Current-driven resonant spin dynamics in a single organic molecule

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Resonant driving of localized spins by electric current provides an alternative route to magnetic resonance at the atomic scale. Whereas conventional electron paramagnetic resonance (EPR) relies on an oscillating magnetic field to drive spin transitions, here the excitation is mediated by spin-polarized transport through a tunnelling junction. Using EPR-STM to probe an organic molecule with well-defined, delocalized electronic states, we show that a radio-frequency spin-polarized tunnelling current can drive electron paramagnetic resonance via spin-transfer torque acting on a localized magnetic moment. Because both excitation and readout are mediated by the transport channel, this approach directly couples spin dynamics to charge flow and provides access to coherent control, relaxation, decoherence, and transport-induced linewidth broadening within a single local-probe experiment. These results establish organic molecular systems as a promising platform for out-of-equilibrium spin dynamics and quantum magnetism at the single-spin level. The same mechanism extends naturally to larger molecular architectures, where electronic delocalization, exchange coupling, and local addressability can be tuned by chemical design.

[1] S. Kovarik, R. Schlitz, A. Vishwakarma, D. Ruckert, P. Gambardella, and S. Stepanow, Science 384, 1368–1373 (2024).