Geometry of Quantum states in Condensed Matter Systems workshop Talk Schedule

Events for:
Monday, April 18th - Friday, April 22nd

Monday, April 18th

10:10am **Barry Bradlyn - SCGP 102**

Title: New frontiers for topological semimetals

Abstract: "Following their insulating counterparts, topological semi-metals have attracted much theoretical and experimental interest. Weyl and Dirac semimetals have recently been theoretically predicted and experimentally observed; both display topologically protected Fermi-arc surface states, as well as large negative magnetoresistance due to the ``chiral anomaly''. In this talk, I will discuss two new avenues for finding topological phenomena in gapless materials. First, I will discuss how an external magnetic field can be used to create a Weyl semimetal from a topologically trivial material, and I will show how this lends insight into recent experiments on the half-Heusler GdPtBi. Second, I will go beyond Weyl and Dirac fermions to discuss how non-symmorphic crystal symmetries can stabilize topological band degeneracies in spin-orbit coupled materials. Some notable consequences of these degeneracies are the presence of Fermi arcs in non-Weyl systems, the fermionic spin-1 generalization of a Weyl fermion, and the existence of Dirac lines. I will pay particular attention to experimentally realizable material candidates.

10:50am **Coffee**

11:20am **Michael Stone - SCGP 102**

Title: Effective Actions for Superconducting Chiral Fermions

Abstract: Motivated by a a recent paper of Qi, Zhang and Witten, I will derive the effective action for a a system of supernconducting chiral fermions and use the result to resolve two potential paradoxes. The talk is based on joint work with Pedo Lopes.

12:00pm **Lunch - SCGP 102**

1:30pm **Sergej Moroz - SCGP 102**

Title: Topological order, symmetry and Hall response of two-dimensional superconductors

2:10pm **Dmitri Kharzeev - SCGP 102**

Title: Anomalies, knots and currents

Abstract: Chiral anomaly gives rise to currents linked to the topology of the gauge field. This has a dramatic effect on the evolution of magnetic helicity in systems that contain charged chiral fermions. In particular, chiral anomaly induces a self-similar inverse cascade of magnetic helicity. Topology-changing reconnections of magnetic flux give rise to the chiral magnetic effect.

2:50pm **Jonathan Simon - SCGP 102**

Title: Topological Photonics with Twisted Resonators

Abstract: I will present recent work realizing photonic Landau levels on a cone. I will first connect the physical picture of photons repeatedly traversing a multi-mirror optical resonator to a Floquet model, and discuss the single-particle dynamics accessible under such conditions: arbitrary quadratic Hamiltonians including a synthetic gauge field for the photons. I will then focus on the case of a trapped photon in a magnetic field, and discuss the approach to the LLL configuration in both planar and conical geometries; the latter is reached by explicitly exploiting the Floquet driving. We explore the cone experimentally, measuring the LDOS in the LLL and validating the Wen-Zee formalism on flux-threaded and unthreaded cones. Near term prospects include demonstration of a Thouless pump, bosonic fractional quantum Hall states via atom-induced photon-photon interactions, and generation of more exotic single-particle dynamics via aberrations of the mirrors.

3:30pm **Tea Time**

Tuesday, April 19th

9:30am **Andrey Gromov - SCGP 102**

Title: Geometric Defects in Quantum Hall states

10:10am **Coffee**

10:50am **Andrea Cappelli - SCGP 102**

Title: Multipole expansion in the quantum Hall effect

Abstract: The effective action for low-energy excitations of Laughlin's state is obtained by systematic expansion in inverse powers of the magnetic field. It is based on the W-infinity symmetry of quantum incompressible fluids and the associated fields of increasing spin. Besides reproducing the Wen and Wen-Zee actions and the Hall viscosity, this approach indicates that the low-energy excitations are extended objects with dipolar and multipolar moments

11:30am **Lunch**

1:00pm **SCGP Weekly Talk: Shinsei Ryu "Bulk/boundary correspondence in (3+1)d topological phases" - SCGP 102**

Speaker: Shinsei Ryu

Title: Bulk/boundary correspondence in (3+1)d topological phases

Abstract: Many of interesting physical (in particular topological) properties of topological phases and symmetry protected topological phases can be "inferred" from their boundary (end, edge, surface, ..) field theories. In particular, the presence of quantum anomalies in boundary field theories (or lack thereof) gives a way to diagnose bulk topological properties. I will discuss such bulk/boundary correspondence in various examples in 3 spatial dimensions.

2:30pm **Semyon Klevtsov - SCGP 102**

Title: Geometry and Large N limits in Laughlin states

Abstract: We consider integer QHE states and Laughlin states on Riemann surfaces with arbitrary metric and complex structure. We derive generating functional for the density of states and compute transport coefficients for the adiabatic transport on the moduli space, in the limit of large number of particles. In addition to Hall conductance and anomalous Hall viscosity, a novel coefficient transpires on moduli spaces of surfaces of genus 2 and higher, due to the gravitational anomaly. We also show that the adiabatic phase acquired by the (integer QHE) wave function under the adiabatic transport, is given by the gauge and gravitational Chern-Simons functional. Finally, we discuss recent results for singular (conical) Riemann surfaces, where the gravitational anomaly effects transpire most prominently.

3:10pm **Dimitra Karabali - SCGP 102**

Title: Quantum Hall effect in higher dimensions: Formulation and droplet dynamics

Abstract: We present the formulation of quantum Hall effect in higher dimensional spaces, such as CP^k. The boundary effective action for the corresponding quantum Hall droplets is shown to be a Wess-Zumino-Witten theory, generalized to higher dimensions. In the presence of gauge interactions the bulk effective action is given by a Chern-Simons type term whose anomaly is cancelled by a contribution from the boundary gauged Wess-Zumino-Witten action.

3:50pm **Tea**

4:20pm **Parameswaran Nair - SCGP 102**

Title: Quantum Hall effect in higher dimensions: Towards an effective action for all dimensions

Abstract: We outline the construction of the topological terms in a bulk effective action for Hall effect for all dimensions using the appropriate index theorems.

Wednesday, April 20th

10:10am **Dam Thanh Son - SCGP 102**

Title: Particle-hole symmetry and the nature of the composite fermion

Abstract: I will describe the new picture of the half-filled Landau level, according to which the composite fermion is a massless Dirac fermion in the limit of vanishing Landau-level mixing. Such a fermion is characterized by a Berry phase of pi around the Fermi disk. Physical consequences of the new picture are outlined.

10:50am **Coffee**

11:20am **Matthew M Roberts - SCGP 102**

Title: A Higher-Spin Theory of the Magneto-Rotors

Abstract: We propose a theory of the magneto- rotons on the quantum Hall plateaux near half filling, namely, at filling fractions \nu = N/(2N + 1) at large N. The theory involves an infinite number of bosonic fields arising from bosonizing the fluctuations of the shape of the composite Fermi surface. The mixing of modes at nonzero momentum q leads to the characteristic bending down of the lowest excitation and the appearance of the magneto-roton minima. A purely algebraic argument show that the magneto- roton minima are located at qL = zi/(2N + 1), where L is the magnetic length and zi are the zeros of the Bessel function J1, independent of the microscopic details. We argue that these minima are universal features of any two-dimensional Fermi surface coupled to a gauge field in a small background magnetic field.

12:00pm **Lunch**

1:30pm **Maissam Barkeshli - SCGP 102**

Title: Physically realizing modular transformations in topologically ordered phases of matter

Abstract: Topologically ordered phases of matter are well-known to give rise to a topologically protected degenerate set of ground states when the spatial manifold has non-trivial topology. The ground state subspace forms a unitary representation of the mapping class group of the space. In this talk, I will show how to realize elements of the mapping class group through a sequence of topological charge projections. I will further discuss how the topological charge projections can be realized by adiabatically tuning microscopic parameters of the system along various paths in the space. Finally I will discuss potential experimental realizations using bilayer fractional quantum Hall states, where topologically non-trivial spaces can be effectively realized by controlling tunneling terms along various disconnected boundaries of the system.

2:10pm **Duncan Haldane - SCGP 102**

Title: A model state for the filling = 1/m composite-fermion Fermi liquid states in a partially-occupied Landau level with periodic boundary conditions.

Abstract: A periodic boundary condition (the torus) is the geometry of choice for explicitly representing a filled Fermi sea with a Fermi surface. Using a reformulation of the states of the quantum geometry of 2D Landau-orbit guiding-centers on the quantum plane in terms of a modular-invariant modified Weierstrass sigma function, I will describe a simple model state for the compressible composite-fermion Fermi-liquid of neutral dipolar composite fermions which appears to be essentially particle-hole symmetric at filling = 1/2. The Fermi sea is centered at the inversion-symmetric state of the cf, and does not exhibit any Dirac-type singular structure.

2:50pm **Loganayagam Ramalingam - SCGP 102**

Title: Topological sigma models and fluid dynamics

3:30pm **Tea**

4:00pm **Yu Hung Chiu - SCGP 102**

Title: Transport properties of Quantum Hall States on Singular surfaces

Abstract: We study quantum Hall states on surfaces with conical singularities. We show that at the cone tip, the electronic fluid gyrates with an intrinsic angular momentum which exist solely due to gravitational anomaly. We show that the quantum Hall state behaves as conformal primaries near the singularity points, with a conformal dimension equal to the angular momentum. We argue that the gravitational anomaly and the conformal dimension determine the fine structure of electronic fluid density at the tip. We show the charge, spin and exchange statistic of the emergent quasiparticle

4:40pm **Vincenzo Vitelli - SCGP 102**

Title: Mechanical topological insulators: from metamaterials to active liquids

Abstract: The effect of constraints on a many-body system is a subject as deeply rooted in mechanical and robotic control theory as in modern theoretical physics. In this talk, I discuss how networks of springs or rigid bars connected by joints mimic electronic topological insulators with zero-energy edge and bulk modes. In some cases, solitons arise from the same constraint equations that, upon linearisation, predict topological edge modes. Non-linear field theories with a topological boundary term capture these zero modes coupled to domain walls or dislocations. Our real space approach goes beyond topological band theory and provides concrete guidelines to design metamaterials that break or fold in controlled ways. Finally, I discuss how to build classical Chern insulators using active liquids that flow spontaneously without external drive. The active flow generates a synthetic gauge field that breaks time-reversal symmetry. As a result, unidirectional acoustic waveguides emerge at sample edges and domain walls. These topological sound waves, immune to disorder, can propagate past obstacles without back-scattering.

5:30pm **Workshop Banquet**

Thursday, April 21st

10:10am **Xie Chen - SCGP 102**

Title: Loop Condensation in Three Dimensional Twisted Gauge Theories

Abstract: Recent discoveries of novel 3D gapped topological phases raises the question of how to drive phase transitions between them. For 2D topological phases, phase transition can be driven by the condensation of bosonic anyons. In 3D, besides point like anyons, topological excitations also come in the form of loops whose condensation can also lead to phase transition. What is the counterpart of the ‘bosonic’ condition on the loops so that they can be condensed? This question becomes especially interesting in the context of twisted gauge theories, where loops can have nontrivial braiding statistics among themselves. I will address this issue in this talk. We find that, when the loop braiding statistics is nontrivial, the condensation of loops must be accompanied by the condensation of some quasi-particles to result in a gapped trivial phase. We enumerate all possible particle / loop condensation possibilities to drive such transitions. Moreover, just like in the 2D case, a correspondence exist between bulk condensation and gapped boundary conditions of topological phases. We investigate the dependence of ground state degeneracy on the boundary condition which provides a way to distinguish different gauge theories.

10:50am **Coffee**

11:20am **Ryan Thorngren - SCGP 102**

Title: Higher symmetries of abelian Chern-Simons theories

Abstract: I will discuss the BZ/k symmetry of U(1) level k Chern-Simons theory, its anomaly, and fractional Chern-Simons theories as gauged versions. I will mention how this bag of tricks can be used to understand the Halperin-Lee-Read state at filling fraction 1/2.

12:00pm **Lunch**

1:30pm **Alexios Polychronakos - SCGP 102**

Title: Dual formulation and solitons of generalized Calogero models

2:10pm **Stephane Ouvry - SCGP 102**

Title: Area distribution of two-dimensional random walks and non Hermitian Hofstadter quantum mechanics

Abstract: When random walks on a square lattice are biased horizontally to move solely to the right, the probability distribution of their algebraic area can be exactly obtained. We map this biased classical random system on a non-Hermitian Hofstadter-like quantum model where a charged particle on a square lattice coupled to a perpendicular magnetic field hopps only to the right. In the commensurate case when the magnetic flux per unit cell is rational, an exact solution of the quantum model is obtained. Periodicity on the lattice allows to relate traces of the Nth power of the Hamiltonian to probability distribution generating functions of biased walks of length N.

2:50pm **Gustavo Monteiro - SCGP 102**

Title: Magnetotransport in Weyl and Dirac Metals

Abstract: Dirac (Weyl) metals are characterized by the linear dispersion of electron quasiparticles, with the Dirac (Weyl) point hidden inside a Fermi surface. In this talk, I will refer to the so-called chiral kinetic theory to describe within the same framework both the negative magnetoresistance caused by the chiral magnetic effect (CME) and quantum oscillations in the magnetoresistance (SdH effect) due to the existence of the Fermi surface in these materials. I will also discuss the relevance of obtained results to recent measurements on TaP and Cd_3As_2.

3:30pm **Tea**

Friday, April 22nd

10:10am **Emil V Prodan - SCGP 102**

Title: Index Theorems for Weak Invariants

Abstract: The algebras of physical observables are usually represented on Hilbert spaces, which are linear spaces over the field of complex numbers endowed with a scalar product. But they can be also represented on Hilbert modules where the field of complex numbers is replaced by a generic algebra and this is at the heart of Kasparov's KK-theory. Paralleling the index theorems for the strong invariants derived within the ordinary K-theory [1], we show how generalized index theorems can be obtain for the weak invariants within Kasparov's KK-theory. The implications for the regime of strong disorder will be discussed.

10:50am **Coffee**

11:20am **Sriram Ganeshan - SCGP 102**

Title: Anomalous spectral flow at the edge of photonic quantum Hall effect

12:00pm **Lunch**

3:30pm **Tea**