# Magnetic molecules in quantum nanoscience: potential and challenges

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Spins, fundamental quantum systems, are the prototype of the building blocks of quantum computation — the qubits. The possibility to fine-tune their properties through chemical design makes molecular spins particularly fascinating. The dimension of the Hilbert space can be controlled at the synthetic level. Molecules hosting several coupled spins can act as quantum gates. Molecules can also be processed for surface deposition, enabling the fabrication of hybrid nanostructures and single-molecule resolution. However, the molecular approach also poses key challenges. Their weak coupling with the environment enhances coherence but complicates single-spin control and readout. Traditional magnetic fields, essential for spin manipulation, cannot be confined to the single-molecule level, and the Zeeman interaction is much weaker than thermal energy at room temperature, hindering high-temperature operation. Solving these issues requires a broader and more integrated perspective. Our approach includes harnessing photoactivated mechanisms, spin-electric effects, and structural chirality. Following a general introduction, an overview of our recent results will be provided.

## Biography

Roberta Sessoli developed her career at the University of Florence, where she has been a full professor since 2012. Working at the interface between chemistry and physics, she played a key role in the discovery of single-molecule magnets (SMMs), i.e., magnetic bistability and memory effects at the single-molecule scale, thereby opening an entirely new field in magnetism and nanotechnology. She extended the investigation of the phenomenon to molecules on metallic and superconducting substrates to explore novel hybrid interfaces. Her current interests include molecules with highly coherent spin dynamics for quantum information and the interplay between magnetism and chirality as a new tool in spin chemistry and physics.

She has published more than 390 articles (>61,000 citations, h-index=107) and has received numerous awards, such as (among others) the recent Solvay Chair 2025, Beller lectureship of the American Physical Society (2023), Centenary Prize of the Royal Society of Chemistry (2019), Distinguished Woman in Chemistry and Chemical Engineering from IUPAC (International Union of Pure and Applied Chemistry) (2015), Lecoq de Boisbaudran Award from the European Rare Earths Society (2015)….She is also a member of prestigious societies such as the Academia Europaea, the European Academy of Sciences, the Accademia Nazionale dei Lincei, the Royal Chemical Society. In 2010, she was awarded an ERC Advanced Grant. Since 2023, she has been the corresponding principal investigator of an ERC Synergy Project exploring the potential of spin-based quantum technologies enabled by chirality.