Dispersive readout of molecular spin qubits

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Magnetic molecules are attractive candidates to encode spin qubits [1,2]. We have performed the first experiments to test the dispersive readout of qubits encoded in the spin states of magnetic molecules by means of a superconducting circuit [3]. The molecules are coupled to lumped-element resonators (LERs) fabricated at the Centro of Astrobiología (CAB) [4]. Sweeping the external magnetic field magnetic changes the detuning $\Delta = \omega_q - \omega_r$ between the frequency of operation of the qubit, ω_q, and the resonator frequency, ω_r. If the detuning is larger than the qubit-resonator coupling, we can perform a non-demolition measurement of the state of the qubit by monitoring the change $\delta\omega_r$ in the resonator's frequency.

As a starting point, we chose the simplest system possible: PTM_r, a free radical (Fig. 1, inset) with spin 1/2 [5] and the qubit states encoded in its two spin projections. The absorption spectrum of the radical can be obtained, at a given field, by sweeping the frequency of a driving electromagnetic pulse, ω_{pump}, and then measuring the shift of the LER resonance (Fig. 1). The spectrum width comes from the inhomogeneous broadening of the sample. By increasing the time delay between the pump pulse and the readout measurement, we have determined the longitudinal relaxation time T_1, which becomes as long as 10-20 s at very low temperatures. The shape of the decay agrees with the distribution of spin-photon couplings generated by a small nano-constriction in the inductor, which locally enhances the coupling. Finally, the first signs of a coherent manipulation of the spin ensemble have been detected using this measurement procedure in a specific superconducting chip designed for that purpose.

References

[1] A. Gaita-Ariño, F. Luis, S. Hill and E. Coronado, Nat. Chem., 11 (2019) 301-309

[2] S. Carretta, D. Zueco, A. Chiesa, A. Gomez-Leon and F. Luis, Appl. Phys. Lett., 118 (2021) 240501

[3] A. Gomez-Leon, F. Luis and D. Zueco, Phys. Rev. Appl., 17 (2022) 064030

[4] B. Aja, M. C. de Ory, L. de la Fuente, E. Artal, J. P. Pascual, M. T. Magaz, D. Granados and A. Gomez, IEEE Trans. Microw. Theory Tech., 69 (2021) 578-589

[5] O. Armet, J. Veciana, C. Rovira, J. Riera, J. Castaner, E. Molins, J. Rius, C. Miravitlles, S. Olivella and J. Brichfeus, J. Phys. Chem., 91 (1987) 5608-5616

Figures

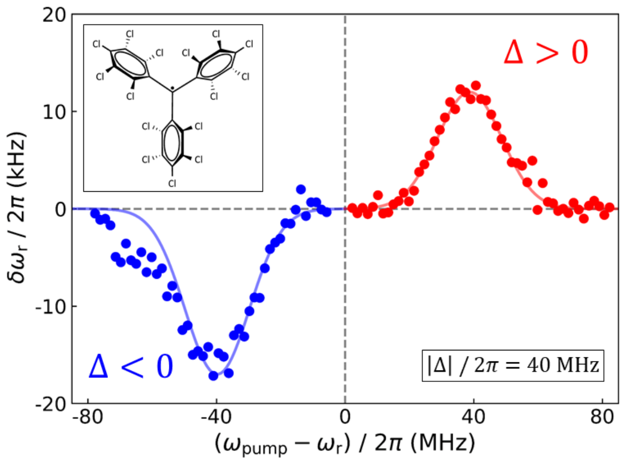

Figure 1: PTM_r spectrum for positive and negative detuning Δ, measured through the shift $\delta\omega_r$ of the resonator's frequency. Inset: The PTM_r molecule.