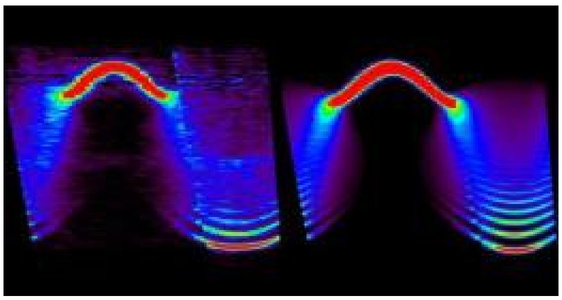
Exotic symmetry seen in ultracold electrons

January 18 2010, by Pete Wilton



Spectrum of magnetic resonances observed by neutron scattering in cobalt niobate in zero magnetic field, data (left) and calculation (right).

(PhysOrg.com) -- An exotic type of symmetry - suggested by string theory and theories of high-energy particle physics, and also conjectured for electrons in solids under certain conditions - has been observed experimentally for the first time.

An international team, led by scientists from Oxford University, report in a recent article in *Science* how they spotted the symmetry, termed E8, in the patterns formed by the magnetic spins in crystals of the material cobalt niobate, cooled to near absolute zero and subject to a powerful applied magnetic field.

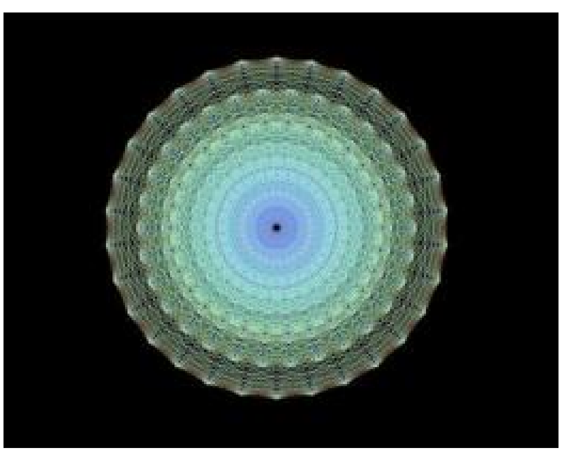
The material contains cobalt atoms arranged in long chains and each atom acts like a tiny bar magnet that can point either ‘up’ or ‘down’.

When a magnetic field is applied at right angles to the aligned spin directions, the spins can 'quantum tunnel' between the 'up' and 'down' orientations. At a precise value of the applied field these fluctuations 'melt' the ferromagnetic order of the material resulting in a 'quantum critical' state.

'You might expect to see random fluctuations of the spins at this critical point but what we uncovered was a remarkable structure in the resonances of the magnetic spins indicating a perfectly harmonious state,' said Radu Coldea from Oxford University's Department of Physics who led the team.

As the critical state was approached the researchers observed that the chain of atoms behaved like a 'magnetic guitar string'.

Radu added: 'The tension comes from the interaction between spins causing them to magnetically resonate. We found a series of resonant modes. Close to the critical field the two lowest resonant frequencies approached closely the golden ratio 1.618..., a characteristic signature of the predicted E8 symmetry.'



A visual representation of E8 symmetry. The two smallest concentric rings of solid red dots have their radius in the golden ratio as seen experimentally for the two lowest resonance frequencies of the magnetic spins. Credit:

Wikimedia/Claudio Rocchini.

He is convinced that this is no coincidence and it reflects a subtle form of order present in the quantum system.

The resonant states seen experimentally in cobalt niobate may be our first glimpse of complex symmetries that can occur in the quantum world. “The results suggest that similar ‘hidden’ symmetries may also govern the physics of other materials near quantum critical points where electrons organize themselves according to quantum rules for strong interactions,’ Radu told us.

The research was supported by EPSRC and Radu aims to use a new EPSRC grant to explore the physics of materials near quantum criticality.

The team included Dr Radu Coldea, Dr Elisa Wheeler and Dr D Prabhakaran from Oxford University’s Department of Physics, as well as researchers from Helmholtz Zentrum Berlin, ISIS Rutherford Laboratory, and Bristol University.

More information: www.sciencemag.org/cgi/content … bstract/327/5962/177

Provided by Oxford University

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