Chez Pierre

Presents ...

**Tuesday, May 3, 2016**
**2:00pm**
**MIT Room 4-331**

# Special Chez Pierre Seminar

## M. Zahid Hasan

Princeton University

## " Discovery of Lorentz-invariant and Lorentz-violating emergent Weyl fermions in topological materials"

Topological materials can host Dirac, Majorana and Weyl fermions as quasiparticle modes on their boundaries or bulk. First, I briefly mention the basic theoretical concepts defining insulators and superconductors where topological fermion modes are robust only in the presence of a gap (Hasan & Kane, Rev. of Mod. Phys. 82, 3045 (2010)). A Weyl semimetal is the rare exception in this scheme which is a topologically robust conductor (semimetal) whose emergent bulk excitations are Weyl fermions. In a Weyl semimetal, the chiralities associated with the Weyl nodes can be understood as topological charges, leading to split monopoles and anti-monopoles of Berry curvature in momentum space. Due to this topology it is expected to exhibit Fermi arc quasiparticles on its surface (Wan et.al., 2011). These arcs are discontinuous or disjoint segments of a two dimensional Fermi contour with non-trivial spin textures, which are terminated onto the projections of the Weyl nodes on the surface observed recently in experiments. Our theoretical predictions (Huang, Xu et.al., Nature Commun. 2015) and several experimental demonstrations (Xu, Belopolski et.al., Science 349, 613 (2015), Nature Physics 2015, Science Advances 2015) reveal that these arc quasiparticles can only live on the boundary of a 3D crystal which collectively represents the realization of a new state of quantum matter beyond our earlier work on spin-textured Fermi arcs in topological metals (Xu, Liu et.al, Science 347, 294 (2014)). Strong spin-orbit interaction and crystalline symmetries in these systems can also lead to a strong tilt of the Weyl cone which manifestly break Lorentz invariance. We present our theoretical predictions and experimental discovery that the LaAlGe materials family host such a state of matter. Finally, we present theoretical and experimental results on a related state of matter, a topological nodal-line semimetal state in (Pb/Tl)TaSe2 (which also superconducts at low temperatures) where the Fermi surface is a protected nodal-line loop (Bian, Alidoust et,al., Nature Commun. 7:10556 (2016)) possibly suggesting a new platform to investigate the interplay of superconductivity and non-trivial topology.