Materials Science and Technology Division
Materials Theory Group

"Search for Majorana Fermions in p-Type Semiconductor Thin Films and Nanowires"

Prof. Chuanwei Zhang
Washington State University

Monday, May 23, 2011
11:00 a.m.
4515/HTML, Room 265

Abstract

Majorana fermions were envisioned by E. Majorana in 1935 to describe neutrinos. Majorana fermions are intriguing because they can be construed as their own anti-particles and follow non-Abelian anyonic statistics under a pair-wise exchange of the many-particle wave function, unlike Dirac fermions where electrons and positrons (holes) are distinct. Although the emergence of Majorana fermions in solid state systems is by itself an extraordinary phenomenon, they have also come under a great deal of recent attention due to their potential use in fault tolerant quantum computation. So far most candidate systems for Majorana fermions suffer from one important problem: the required experimental parameters are beyond the capacity of current experiments. In this talk, I will show that a p-type semiconductor nanowire or thin film, under certain external conditions, can support Majorana excitations in a regime of parameters already within experimental reach in routine experiments. A hole-doped nanowire or thin film, with its fundamentally different underlying physics from its electron-doped counterpart, also leads to many other topical advantages for realizing a topologically non-trivial state. Thus, these two systems are uniquely suited among all solid state systems for realizing and manipulating Majorana fermions in controllable experiments.

Reference:

[1] L. Mao, J. Shi, Q. Niu, C. Zhang, Superconducting phase with a chiral *f*-wave pairing symmetry and Majorana fermions induced in a hole-doped semiconductor, Phys. Rev. Lett. 106, 157003 (2001). Editors' Suggestions.

[2] L. Mao, M. Gong, E. Dumitrescu, S. Tewari, and C. Zhang, Hole-doped semiconductor nanowire: A new and experimentally accessible system for Majorana fermions, submitted for publication

[3] L. Mao, C. Zhang, Robustness of Majorana Modes and Minigaps in a Spin-Orbit-Coupled Semiconductor-Superconductor Heterostructure, Phys. Rev. B 82, 174506 (2010).

[4] C. Zhang, S. Tewari, R. Lutchyn, S. Das Sarma, p_{x}+ip_{y} superfluid from s-wave interactions of fermionic cold atoms, Phys. Rev. Lett. 101, 160401 (2008).

Host: Di Xiao (576-0301, xiaod@ornl.gov)