Neutrons confirm their potential to probe nanomagnets and the future of quantum computing

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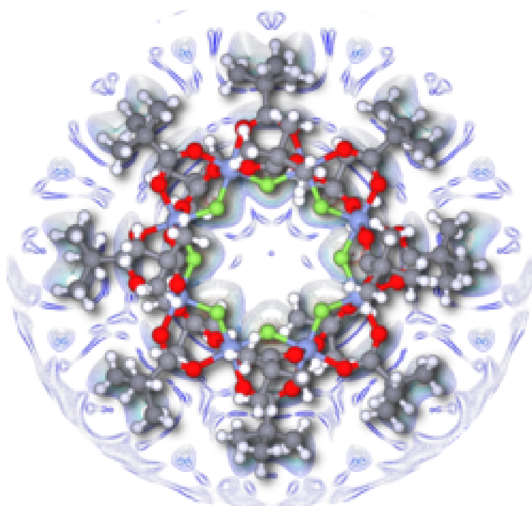

Cr8-Piv molecule superimposed to the iso-energy spectrum of the transition, showing that the magnetism reflects the symmetry of the Cr ions.

(Phys.org)—Neutron scientists at the ILL have partnered with researchers from the University of Manchester, the University of Parma, the Rutherford Laboratory and the University of Bern to investigate molecular nanomagnets, materials composed of only a few atoms carrying magnetic moments. Their findings have been published in *Nature Physics*.

In a world first, researchers have used inelastic neutron scattering on single-crystal samples of these materials to directly probe the motion of magnetic moments within the molecules, a technique which could be used in the future to assess their feasibility and potential application in quantum computers and high-density data storage.

The magnetic properties of materials are caused by a characteristic of their electrons known as spin. When a number of atoms carrying electronic spins come together they can form nanoscale units with a unique magnetic nature. In particular, quantum mechanical effects are enhanced by the finite size of magnetic nanostructures, and profoundly affect the motion of spins.

In this new experiment, scientists fired a beam of neutrons at a sample containing these nanoscale units, in order to probe their characteristic energies. The novelty of this approach was that the scientists were able to examine in detail the spatial structure of the magnetic excitations. This technique is the most powerful tool available to scientists studying the behaviour of magnetic moments within individual nanoscale magnetic molecules.

The results not only proved the validity of this new technique going forward but also gave a detailed picture of how magnetic moments within the molecule move. The most unusual aspect of the work was that this was done directly, without the use of a mathematical model.

This new technique could aid research into the use of these materials and their magnetic moments for data recording and the next generation of computing technology. Potential future applications include the encoding of qubits, the unit of quantum information for quantum computing. Whilst quantum computing will not be hitting the mainstream market for a long time yet, , they may in a few years be used for highly specialised government and corporate functions. The quantum computer is one of the main objectives of modern physics as it is much better than a traditional computer for code breaking and factoring large numbers, and it vastly increases the computational power in simulating quantum systems.

Current technology limits allow for only a few spin qubits to be brought together and controlled in a computing system. It is estimated this will need to increase to between 50 and 100 for even the most simple research-related tasks. This is the next challenge to be overcome: a large number of molecular nanomagnets will have to be linked together in supramolecular complexes whose geometry enables fundamental logical gates to be implemented.

Scientists are now keen to produce and exploit such exotic systems, and here again inelastic neutron scattering has a role to play.

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