ELECTRON BEAMS

An atom-sized vortex

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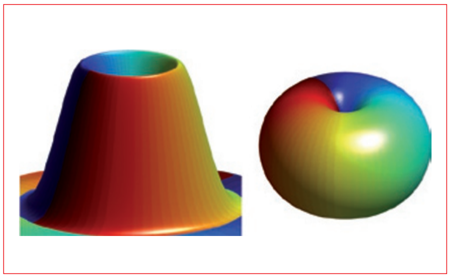

Electron beams are typically plane waves. This means that the beam phase is identical for all points in a plane perpendicular to the beam direction. The phase of an electron vortex beam, on the other hand, describes a spiral. As a result, vortex beams carry orbital angular moment and magnetic moment, which leads to unique interactions with matter. Jo Verbeeck of the University of Antwerp and colleagues from Austria, the Netherlands and Canada have now demonstrated an electron vortex beam with a diameter of less than 1.2 Å.

Electron vortex beams were first created by passing a plane wave beam through a graphite film that spontaneously formed a spiral structure, and acted as a phase plate. This was difficult to reproduce and gave limited control over the resulting beam. Verbeeck and co-workers had improved on this approach by creating a vortex beam with a holographic mask inside a transmission electron microscope. However, the effective beam diameter was several micrometres.

Verbeek and colleagues have now reduced this beam diameter to atomic dimensions by placing a holographic mask in the condenser plane of a state-of-the-art microscope with double aberration correction. At 1.2 Å, the beam size is comparable to the size of the 2*p* orbital in a nitrogen atom (see image; left and right panels show the beam and the 2*p* orbital respectively, drawn approximately to scale). The tiny vortex beam may allow atomic-resolution mapping of magnetic states. *MS*

NANOELECTROMECHANICAL SYSTEMS

Keeping the noise down

Nature **480,** 351–354 (2011)

Any device that amplifies a signal inevitably adds noise, and quantum mechanics prevents this added noise being reduced below a certain value. It is possible to approach this quantum limit by using superconducting devices to amplify electrical signals, but these devices are complex. Now Francesco Massel and co-workers at Aalto University and the VTT Technical Research Centre of Finland have shown that nanomechanical resonators can amplify microwave signals, and that it may be possible to reach the quantum limit with this approach.

The Finnish team start by using lithography and focused ion-beam etching to define a mechanical resonator and a microwave cavity in a 150-nm-thick layer of aluminium on a silica surface. When a pump signal is fed into this system, energy is transferred from the cavity to the resonator if the pump frequency is higher than the resonance frequency of the cavity, and vice versa. And if a weak probe signal is sent into the system when energy is being transferred to the resonator, this probe can also be amplified. Massel and co-workers show that approximately 20 noise quanta are added to the signal, and predict that it should be possible to reach the quantum limit of adding just half a quantum of noise. *PR*

ELECTRON MICROSCOPY

Mapping ensembles

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Electron microscopy is routinely used to characterize the structure of metal nanoparticles, and with the help of electron energy-loss spectroscopy, chemical maps with atomic resolution can also be obtained. A chemical map of a single particle can, however, take hours to record. Therefore, acquiring a statistically significant sample of a system that contains nanoparticles with a variety of different compositions, such as a heterogeneous catalyst, is impractical. David Muller, Zhongyi Liu and colleagues at Cornell University, General Motors and Florida International University have now shown that the improved electron optics of an aberration-corrected electron microscope can allow hundreds of platinum–cobalt nanoparticles to be chemically mapped.

The US team used a scanning transmission electron microscope that can correct up to the fifth-order of aberrations and allows data to be collected around a thousand times faster than on a conventional microscope. With the instrument, the platinum–cobalt nanoparticles — which are promising as a fuel-cell catalyst but are known to degrade over time — were mapped at various stages of ageing in a proton-exchange-membrane fuel cell. By mapping ensembles of nanoparticles, the precise structure and composition of the catalyst could be linked to its bulk electrochemical performance with statistical confidence. *OV*

MAGNETIC NANOPARTICLES

At the crime scene

Analyst http://dx.doi.org/10.1039/c1an15200a (2011)

DNA profiling is widely used by forensic investigators to identify an offender from just a single cell. However, equally valuable is the ability to detect and identify traces of body fluids such as saliva, semen and blood on various objects at the crime scene. At present, methods and tests used to analyse body fluids are destructive and have a low specificity. Now, Nunzianda Frascione and colleagues at King's College London have shown that magnetic nanoparticles conjugated with specific antibodies can detect and identify blood and saliva *in situ* on different types of substrates.

The researchers functionalized magnetic nanoparticles with fluorescently labelled antibodies that recognize specific components of red blood cells, white blood cells or saliva. They applied the nanoparticles to human blood or saliva that had been smeared onto a glass slide. After 30 mins the unbound nanoparticles were removed by a magnet and the bound conjugates were visualized under a fluorescent microscope. The antibodies showed good specificity and had little cross reactivity with other body fluids. Furthermore, blood stains that were treated with the nanoparticles could still be used for DNA profiling, suggesting that this method could potentially save money as DNA profiling would only be carried out on identified sections of the samples. The method also worked on samples on substrates such as ceramic, paper and dark fabrics, thereby increasing the likelihood of uncovering important evidence at the crime scene. *ALC*

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