Discovery of a new physical phenomenon governed by a quantum law

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A team of researchers has just discovered a new macroscopic physical phenomenon governed by a quantum law: quantum magnetic deflagration. The discovery, published in November in the American journal *Physical Review Letters*, was made by a team led by Javier Tejada, Professor of Fundamental Physics at the UB, and Paul Santos, a researcher at the Paul Drude Institute in Berlin.

Javier Tejada says that “to understand the idea a parallel could be drawn between chemical combustion and what we know as magnetic combustion. 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 combustion process produced by thermal conductivity and is propagated more slowly than the speed of sound. 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 remains are the ashes”.

What, however, happens with a magnetic material? If we have a magnetic material with all the poles aligned in the same direction (for example, a material made of very small compasses, all of which have the north pole facing upwards) and we apply a magnetic field in the opposite direction the compass poles should turn slowly until, eventually, they are all aligned downwards. If we fire acoustic microwaves at the material to

heat it up, then in a certain part of the material the heat will be sufficient to cause the compass poles to reverse in this area. This part of the material then heats the surrounding areas enough to produce the same reaction and the poles of other compasses are reversed; this propagation continues until all the spins are aligned downwards (the opposite of their initial orientation). The reversal of the poles is produced by the tunnelling effect of the magnetic moment, which is a quantum effect.

The researchers have discovered that the propagation speed at which the compass poles are reversed follows a law determined by quantum mechanics. In other words, and contrary to expectations, it is a macroscopic effect governed by a quantum law.

The discovery of quantum magnetic deflagration opens up a new experimental field of relevance to both basic science and technological applications. The article published in Physical Review Letters is the latest scientific advance to be derived from the discovery — ten years ago — of the spin tunnelling effect. The experiment was carried out in the UB under the leadership of Javier Tejada, Professor of Fundamental Physics, and Paul Santos, a researcher at the Paul Drude Institute in Berlin, with the collaboration of the lecturer Antonio García-Santiago, Alberto Hernàndez and Ferran Macià (doctoral students) and Joan Manel Hernàndez (Ramon y Cajal researcher) from the Department of Fundamental Physics at the UB. The research was funded by the company SAMCA, the Spanish Ministerio de Educación y Ciencia and the European Union, and was conducted using new generation equipment developed by the company Agilent Technology.

In addition to its impact in the research world the spin tunnelling effect discovered by J. R. Friedman, M. Sarachik, Javier Tejada and Ron Ziolo, and reported in Physical Review Letters in 1996, now features in text books on magnetism. Recognized as a scientific discovery by the editorials of prestigious journals (Science, Nature, Physics Today), this

initial study on the discovery of the tunnelling effect has achieved one of the most significant citation indexes for publications from Physical Review Letters.

Source: Universidad de Barcelona