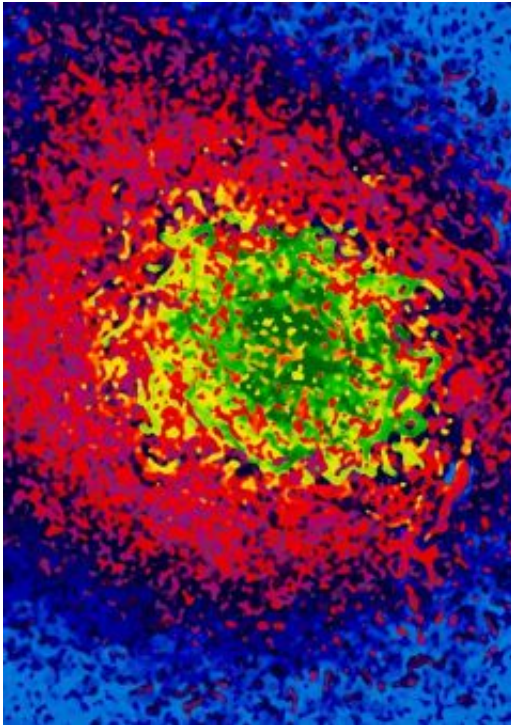


X-ray holograms expose secret magnetism

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By observing changes in coherent X-ray speckle pattern, such as the one shown above, researchers are able for the first time to investigate nanoscale dynamics of antiferromagnetic domain walls, and observe a cross over from classical to quantum behavior. Credit: O. Shpyrko, Center for Nanoscale Materials, Argonne National Laboratory

Collaborative research between scientists in the UK and USA has led to a major breakthrough in the understanding of antiferromagnets, published in this week's *Nature*. Scientists at the London Centre for Nanotechnology, the University of Chicago and the Center for

Nanoscale Materials at Argonne National Laboratory have used x-rays to see the internal workings of antiferromagnets for the very first time.

Unlike conventional magnets, antiferromagnets (such as the metal chromium) are materials which exhibit 'secret' magnetism, undetectable at a macroscopic level. Instead, their magnetism is confined to very small regions where atoms behave as tiny magnets. They spontaneously align themselves opposite to adjacent atoms, leaving the material magnetically neutral overall.

Professor Gabriel Aeppli, Director of the London Centre for Nanotechnology, said: "People have been familiar with ferromagnets for hundreds of years and they have countless everyday uses; everything from driving electrical motors to storing information on hard disk drives. We haven't been able to make the same strides with antiferromagnets because we weren't able to look inside them and see how they were ordered.

"This breakthrough takes our understanding of the internal dynamics of antiferromagnets to where we were ninety years ago with ferromagnets. Once you can see something, it makes it that much easier to start engineering it."

The magnetic characteristics of ferromagnets have been studied by scientists since Greek antiquity, enabling them to build up a detailed picture of the regions - or "magnetic domains" - into which they are divided. However, antiferromagnets remained a mystery because their internal structure was too fine to be measured.

The internal order of antiferromagnets is on the same scale as the wavelength of x-rays (below 10 nanometers). The latest research used x-ray photon correlation spectroscopy to produce 'speckle' patterns; holograms which provide a unique 'fingerprint' of a particular magnetic

domain configuration.

Dr. Eric D. Isaacs, Director of the Center for Nanoscale Materials, said: "Since the discovery of x-rays over 100 years ago, it has been the dream of scientists and engineers to use them to make holographic images of moving objects, such as magnetic domains, at the nanoscale.

"This has only become possible in the last few years with the availability of sources of coherent x-rays, such as the Advanced Photon Source, and the future looks even brighter with the development of fully coherent x-ray sources called Free Electron Lasers over the next few years."

In addition to producing the first antiferromagnet holograms, the research also showed that their magnetic domains shift over time, even at the lowest of temperatures. The most likely explanation for this can be found in quantum mechanics and the experiments open the door to the future exploitation of antiferromagnets in emerging technologies such as quantum computing.

"The key finding of our research provides information on the stability of domain walls in antiferromagnets," said Oleg Shpyrko, lead author on the publication and researcher at the Center for Nanoscale Materials.

"Understanding this is the first step towards engineering antiferromagnets into useful nanoscale devices that exploit it."

Source: University College London

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