Solid State Physics 601 Fall 2018

with Jak Chakhalian

Grading: Homeworks (30%), mid-term (30%), final (40%). Final grade is determined by averaging over all the components.

Office hours: Monday 9:30-10:30 am, room 109 Physics & Astronomy

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Topics (tentatively) to be covered:

1. Ginzburg Landau theory of **phase transitions**
    a. 2d order phase transitions
    b. 1^{st} order phase transitions
    c. Inhomogeneous cases
    d. Quantum phase transitions
2. Generalization of order parameter and Goldstone theorem
3. Brocken symmetry from field theory point of view (OPTIONAL)

4. What are **quasiparticles** and **excitations**?
5. Main characteristics of QPs.

6. Ground state of a crystal. Zero energy oscillations.
7. Methods for description of thermal oscillations. **Phonons** in 1D and 2D
    a. Standing waves
    b. Running waves
    c. Dispersion
    d. Acoustic waves with nn interactions
    e. Acoustic waves with nnn interactions

8. Acoustic phonons in 3D
9. Energy spectrum of acoustic phonons
10. Spectral density of acoustic phonons
11. Van Hove singularity in 3D and 2D
12. Optical phonons
    a. Dispersion of optical phonons
    b. Optical phonons in 3D
    c. Spectral density of optical phonons
13. Interaction of phonons (OPTIONAL)
    a. Anharmonic effects
14. Phonon-phonon scattering (OPTIONAL)
15. Heat capacity – Debye theory
16. Heat capacity in 2D

17. Thermal conductivity
18. Surface phonons (OPTIONAL)

19. **Fermi liquid theory**
    a. Non-interacting electrons
    b. Fermi energy and momentum
    c. How to describe excitations
    d. A model of fermi liquid
20. Quasiparticles on the hole like Fermi surface
21. Lifetime of quasiparticles
22. Electrons in a periodic potential
23. Bloch theorem
    a. Fermi momentum
24. Brillouin zones
    a. 2D and 3D
    b. Examples
25. Fermi surface
26. How to build Fermi surface?
27. Examples of standard Fermi surfaces.
28. Fermi surface and extended Br. zones.
29. Topology of fermi surface
30. Singularities of Fermi surface
31. Dynamics of quasiparticles
32. Effective mass
33. Quasiparticle scattering.
34. Electrical conductivity
35. Electronic contribution to thermal conductivity.
36. Electrons in a constant magnetic field
37. Energy spectrum of quasiparticles in magnetic field for the case of ideal fermi gas
38. Landau quantization
39. Density of electrons in magnetic field

40. Quantum Hall effect
41. Berry phase and Berry connection
42. Chern **topological insulator**

Other issues:

I will use several texts including journal papers, other people lecture notes, my personal notes etc. to make the topics are clear as possible. All the class notes and extra material will be posted ion our web site: http://physics.rutgers.edu/~chakhalian/CM2018/

Having said this, I expect the basic amount of knowledge you should have after my class is on the level covered in **The Oxford Solid State Basics** by Steven H. Simon.

4 other texts will be extensively used:

1. Daniel Khomskii, Basic Aspects of the Quantum Theory of Solids (superb)
2. Marvin Cohen and Steven Louie, Fundamentals of Condensed Matter Physics
3. Tom Lancaster and Stephen Blundell, Quantum field theory for the gifted amateur (superb)
4. A. Zee, Quantum field theory in nutshell.

You cannot learn how to play piano by only listening music. Practice is the only way to acquire real knowledge of the subject. Every week or every other week (depending on the topic) you will receive a problem set.

Midterm and final exams will be administered to develop confidence.

A 100% class attendance is expected, however, in a case you need to miss the class please notify me via email.

And finally, If you already know all the topics for the class, please, see me.

- We will follow the University increment weather policy.
- We will follow the University integrity and ethics policies.