [6]. In addition, we find that spin clock transitions help optimizing both the spin-photon coupling and the isolation from magnetic noise sources. The results provide the basis for reading out the states of electro-nuclear spin qudits and for performing with them proof-of-concept implementations of qudit based algorithms.

References

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Figures

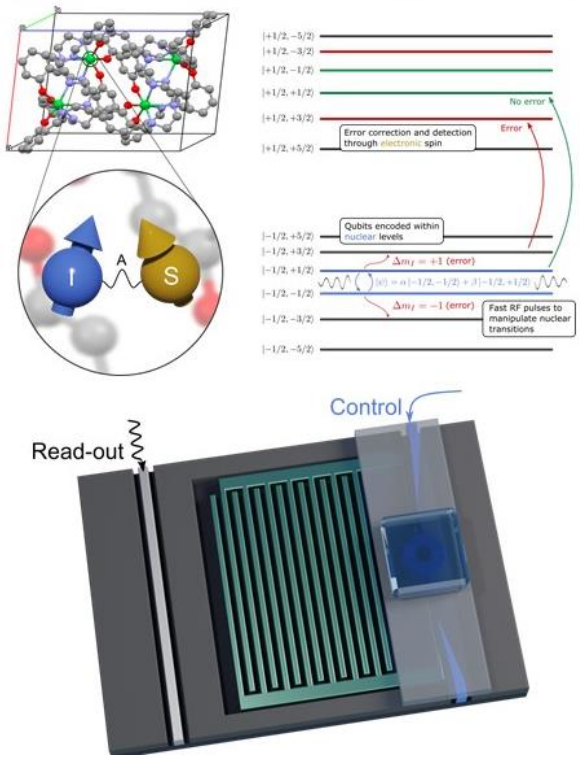

Figure 1: Sketch of a hybrid quantum processor based on molecular spin qudits (here Yb-trensal molecules diluted in a diamagnetic Lu-trensal crystal) coupled to an on-chip superconducting resonator (adapted from [6]).