Researchers create 'tornados' inside electron microscopes

February 16 2012

Researchers from the University of York are pioneering the development of electron microscopes which will allow scientists to examine a greater variety of materials in new revolutionary ways.

The team, headed by Professor Jun Yuan and Professor Mohamed Babiker, from the University's Department of Physics has created electron beams with orbital angular momentum – electron vortex beams – which will open the way to many novel applications including the more efficient examining of magnetic materials.

Electron microscopes use a beam of electrons to illuminate a specimen and produce a magnified image, allowing scientists to investigate atomic arrangements. Compared to conventional electron beams, electron vortex beams improve the resolution and sensitivity of imaging, which is key when determining the structure of biological specimens such as proteins. They also have applications in the manipulation of nano-scale objects such as atoms and molecules.

As the electron vortex consists of moving charged particles, there is a magnetic field associated with the vortex. This magnetic field will be invaluable in examining magnetic materials, enabling the nanoscale magnetic structure to be imaged.

The York team has created a design for a holographic mask to generate an electron vortex beam and now plans to use this to improve the imaging capabilities of the electron microscope in its York-JEOL

nanocentre.

Details of York's latest work - part of the research by second year PhD student Sophia Lloyd - showing that orbital angular momentum of electron beams with vortex structure are more efficient than light for probing atomic magnetism, are published in the February edition of the *Physical Review Letters*.

Professor Yuan said: "The introduction of vortex beams into electron microscopy, with its screw-like revolving wave front – much like tornados, will revolutionise the study of magnetic nanostructures, as well as creating new applications in terms of nanoparticle manipulation and trapping, and edge contrast detection."

Professor Babiker, an expert in light vortex research, added: "Optical vortex beams, created using beams of light photons, have been studied for the past 20 years. They have found a great many applications, most notably in fine scale manipulation of single molecules and nano-objects in so-called optical tweezers and optical spanners.

"Research being carried out at York is intended to further current understanding of electron vortices so that a similarly broad range of applications can be realised."

More information: The full paper, co-authored by Sophia Lloyd, Mohamed Babiker and Jun Yuan, “Quantised orbital angular momentum transfer and magnetic dichroism in the interaction of electron vortices with matter”, is published in *Physical Review Letters* link.aps.org/doi/10.1103/PhysRevLett.108.074802

Provided by University of York