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TITLE

Towards realization of Kitaev Quantum Spin Liquid

ABSTRACT

In conventional magnetic materials, interactions between the spins lead to a phase transition from a high-temperature disordered state to a magnetically ordered state as the temperature is lowered. The transition is typically accompanied by singularities in the thermodynamic observables at the transition point, and spontaneous symmetry breaking and a reduction of the spin entropy to zero as the system enters a unique ground state. However, the spin entropy can also be released without any symmetry breaking, down to zero temperature, by forming a collective quantum spin state with long-range quantum entanglement. This exotic state of matter is called a quantum spin liquid. A goal of condensed matter physics is to discover new quantum phases formed by the ensemble of interacting spins and charges in solids. The QSL is perhaps one of the most exotic quantum phases known so far partly because of the nontrivial elementary excitations and has been attracting the attention of condensed matter scientists for several decades.

The concept of QSL[1] was first established in 1D Heisenberg antiferromagnet and then extended to 2D by the proposal of RVB-type QSL in S=1/2 triangular antiferromagnet by P. W. Anderson in 1973. Until recently, 2D geometrically frustrated antiferromagnets with triangular motif in their structure, as well as 1D antiferromagnets, had been a major arena in the experimental realization of QSL. In 2006 a theoretical breakthrough in the field of QSLs was reported. Alexei Kitaev proposed a simple but elegant model that is exactly solvable and that gives a QSL ground state, in which the spins fractionalize into emergent quasiparticles — Majorana fermions[2]. Soon after, a spin-orbital Jeff = 1/2 Mott insulator was identified in a complex 5d iridium oxide. This led to a theoretical proposal for the realization of the Kitaev model using Jeff = 1/2 pseudo-spins in an iridate, and initiated a search for the QSL state and the hidden Majorana fermions in a family of iridium and ruthenium compounds[3]. I am going to talk about first the development of concept of QSL from RVB to Kitaev, and then the rapid progress in the materialization Kitaev QSL as well as the hunting of Majorana fermions through the detection of unusual heat transport.

1. L. Balents, Nature 464, 199–208 (2010). 2. A. Kitaev, Ann. Phys. 321, 2-111 (2006).
3. H.Takagi, T. Takayama, G. Jackeli, G. Khaliullin, S. E. Nagler, Nature Review Physics 1, 264–280 (2019).

SPEAKER

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Prof. Hidenori Takai is a Director of the Max Planck Institute for Solid State Research in Stuttgart, and a Professor of Physics at the University of Tokyo. He received his PhD from University of Tokyo in 1989. He joined AT&T Bell Laboratories as a Post-Doctoral member in 1990 and returned to the University of Tokyo as an Associate Professor in 1994 and became a Professor in 1999. He moved to RIKEN, Japan as director of the Magnetic Materials Laboratory in 2002. In 2013, he moved to Germany to become a Director of the Max Planck Institute for Solid State Research, Stuttgart. His research interests lie in the correlated electron systems in condensed matter with focus in quantum spin liquids, metal-insulator transition, superconductivity, etc. He received the IBM science prize (1988), Nissan science prize (1994), K. H. Onnes prize (2006), Honda Frontier Award (2009), and is a Fellow of the American Physical Society. In 2013 he was appointed Alexander von Humboldt Professor.