Topological Transitions, Chiral Majorana Fermion, and Quantum Computing

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Abstract

Symmetry breaking and topological transitions have revealed new effects and at the same time made possible many device possibilities. For the latter, dissipation-less quantum anomalous Hall was demonstrated in the magnetic doped topological insulator and spin textures could also be manipulated. Topological material heterostructures composed of, e.g., TI and antiferromagnets (AFM) or superconductors were shown to offer interesting new physics. In this talk, we will discuss the topological transitions at the interface of the TI/AFM heterostructure, which can be controlled by applying a small magnetic field. The edge state of the quantum anomalous Hall using a magnetic doped topological insulator (Cr doped BiSbTe), has been demonstrated to have millimeter coherent transport lengths. For the heterostructure consisting of a QAH edge state interfaced with a superconductor, new topological phase transitions can also occur to form a topological superconductor. For such heterostructure, chiral Majorana can be hosted. Majorana has been under intensive pursuit both theoretically and in experiments in the past 80 years. In the heterostructure consisting of a QAH insulator and a superconductor, our recent experimental results showed a half-integer and a two-integer of quantized conduction plateaus (0.5 e^2/h and 2 e^2/h), which give the firm signatures of the elusive Majorana fermion for the first time in 80 years. A recent report of different systems using an InSb nanowire interfaced with a superconductor confirmed a similar two-quantized plateau [1]. The contrast of our results with the more recent confirmation using the InSb nanowire with a superconductor mentioned above will also be discussed [2]. More recently, a half quantization of thermal conductance was also confirmed in $RuCl_3$.[3] Using Majorana particles as topological qubits, a topological quantum computer may be realized. The findings offer a new direction for robust topological quantum computing to mitigate the de-coherence challenge. Our finding offers the potential for constructing a robust topological approach to mitigate the challenge of decoherence of today's approaches in a quantum computer.

[1]. Qinglin He, .. Kang L Wang, Science, V.357, Issue 6348, pp. 294-299 (21 July 2017);
[2]. Hao Zhang, … Leo Kouwenhoven, Nature V.556, pages 74–79 (05 April 2018)
[3]. Y. Kasahara, …, Y. Matsuda, Nature, 5 5 9, 2 2 7 (12, July 2018)

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A short biography:

Dr. Kang L. Wang is currently Distinguished Professor and the Raytheon Chair Professor in Physical Science and Electronics in the University of California, Los Angeles (UCLA). He is affiliated with the Departments of ECE, MSE and Physics/Astronomy. He received his M.S. and Ph.D. degrees from the Massachusetts Institute of Technology and his B.S. degree from National Cheng Kung University (Taiwan). He is a Guggenheim Fellow, Fellows of American Physical Society and IEEE, and a Laureate of Industrial Technology Research Institute of Taiwan. He is an Academician of Academia Sinica. His awards include the IUPAP Magnetism Award and Néel Medal, the IEEE J.J. Ebers Award for electron devices, SRC Technical Excellence Award, the Pan Wen-Yuan Award, Chinese American History Makers Award, and others. He served as the editor-in-chief of IEEE TNANO, editor of Artech House, editors for J of Spins and for Science Advances and other publications. His research areas include topological insulators – condensed matters and physics; quantum information and computing; spintronics/magnetics and nonvolatile electronics, and nanoscale physics and materials; molecular beam epitaxy.