Announcing the Final Examination of Michael Lodge for the degree of Doctor of Philosophy in Physics

Date: April 5, 2018
Time: 9:30 a.m.
Room: PSB 445
Dissertation title: Experimental evidence of ballistic nanofriction and scattering in Dirac materials with pseudospin degree of freedom

Abstract:
Friction phenomena and electron scattering reduce the efficiency of mechanical devices and performance of electronic devices, respectively. The ubiquity of interfacing surfaces and electronic devices mean that even incremental improvements to device performance, realized by better understanding impacting phenomena, can lead to huge economics gains. The empirical friction parameter "μ" is the manifestation of the statistical interaction between the ensemble of contacting asperities at the interface of two surfaces. The nature of μ can be understood by investigating friction phenomena on the size scale of a single asperity, which can have many velocity-dependent contributions. The isolation of any one contribution for study can be challenging, as other forces may dominate at the velocity range of interest and the contact geometry can be impossible to determine. Here, I measure high-speed, viscous friction for a clean, nanoscopic system having a well-defined contact geometry using a novel quartz crystal microbalance technique. Our experimental apparatus can access sliding speeds on the order of 10 cm/s, which is two orders of magnitude higher than conventional high-speed nano-friction measurement systems. Using this system, I evidence the existence of a predicted ultra-low friction regime for a crystalline system having high sliding speed and low shear stress. Pursuant to the realization of a material system that is robust against detrimental electron scattering, I investigate energy-dependent quasiparticle scattering from an atomic defect in ZrSiS. This material is predicted to be a 3D line node semimetal, with linear band dispersion along high-symmetry directions. The Dirac nature of this material is expected to protect electrons from certain scattering process due to the existence of an "effective" spin, or "pseudospin." I experimentally confirm the Dirac dispersion for this material for energies above the Fermi level. I also show that certain scatterers in the material can cause breakdown of the pseudospin protection.

Outline of Studies:
Major: Physics

Educational Career:
B. S. University of Central Florida, 2010

Committee in Charge:
Dr. Masahiro Ishigami (Chair)
Dr. William Kaden
Dr. Patrick Schelling
Dr. Enrique del Barco
Dr. Tania Roy (External Committee Member)

Approved for distribution by Dr. Masahiro Ishigami, Committee Chair, on March 30, 2018.

The public is welcome to attend.