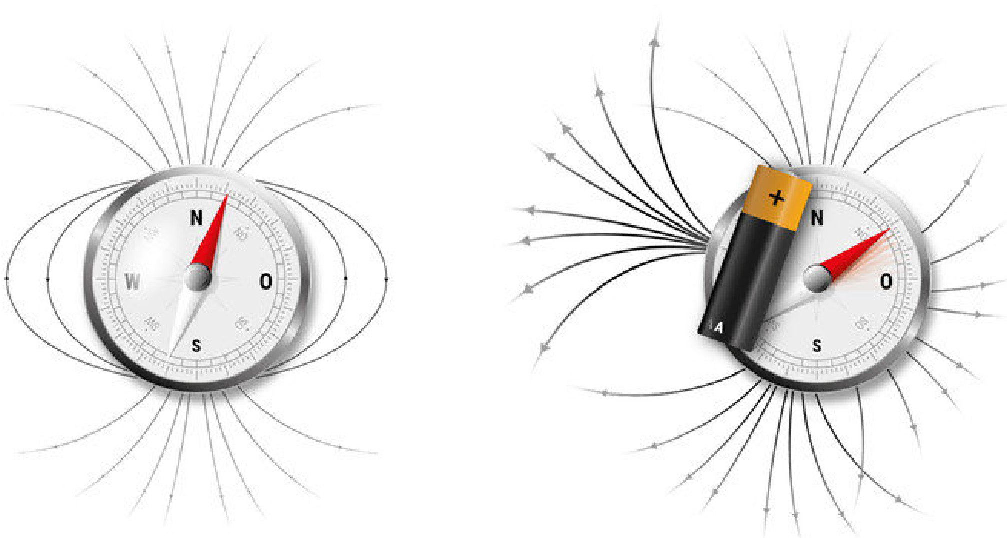
Using electricity to switch magnetism

January 17 2018



Electricity and magnetism. Credit: TU Wien

At TU Wien, researchers have taken a major step toward linking electrical and magnetic material properties, which is crucial for possible applications in electronics.

It's not exactly a new revelation that electricity and magnetism are closely linked. And yet, magnetic and electrical effects have been studied separately for some time now within the field of materials science. Magnetic fields will usually be used to influence magnetic material properties, whilst electrical properties come down to electrical voltage. Then we have multiferroics – a special group of materials that combine the two. In a new development, TU Wien has managed to use electrical fields to control the magnetic oscillations of certain ferrous materials. This has opened up huge potential for computer technology applications, as data is currently transferred in the form of electrical signals but stored magnetically.

Electrical and magnetic materials: poles apart

Within the field of solid state physics, it is often a case of working with material properties that can be influenced by either magnetic or electrical fields. As a general rule, magnetic and electrical effects can be studied separately because their causes are completely different. Magnetic effects come about because particles have an internal magnetic direction called the 'spin', whereas electrical effects result from positive and negative charges within a material that can shift position in relation to one another.

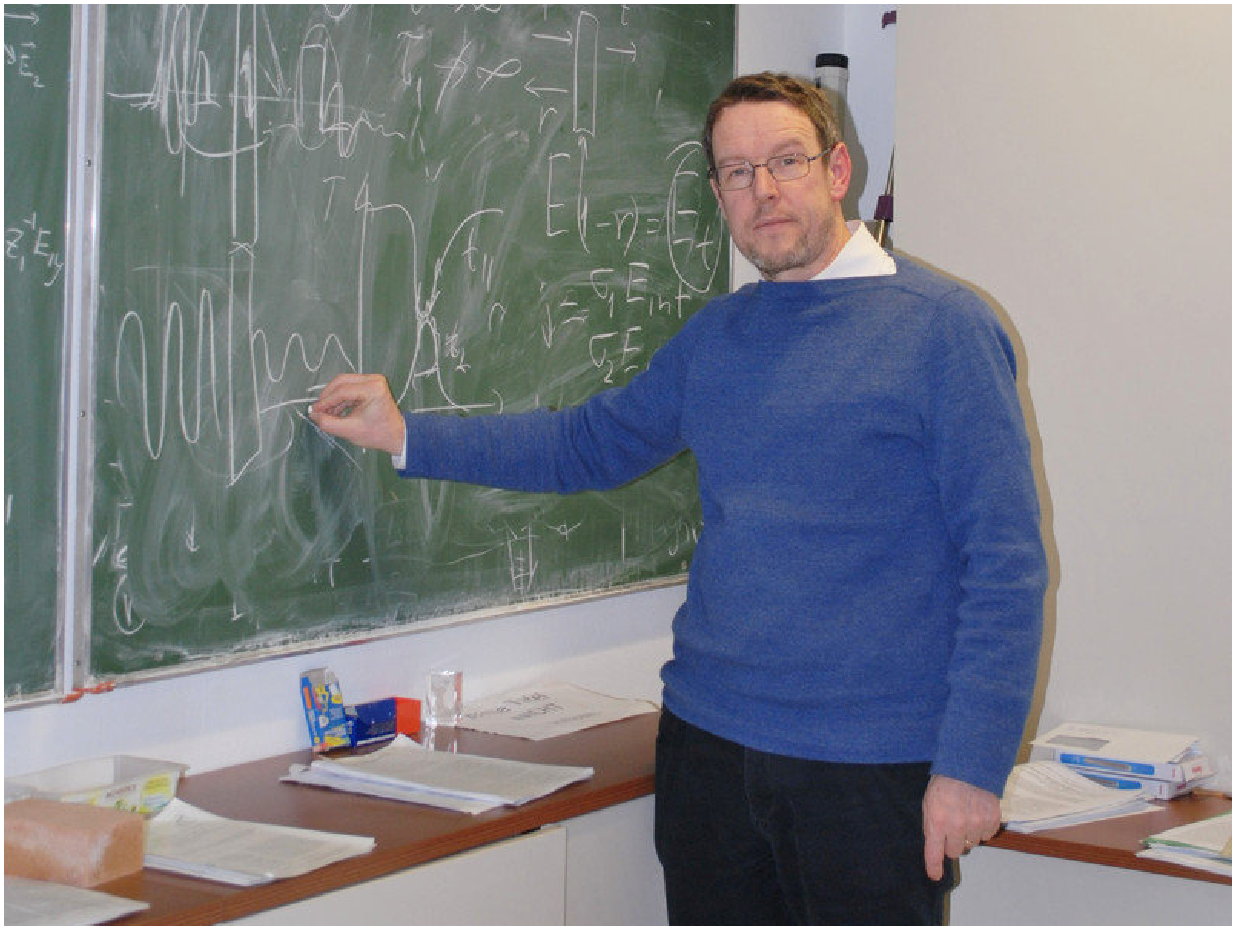
It is a challenge to combine magnetic storage and electric writing procedures.
Credit: TU Wien

"When it comes to materials with very specific spatial symmetries, however, the two can be combined," explains Professor Andrei Pimenov from the Institute of Solid State Physics at TU Wien. He has been conducting research into this special kind of material – 'multiferroics' – for a number of years now. Multiferroics are currently considered to be a promising new area within solid state physics on a global scale. Interesting experiments have already been performed to research how magnetic and electrical effects can be linked and now Pimenov and his team of researchers have managed to use electrical fields to control the high-frequency magnetic oscillations of a material consisting of iron, boron and rare-earth metals for the first time.

"The material contains iron atoms which are threefold positively charged. They have a magnetic moment oscillating at a frequency of 300 GHz," says Pimenov. "There is no question that these oscillations could be controlled using a magnetic field. But what we have managed to demonstrate is that these oscillations can be altered in a targeted way using an electrical field." This means that a dynamic magnetic effect – the iron atoms' magnetic state of oscillation – can be activated or deactivated using a static electrical field.

Magnetic data storage, electrical writing

This development is particularly interesting for future electronics applications: "Our hard drives store data magnetically, but it is incredibly difficult to write data quickly and accurately in the same way," says Pimenov. "It is so much easier to apply an electrical field with pinpoint precision, as all you need is a simple voltage pulse. The process is very speedy and doesn't involve any significant loss of energy." But now we could potentially have the option of using materials that combine magnetic and electrical effects to bring together the advantages of magnetic storage and electrical writing.



Prof. Andrei Pimenov. Credit: TU Wien

More information: A. M. Kuzmenko et al. Switching of Magnons by Electric and Magnetic Fields in Multiferroic Borates, *Physical Review Letters* (2018). [DOI: 10.1103/PhysRevLett.120.027203](https://doi.org/10.1103/PhysRevLett.120.027203)

Provided by Vienna University of Technology