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Propagation of avalanches in magnets assisted by quantum law

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A new macroscopic physical phenomenon governed by quantum law, quantum magnetic deflagration, has been unveiled by a team of European researchers. The discovery, published in the American journal Physical Review Letters, could lead to future quantum and nano-information technology applications.

The team, led by Javier Tejada, Professor of Fundamental Physics at the University of Barcelona, and Paul Santos, a researcher at the Paul Drude Institute in Berlin, have reported controlled ignition of magnetisation reversal avalanches in Mn12 acetate. Mn12-acetate is a material widely used to study quantum tunnelling, and a contender for use in magnetic memory storage and quantum computing.

Since the 1990s, it has been known that, when a magnetic field is applied to them, the molecule-sized magnets that make up a magnetic crystal can suddenly flip their spins, and that the progress of pole reversal occurs in so-called magnetic avalanches. Earlier this year, researcher Myriam P. Sarachik and graduate student Yoko Suzuki, at the City College of the City University of New York (CUNY), set up an experiment to track magnetic avalanches. They discovered that the reversal of the magnetisation of crystals of Mn12-acetate, when a source of heat is applied, progresses in a similar way as the propagation of a flame front through a flammable chemical substance. The phenomenon has been named 'magnetic deflagration'.

Now, the team led by Professors Tejada and Santos has reported controlled ignition of magnetisation in a single crystal of Mn12 acetate. The researchers have discovered that the propagation speed at which the compass poles are reversed follows a law determined by quantum mechanics. Combined with the evidence of magnetic deflagration in Mn12 acetate, this suggests a novel physical phenomenon: deflagration assisted by quantum tunnelling. In other words, and contrary to expectations, it is a macroscopic effect governed by a quantum law.

Professor Tejada suggests that in order to understand the idea of magnetic deflagration, a parallel could be drawn between chemical combustion and what we know as magnetic combustion. Chemical combustion involves a reaction between a substance (the fuel) and a gas (the oxidizer), and a great amount of heat is released. In a complete combustion reaction the components of the material interact with the oxidizer to yield new components (burnt fuel).

Deflagration is a slow combustion process governed by thermal conductivity and is propagated more slowly than the speed of sound. Professor Tejada explains that the simplest example is that of a piece of paper heated with a lighter at one end: 'one layer of paper burns and heats up the next layer until the whole piece of paper is burnt. That which is propagated and burnt is the flame, while what