



European Award for Doctoral Thesis in Molecular Magnetism, 2020

The winners of the "**European Award on Molecular Magnetism Doctoral Thesis**", ADocMolMag 2020 Edition, organised by the European Institute of Molecular Magnetism, EIMM a.i.s.b.l., have been selected by the jury composed by three renowned scientists (Prof. Jesper Bendix, Department of Chemistry of the University of Copenhagen, Denmark; Dr. Tatiana Guidi, scientist within the ISIS Excitations Group, ISIS, Great Britain; Prof. Jürgen Schnack, Fakultät für Physik, Universität Bielefeld, Germany); they are:

- **Dr. Claudio Bonizzoni** - Department of Physics, Informatics and Mathematics - University of Modena and Reggio Emilia, Italy

With a thesis entitled: **Coherent coupling of molecular spins with YBCO microwave resonators – towards the integration of molecular spins into quantum circuits**

- **Dr. Clement Godfrin** - Quantum Institute, Sherbrooke, Canada (now at IMEC, Belgium)

With a thesis entitled: **Quantum information processing using a molecular magnet single nuclear spin qudit**

- **Dr. Manuel Souto** - CICECO - University of Aveiro Campus de Santiago, Portugal

With a thesis entitled: **Multifunctional Materials based on TTFPTM dyads: towards new Molecular Switches, Conductors and Rectifiers**

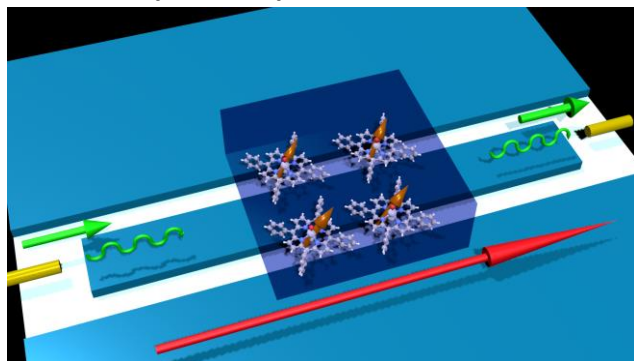
They will be awarded at the ICMM 2021, Manchester, UK. The winners will receive the diploma and the support toward the attendance of the same International Conference on Molecular Magnetism in Manchester (September 2021) or the European School in Molecular Nanoscience, EsMolNA (2020 or 2021 edition) in Peniscola (Spain), or the European Conference Molecular Magnetism 2021 in Rennes (France).

This fifth edition of the ADocMolMag awards, continue the tradition dated back to the first award, presented at the International Congress of Molecular Magnetism, ICMM 2008, held in Firenze, Italy, September 2008.

The previously awarded scientists are: in the first edition, 2008, Dr. Kevin Bernot (University of Firenze and University of Rennes), Dr. Luminita Toma (University of Valencia and University of Groningen) and Dr. Theocharis Stamatatos (University of Florida); in the second edition - presented at MolMat 2010 in Montpellier, France - Alessandro Prescimone (University of Edinburgh), Angelika Boeer (University of Manchester) and Francesco Pineider (University of Firenze); in the third, presented at European Conference of Molecular Magnetism, ECMM 2017 in Bucharest, Romania, Joseph Zadrozny (Northwestern University) and Abhishake Mondal (Centre de Recherche Paul Pascal – Pessac); in the fourth edition, ECMM held in Florence (Italy) in 2019, Eufemio Moreno-Pineda (Karlsruhe Institute of Technology), Alessandro Chiesa (University of Parma), Julie Jung (Los Alamos National Laboratory) and Alessandro Lunghi (Trinity College Dublin).

In a nut, the thesis of the fifth editions concern:

- **Coherent coupling of molecular spins with YBCO microwave resonators – towards the integration of molecular spins into quantum circuits**



The thesis is an experimental work concerning the viability of the integration of molecular spin ensembles into quantum circuits and of their applications for quantum technologies. In particular, the conditions to achieve the coherent spin-photon coupling regime with molecular spin ensembles embedded into planar superconducting microwave resonators at low temperature are investigated. The coherent coupling regime is experimentally

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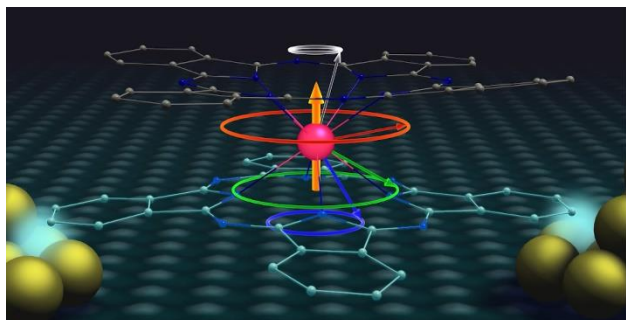
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demonstrated with both concentrated ensembles of organic radicals (DPPH, PyBTM) as well as with a diluted ensemble of VOPc, and the results found compare well with the ones reported in the literature for the spin ensembles (e.g. NV centers) typically used in quantum circuits. The simultaneous coherent coupling of multiple ensembles of organic radicals through the same resonator is further demonstrated, showing the possibility to coherently transfer information between distinct and spatially separated ensembles. The results achieved demonstrate that molecular spin ensembles can be successfully integrated into quantum circuits and can be suitable also for applications in quantum technologies.

- Quantum information processing using a molecular magnet single nuclear spin qubit



During its PhD, prepared under the supervision of Franck Balestro and Wolfgang Wernsdorfer, Clément manipulation of the $3/2$ nuclear spin of the Tb^{3+} ion embedded in a $TbPc2$ single molecular magnet transistor. They first characterized each nuclear spin transition to show the remarkable coherent properties of this system. Indeed, they demonstrated that thousands of quantum operations could be performed on each transition. Then they

implemented the Grover's quantum algorithm. This algorithm enables a quadratic acceleration, to compare with classical one, to find an element in an unsorted list. Finally, they operated interferometric protocols to measure geometric phases on this single nuclear spin. "

- Multifunctional Materials based on TTFPTM dyads: towards new Molecular Switches, Conductors and Rectifiers



Manuel Souto followed a molecular approach to develop the next generation of electronic devices at the nanoscale level, because of the high versatility and tunability that molecular chemistry offers. The thesis was focused on the design and synthesis of a new family of multifunctional organic materials based on donor-acceptor (D-A) dyads formed by the electron-donor tetrathiafulvalene (TTF) unit and the electron-acceptor perchlorotriphenylmethyl (PTM) radical linked through different π -conjugated bridges. These compounds exhibited interesting physical properties such as bistability and nonlinear optical properties in solution, pressure-induced electrical conductivity in the solid state and

rectifying behavior when anchored on surfaces as Self-Assembled Monolayers (SAMs). This family of organic D-A radical dyads are promising molecular materials towards different applications in the fields of molecular electronics and spintronics as molecular switches, conductors, and rectifiers.

Firenze, 04/05/2020

The EIMM board,

Prof. Andrea Caneschi, Prof. Eugenio Coronado, Prof. Richard E.P. Winpenny