清华大学高等研究院
Institute for Advanced Study, Tsinghua University
物理学术报告
Physics Seminars (biweekly)

Title: Topological states of matter in correlated electron systems

Speaker: Prof. Qiang-Hua Wang

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Time: 3:15pm, Wednesday, Dec. 5, 2012
(2:45~3:15pm, Tea, Coffee, and Cookie)

Venue: Conference Hall 322, Science Building, Tsinghua University

Abstract: Topological states of matter are protected by the nontrivial topology of the hamiltonian. States of different topologies are bridged either by gapless edge states in real space, or a quantum phase transition in the parameter space with gapless excitations at the transition point. The nontrivial topology is either an inheritage of the bare band structure (as in topological insulators), or generated spontaneously by the strong correlations between the electrons. On the latter we will focus in this talk. We consider both time-reversal-symmetry breaking (T-breaking) and invariant (T-invariant) states. 1) Since the spontaneous phase is a low energy phenomenon but the effective interaction follows from renormalization by virtual excitations at higher energy scales, we discuss briefly an efficient functional renormalization group method to treat the hierarchy of energy scales and treat the variable phases on equal footing. 2) We show that a doped graphene (near the van Hove filling) is a candidate for TRS breaking states, such as chiral-SDW and chiral d+id' superconducting states. The former leads to quantized anomalous Hall effect, while the latter to quantized thermal Hall conductivity. We show that similar situations occur in Kagome lattices at van Hove filling. Furthermore, with geometrical frustration richer phases appear in Kagome lattices.   3) We show that proximity to van Hove singularity, as well as small-q inter-pocket scattering are efficient mechanisms for ferromagnetic-like spin fluctuations. This leads to degenerate p-wave pairing channels. The degeneracy is easily broken by even a weak spin-orbital coupling, leading to a T-invariant topological superconducting phase. Bandstructure-wise, the normal state must have 2*(2n+1) spin-split fermi pockets (encircling T-invariant momenta) in order to have a strong T-invariant topological superconductor. The edge states of such a superconductor are Majorana fermions. Perspectives on promising materials are discussed.

王强华，1993 年于南京大学获博士学位,后在南京大学物理系任教，历任讲师、副教授、教授，期间在香港大学和加州大学伯克利分校做访问研究，其在高温超导及一些其他强关联体系的研究方面做了重要的贡献。目前研究兴趣：高温超导体及有关强关联电子系统的理论研究，新超导材料的超导机理和物理性质的理论研究，拓扑绝缘体与拓扑超导体的理论研究，量子信息与量子计算的理论研究。