Title: Topological states of matter in correlated electron systems

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(2:45~3:15pm, Tea, Coffee, and Cookie)

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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 inheritance 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.