筑波大学
University of Tsukuba

Condensed Matter Seminar
物性論セミナー

Supported by Variety and universality of bulk-edge correspondence in topological phases: From solid state physics to transdisciplinary concepts
Grant-in-Aid for Scientific Research (S) Project No.17H06138

2018年12月14日 (金), Dec. 14 (Fri), 2018, 13:30-14:30
自然系学系棟B棟６階: ６０２号室, B602, Univ. Tsukuba
[Map]

Majorana fermions and half-integer thermal quantum Hall effect in a quantum spin liquid

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The quantum Hall effect (QHE) is one of the most remarkable phenomena in contemporary condensed matter physics, which rivals superconductivity in its fundamental significance as a manifestation of quantum mechanics on a macroscopic scale. The quantum Hall state is a topological property of quantum matter. There are two classes of the QHE, where integer and fractional electrical conductance are measured in units of e^2/h. Here we report a novel type of quantization of the Hall effect caused by charge neutral quasiparticles, i.e. Majorana fermions due to the fractionalization of quantum spins, in an insulating two-dimensional (2D) quantum magnet, α-$RuCl_3$ with a dominant Kitaev interaction (a bond-dependent Ising-type interaction) on a two-dimensional honeycomb lattice[1][2]. This material has been suggested to be a candidate of Kitaev quantum spin liquid (QSL), where significant entanglement of quantum spins is expected. In the low-temperature regime of the QSL state, the 2D thermal Hall conductance reaches a quantum plateau as a function of applied magnetic field. Moreover, the plateau attains a quantization value, which is exactly half of that in the integer QHE. This half-integer thermal Hall conductance is a direct signature of topologically protected chiral edge currents of emergent Majorana fermions, whose degrees of freedom are half of those of electrons, and non-Abelian anyons in the bulk.

[1]Y. Kasahara et al. Phys. Rev. Lett. 120, 217205 (2018).
[2]Y. Kasahara et al. Nature 559, 227 (2018).

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