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Strong coupling for spin clock states in electronuclear spin qudits based on vanadyl porphyrin molecules

The possibility of encoding several qubits in vanadyl porphyrin molecules hosting a S = 1/2 electronic spin coupled to a I = 7/2 nuclear spin has been explored. A complete study of the spin Hamiltonian and the spin dynamics has been performed via a combination of electron paramagnetic resonance, heat capacity, magnetization and on-chip magnetic spectroscopy experiments performed on single crystals, observing several properties that make each molecule fulfil the conditions to act as a universal 4-qubit processor or, equivalently, as a d = 16 qudit in the low field region (B < 0.1 T). In this region, the combined effect of Zeeman and hyperfine interactions gives rise to a set of anticrossings between the electronuclear spin states. In these anticrossings, known as spin-clock transitions, the system becomes almost insensitive to fluctuations of the magnetic field, making the spin coherence time T2 maximum.1 At the same time, the overlap between the spin states involved in the transition becomes maximum, being possible to increase the spin-photon coupling G without the cost of increasing decoherence. Here, we show the possibility of achieving the strong coupling regime (G > ⍰ ~ ⍰2
−1) close to the clock transitions that take place in
molecular crystals formed by these vanadyl porphyrin molecules. An analysis of these transitions via on-chip magnetic spectroscopy has been performed using concentrated and diluted crystals, determining the evolution of the spin-photon coupling as we move away from the level anticrossings.

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References

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Authors: CAMÓN, Agustín (INMA, UNIZAR); URTIZBEREA, Ainhoa (INMA, UNIZAR); ZUECO, David (Instituto de Nanociencia y Materiales de Aragon); LUIS, Fernando (INMA, UNIZAR); GIMENO, Ignacio (INMA, UNIZAR); ROMÁN ROCHE, Juan (INMA, UNIZAR); ROUBEAU, Oliver (INMA, UNIZAR); J. ALONSO, Pablo (INMA, UNIZAR)

Presenter: GIMENO, Ignacio (INMA, UNIZAR)