MAGNETIC MOLECULES IN QUANTUM NANOSCIENCE: POTENTIAL AND CHALLENGES

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Implementation of modern Quantum Technologies might benefit from the remarkable quantum properties shown by molecular spin systems.[1] The versatility of the molecular approach combined with rational design has recently boosted the operativity temperature of molecules acting as bits of memory, otherwise known as Single-Molecule Magnets. Molecular spins, if characterized by long coherence time, can also act as quantum bits, with great potential for the implementation of embedded quantum error correction or quantum gates and quantum simulators. Molecules can also be processed to be deposited on surfaces, allowing the realization of hybrid nanostructures where different degrees of freedom are coupled as in the case of molecular spins interacting with the cooper pair of the underlying superconductor.[2]

However, the molecular approach also poses key challenges, such as the presence of low-energy vibrational modes typical of molecular lattices. This drawback can be in part overcome by chemical design. Achieving the control of the spin of a single molecule is a key step toward the implementation of quantum technologies but is also very challenging because the spin is weakly coupled with the magnetic field and even more weakly with the electric field, which can be confined at the molecular scale, with the spin degrees of freedom of the molecule. Learning from nature, we propose exploiting chirality, particularly spin selectivity in electron transfer processes through chiral structures, as an innovative spin-to-charge mechanism for molecular spin control and readout.[3]

[1] Atzori, M.; Sessoli, R. *J. Am. Chem. Soc.* **141**, 11339-11352 (2019).

[2] Serrano, G. et al. *Nat. Mater.* **19**, 546–551 (2020).

[3] Chiesa, A. et al. *Adv. Mater.* **35**, 2300472 (2023).