Course Syllabus, 7364 Advanced Solid State, Spring 2017

This course will follow the approach taken in texts such as Ashcroft and Mermin, Kittel, Ibach and Luth, etc. to solid state physics. I will also use materials from http://www.phys.lsu.edu/~ . It will complement the course taught by Prof. Jin, 7363, but will be more quantitative.

The course will be run and graded as a post-qualifier course, with the grades based on 5 or 6 common homework problems that you will be encouraged to work on together and present as a team in class or hand in as a group (i.e., only one presentation or hand in) that count towards 80% of the grade. The final 20% will be from class participation.

The subjects to be covered were determined from polling your advisers and discussions in the first class. They include (in no particular order right now)

- Crystal Lattice Dynamics and the Quantum Theory of Neutron Scattering.
    - Lattice vibrations
    - Second quantization
    - Theory of inelastic neutron scattering.
- Thermal properties of lattice vibrations
    - Basics
    - Models of lattice dispersion
    - Thermodynamics of Crystal Lattices
- Fermi liquid theory
    - Review of the free Fermi gas
    - Weakly interacting Fermi liquid
    - Landau Fermi liquid theory of interacting electrons.
- DFT and band structure
    - Block's theorem
    - Nearly free and nearly bound electron pictures.
    - Basic ideas and theorems
    - Using Wannier 90 or Wein2k to solve real problems
- Magnetism
    - Magnetic exchanges including RKKY, SuperExchange, Double Exchange, exchange hole...
    - Mean field theory and Stoner magetism
    - Ginzburg Landau
    - "Mean field" theories for fluctuations
        - Holstein Primakoff
        - Schwinger bosons
- Criticality
    - Broken symmetry, level repulsion, and exponents
    - Fisher Scaling

- (optional) basic ideas of RG

- Transport, Disorder and Defects
  - Role of defects in metals, semiconductors, and superconductors
  - Boltzmann equation
  - Onsager coefficients and their relation to resistivity, thermopower, etc.
  - Wiedemann-Franz Law
  - Anderson and Mott localization
  - Spin Orbit Rashba-Dresselhaus effect
- Unconventional superconductivity
  - Quantitative review of London equations, Copper pairing, and BCS theory
  - Messner Effect
  - Quantization of flux
  - Tunnel junctions
  - Superconductivity from complex (non-phonon mediated) interactions and with momentum dependent order parameters.
  - Bogoliubov transformation
  - Bogoliubov DeGennes