New technique allows 3-D visualization of quantum property

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Scientists at the U.S. Department of Energy's Argonne National Laboratory have developed a new technique that maps the magnetic vector potential — one of the most important electromagnetic quantities and a foundation of quantum mechanics — in three dimensions.

"The vector potential of magnetic structures is essential to the understanding of several areas in condensed matter physics and magnetism on a quantum level, but until now it has never been visualized in three dimensions," Argonne Distinguished Fellow Amanda Petford-Long said. "If you want to understand the way magnetic nanostructures behave, then you have to understand the magnetic vector potential."

According to Petford-Long, research into the creation and manipulation of magnetic nanostructures will enable the development of the next generation of data storage in the form of magnetic random access memory.

Petford-Long and post-doctoral researcher Charudatta Phatak used a transmission electron microscope (TEM) to examine a series of different nanostructures. The theoretical and numerical reconstruction procedure was developed in collaboration with Prof. Marc De Graef at Carnegie Mellon University.

Using the TEM, the researchers were able to take images from several different angles and then rotate the structure by 90 degrees until they had several series of images. The scientists then extracted the vector

potential by reconstructing how the electrons in the material shifted phase.

“The development of next generation magnetic sensors and devices requires studying the physics underlying the magnetic interactions at the nanoscale,” Phatak said. “This 3-D map is the first step to truly understanding those interactions.”

A paper on this research has been published in the June 25 issue of Physical Review Letters (Vol. 104, No. 25).

Provided by Argonne National Laboratory