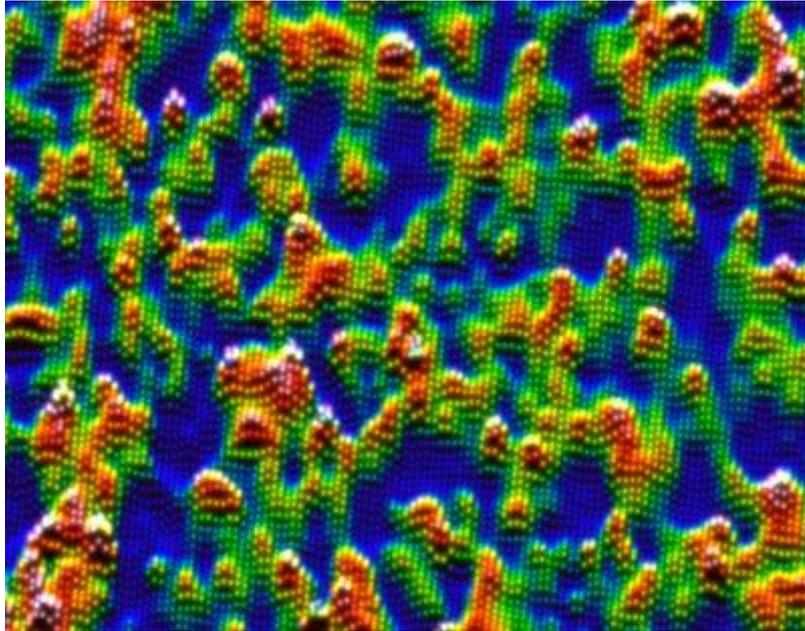


Fractal patterns spotted in the quantum realm

Feb 9, 2010



Quantum repetition Fractal patterns enter the quantum world

From thunderous mountain landscapes viewed from above to the erratic trajectories of Brownian motion, **fractal** patterns exist at many scales in nature. Physicists believe that **fractals** also exist in the quantum world, and now a group of researchers in the US has shown that this is indeed the case. This image shows the **fractal** pattern that results when the waves associated with electrons start to interfere with each other.

A **fractal** is a geometric entity whose basic patterns are repeated at ever decreasing sizes. For example, a river system is an approximate **fractal** pattern as the channels branch off into progressively narrower tributaries moving upstream; at each confluence the pattern is a smaller version of the previous branching.

A sudden transition

Ali Yazdani at Princeton University in the US and his colleagues have revealed that these patterns also exist at the scale of individual atoms in a solid. And the key to this effect is a sudden transition where a material changes from a metal to an insulator. At this transition, the waves associated with individual electrons go from being extended across the whole system to being localized at lattice sites.

We do this stuff every day, but once we managed to get the experiment to work with this material, we were confronted with what look like random patterns **Ali Yazdani, Princeton University**

At this metal–insulator transition the electron waves become squashed together. They begin to affect each other in a complicated network of constructive and destructive interference, which results in a **fractal** pattern. Yazdani and his team were able to observe this effect using a scanning tunnelling microscope (STM), which provided the atomic scale resolution.

The material used was the ferromagnetic semiconductor gallium arsenide doped with up to 5% manganese, chosen because the researchers are interested in efficient ways of turning a semiconductor into a magnet. Indeed, doping gallium arsenide in this way has become a popular approach in the burgeoning field of spintronics – electronics that exploits the spin of particles as well as their charge. Spintronics has the potential to boost the speed of computing and electronics.

Serendipitous discovery

Talking about his research, Yazdani admits that observing these **fractals** was not the primary aim of this research. "We do this stuff every day, but once we managed to get the experiment to work with this material, we were confronted with what look like random patterns," he says. His group went on to develop the theory and realized that the electrons they were observing were on the brink of localization.

Yazdani and his team intend to develop their research by comparing the collective versus individual behaviour of electrons in their system and how this influences the spatial patterns. The bigger picture of this research is to connect these patterns with theories of magnetism to advance both fundamental research and the development of spintronics applications.

This research is published in *Science*.

About the author

James Dacey is a reporter for *physicsworld.com*