Physics Colloquium

Ryan Mishmash

“Uncovering and exploiting emergent phenomena in quantum matter: From fermionic spinons to Majorana fermions”

Emergence is a ubiquitous feature of quantum condensed matter systems: the collective low-energy behavior of an interacting quantum many-body system oftentimes exhibits behavior profoundly different from that of the constituent degrees of freedom. In this talk, I will present a survey of recent results on one- and two-dimensional quantum systems which dramatically demonstrate this concept. In the first part of the talk, I will focus on a set of problems in which we are able to *uncover* — through both computational and analytical lines of attack — novel and striking emergent behavior in two paradigmatic many-body systems: a quantum antiferromagnet on the kagome lattice and a 2D electron gas in a strong perpendicular magnetic field at filling factor nu=1/2 (i.e., the half-filled Landau level). In the second part of the talk, I will switch gears and discuss how we can *exploit* such emergence for technological gain. In particular, I will discuss how Majorana fermions can emerge as zero-energy features of certain superconducting wires and how these “Majorana zero modes” can in principle be used to build superior quantum computing hardware: In this so-called topological approach to quantum computation, Majorana-based qubits remarkably allow perfect insensitivity to local noise as well as implementation of perfect quantum gates. Focusing on the former property, I will discuss our recent proposals for verifying topological (“perfect”) protection of quantum information in present-day devices being pursued vigorously by experimental groups at Microsoft and elsewhere. I will conclude with an outlook on this ambitious goal of topological quantum computation and comment on where the field stands at present day.

Ryan Mishmash *is currently a Postdoctoral Researcher at Princeton University. From 2014 to 2017, he was a DuBridge Postdoctoral Scholar in Theoretical Physics at Caltech. In 2014, he received his PhD in Physics from UC Santa Barbara under the guidance of Matthew P.A. Fisher. Ryan is a quantum condensed matter theorist who applies both computational and analytical techniques to research problems which revolve around understanding exotic quantum phenomena relevant to present-day experiments on a variety of physical systems; examples range from strongly correlated electrons, quantum spin liquids, and topological phases of matter to pursuits of building a topological quantum computer.*

Physics Faculty and Search Committee Candidate

Thursday February 8th in LL 316 at 4:10

Refreshments available at 3:45