



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: Phase transitions, quantum critical behavior and emergent symmetries of interacting Dirac materials

Speaker: Michael Scherer (*Universität zu Köln*)

Time: 4:00pm, Tuesday, April 10, 2018
(3:30~4:00pm, Tea and Coffee)

Venue: Conference Hall 322, Science Building, Tsinghua University

Abstract

Fermions on honeycomb lattice geometries with Coulomb interactions as well as zero or finite doping can host a large variety correlated states including Mott insulators as well as unconventional superconductivity. The determination of the corresponding many-body phase diagram is a formidable task and in my talk, I will present a series of recent results on aspects of this phase diagram based on renormalization group approaches. First, I will discuss a study of the quantum many-body ground states of electrons on the half-filled honeycomb lattice with short- and long-ranged interactions as a model for graphene. To this end, we employed a specific functional renormalization group approach which allows for a high resolution of the interaction vertex' wave vector dependence. We connect to previous lattice quantum Monte Carlo (QMC) results which predict a stabilization of the semimetallic phase for realistic *ab initio* interaction parameters and confirm that the application of a finite biaxial strain can induce a quantum phase transition towards an ordered ground state. I also comment on the effects of doping and the concomitant pairing instabilities. In the second part of my talk, I focus on effective models for the Dirac fermions which emerge as quasi-particle excitations on the honeycomb lattice and many other condensed-matter systems. Here, I discuss the quantum transitions which represent unconventional universality classes related to the variants of the Gross-Neveu model. In particular, I present a perturbative renormalization group study at four-loop order. We applied the computed series for the critical exponents and their Padé approximants to several phase transitions of current interest: metal-insulator transitions of spin-1/2 and spinless fermions on the honeycomb lattice, emergent supersymmetric surface field theory in topological phases, as well as the disorder-induced quantum transition in Weyl semimetals. Comparison with the results of other analytical and numerical methods is discussed. Depending on time, I will also discuss functional RG results for the fermion-induced quantum critical points, which were pioneered in Yao's group and emergent symmetries of compatible order parameters in Dirac systems.