"Modern semiclassical theory of magnetic quantum oscillations and Landau-level degeneracies"

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**Abstract:** The modern semiclassical theory of a Bloch electron in a magnetic field now encompasses the orbital magnetic moment and the geometric phase. These two notions are encoded in the Onsager-Lifshitz quantization rule as a phase ($\lambda$) that is subleading in powers of the field; $\lambda$ is measurable in the phase offset of the de-Haas-van-Alphen oscillation, as well as of fixed-bias oscillations of the differential conductance in tunneling spectroscopy. In some solids and for certain field orientations, $\lambda/\pi$ are robustly integer-valued owing to the symmetry of the extremal orbit, i.e., they are the topological invariants of magnetotransport. Our comprehensive symmetry analysis identifies solids in any (magnetic) space group for which $\lambda$ is a topological invariant, as well as identifies the symmetry-enforced degeneracy of Landau levels. The analysis is simplified by our formulation of ten (and only ten) symmetry classes for closed, Fermi-surface orbits. In the absence of crystalline point-group symmetries, three tunable real parameters are needed to attain a spin-degeneracy between two Landau levels; we have exhaustively identified all symmetry classes of orbits for which this number is reduced from three. In particular, only one parameter is needed for rotational-symmetric orbits; this parameter may be the magnitude or orientation of the field, or the bias voltage in tunneling spectroscopy.

Case studies are discussed for 3D Weyl and Dirac metals, crystalline and $\mathbb{Z}_2$ topological insulators, and the Rashba 2DEG subject to an arbitrarily-oriented magnetic field.

**12:00pm noon**
**Friday, October 5, 2018**
**Duboc Room (4-331)**

Host: Liang Fu