Solid State Physics

PHY210

Solid State Physics

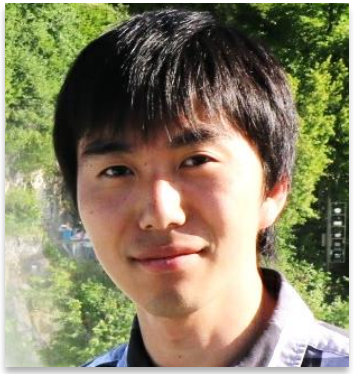
Vorlesung/ Lectures: Tuesday 13h00 – 14h45 (room Y13-L-11/13)
Fridays 08h00 – 09h45 (room Y27-H-35/36)

Marta Gibert gibert@physik.uzh.ch

Übungen/ Exercise class: Approximately Every Second Friday

Gabriele De Luca deluca@physik.uzh.ch

Masafumi Horio horio@physik.uzh.ch



Lecture material: https://www.physik.uzh.ch/en/study/lecturematerial.html

#	Date	Title
1	17.09	Introduction + First lecture
2	20.09	Lecture
3	24.09	Lecture
4	27.09	*Exercises*
5	01.10	Lecture
6	04.10	Lecture
7	08.10	1h Lecture / *1h Exercises*
8	11.10	Lecture
9	15.10	Lecture
10	18.10	*Exercises*
11	22.10	Lecture
12	25.10	Lecture
13	29.10	Lecture
14	01.11	*Exercises*
15	05.11	Lecture
16	…	…

Teaching Principle

Constructive alignment

Goals

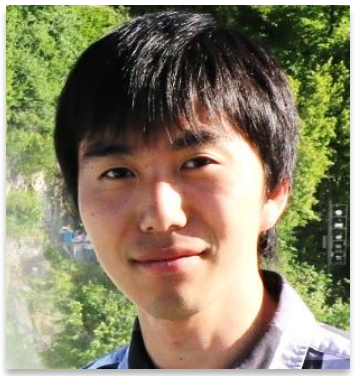
- Understanding of concepts
- General knowledge of condensed matter
- Develop problem solving skills

Exam

- Testing understanding of concepts
- Testing general knowledge
- Testing problem solving skills

Exercise class

- Hand in the exercises on their due date (once per week – typically on Friday)
- Exercise class is mandatory. Write to Gabriele or Masafumi in case of justified absence
- You need at least 60% of points to qualify for the exam
- Exam questions can be related to exercises
- Students are presenting solutions during the exercise class



Course evaluation (Exam)

Exam structure:

1) 10 min student presentation of 1 ~~one out of 8(10)~~ a pre-defined topics
2) 10 min discussion of one of the exercises
3) 10 min questions spread over the material covered during the lectures

Exam

- Testing understanding of concepts
- Testing general knowledge
- Testing problem solving skills

Exam dates: to-be-announce

(at least 60% of exercise points are needed to qualify for the exam)

Practical information

Solid State Physics course + Praktikum= 7 ETCS points

Final grade = ¾ course and ¼ Praktikum weighted average

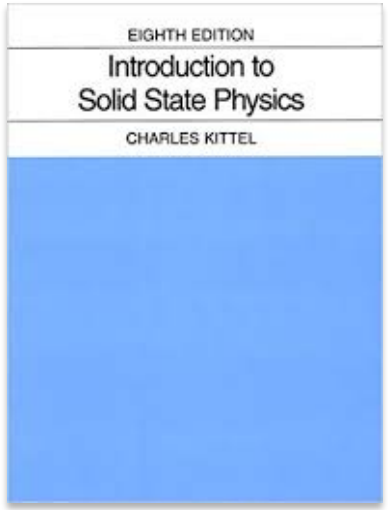
Proposed work-load distribution

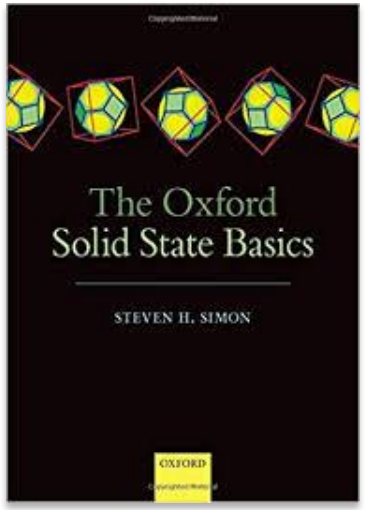
Lectures + Exercises class	Reading/Studying	Solve Exercises
4 hours	~2 hours	~2 hours

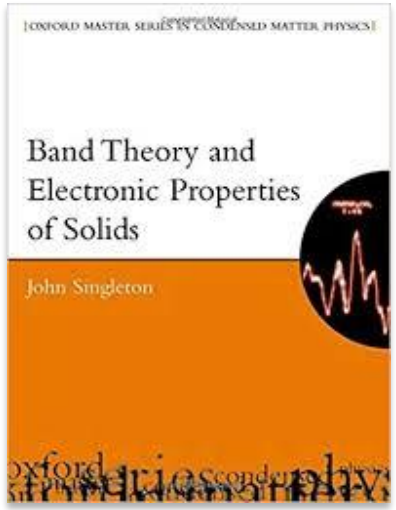
Strategy / Advice

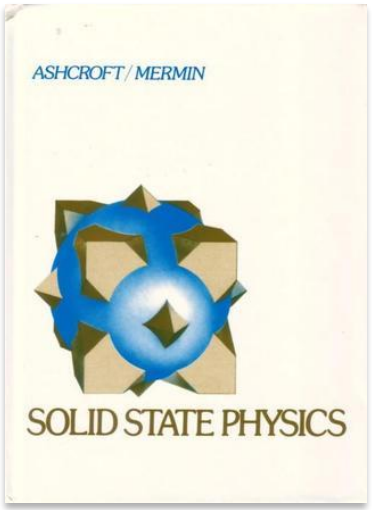
- Solve the exercises yourself
- Read and study continuously
- Be active during the lecture and exercise class

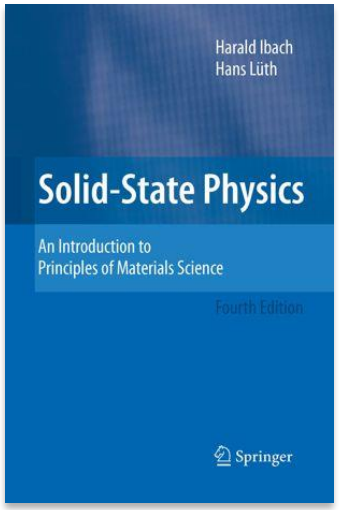
Literature

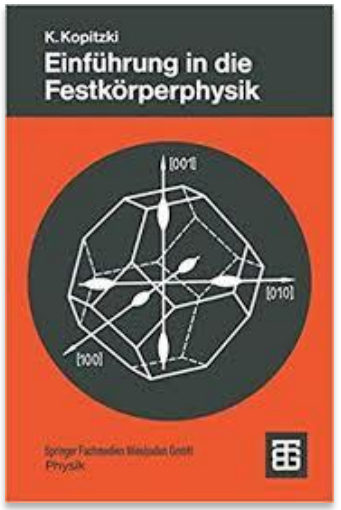

EIGHTH EDITION
Introduction to
Solid State Physics
CHARLES KITTEL

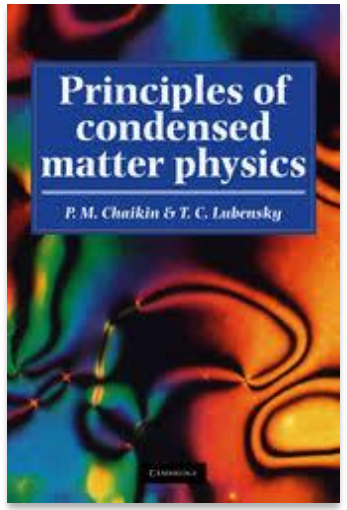

The Oxford
Solid State Basics
STEVEN H. SIMON
OXFORD


Band Theory and
Electronic Properties
of Solids
John Singleton


ASHCROFT / MERMIN
SOLID STATE PHYSICS


Harald Ibach
Hans Lüth
Solid-State Physics
An Introduction to
Principles of Materials Science
Springer


K. Kopitzki
Einführung in die
Festkörperphysik


Principles of
condensed
matter physics
P. M. Chaikin & T. C. Lubensky

Why is Solid State Physics interesting?

Why is Condensed Matter interesting?

Condensed Matter Physics

“Condensed matter physics is the field of physics that deals with the macroscopic and microscopic physical properties of matter. In particular it is concerned with the "condensed" phases that appear whenever the number of constituents in a system is extremely large and the interactions between the constituents are strong. The most familiar examples of condensed phases are solids and liquids, which arise from the electromagnetic forces between atoms.”

Many subfields: cold atoms, biophysics, solid-state physics....

APS physics

APS March Meeting 2019
Volume 64, Number 2
Monday–Friday, March 4–8, 2019; Boston, Massachusetts

All | Saturday | Sunday | Monday | Tuesday | Wednesday | Thursday | Friday

Session A

A01. Focus Correlations and Topological States
A02. Focus Dielectric & Ferroic Oxides -- Emergent Interfacial Phenomena
A03. Interactions and Dynamics in Topological Systems
A04. Focus Dirac/Weyl Semimetals -- Thin Films and Nanostructures
A05. Focus Topological Superconductivity: Majorana
A06. Focus Beyond Fermi Liquid Theory
A07. Focus Charge Order
A08. Low Carrier Density Superconductors
A09. Superconductivity: Theory General
A10. Focus Fe-based Superconductors I
A11. Focus Defects in Semiconductors -- 1D, 2D, and Layered Materials
A12. Focus Devices from 2D Materials -- Microscopy and Spectroscopy
A13. Focus 2D Materials (General) -- Transport
A14. Focus 2D Materials (Metals, Superconductors, and Correlated Materials) -- CDWs
A15. 2D Materials (Semiconductors) -- Monolayers
A16. Focus Transport in Nanostructures -- Thin Films, Heterostructures and Nanodevices
A17. Focus Matter in Extreme Environments: Energetic Materials
A18. Focus Machine Learning Material and Experimental Data I
A19. Focus Precision Many Body Physics I
A20. Focus First-principles Modeling of Excited-state Phenomena in Materials I: Many-body Perturbation Theory (Techniques and Applications)
A21. Focus Big Data in Physics
A22. Focus Building the Bridge to Exascale: Applications and Opportunities for Materials, Chemistry, and Biology I
A23. Focus Advanced Nanolithography and Machine Learning
A24. Strongly Interacting Quantum Fermi and Bose Gases
A25. Deformation, Flow and Relaxation of Melt and Glassy Polymers
A26. Superconducting Circuits: Qubit Control and Entanglement
A27. Focus Quantum Simulation of Many-Body Physics
A28. Focus AMO Quantum Information
A29. Focus Superconducting Circuits: New Qubit Technologies and Design I
A30. Focus Fracture in Soft Materials
A31. Focus Addressing Molecular Magnetic Qubits (QIS1)
A32. Focus Gas Phase Clusters - Experiment and Theory in Concert (A): Metal-oxide Clusters
A33. Focus 2D Materials and Transition Metal Chalcogenides
A35. Focus Semiconducting Quantum Computing with Donors
A36. Invited Hybrid Quantum Systems
A37. Focus Kitaev Magnetism
A38. Focus Magnetoelectric and Multiferroic Effects in Molecular Systems
A39. Focus Coherent Spins in Semiconductors
A40. Focus Electric Field and Strain Control of Magnetism
A41. Focus Spin Transport and Excitations in Antiferromagnets
A42. Focus Multi-Qubit Characterizations and Cross-talk For Superconducting Qubits
A43. Invited 2D Materials Twistronics: Correlations and Moiré Physics
A44. Invited Polariton Condensates at Room Temperature and Equilibrium
A45. Focus Photophysics and Pattern Formation in Thin Films
A46. Focus 4d/5d Transition Metal Systems -- Perovskite and Honeycomb Iridates
A47. Energy Storage: Cathodes and Supercapacitors

Why is condensed matter interesting?

1. It is the world around us

2. It is useful

3. It is antireductionistic: many concepts are needed

It is the world around us!

Why my ceramic coffee mug is good for handing hot liquids?

Why is glass transparent?

Why some materials are good electric conductors and others not?

Why a magnet sticks on my fridge?

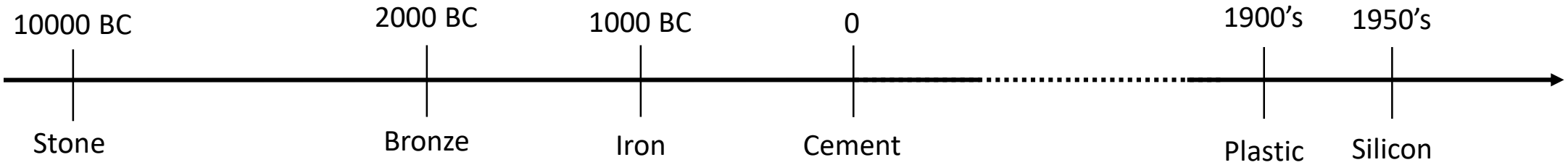
Why is condensed matter interesting?

1. It is the world around us

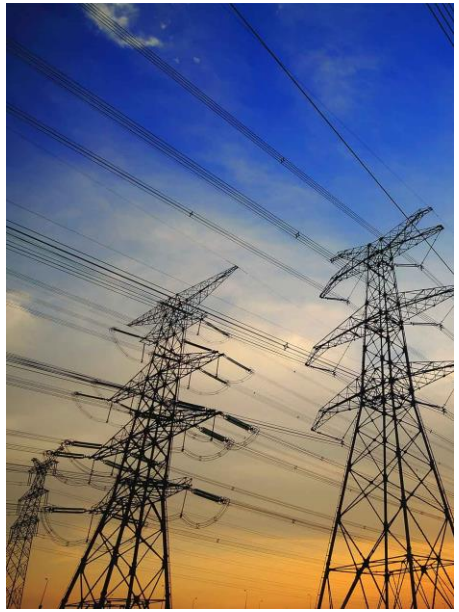
2. It is useful

3. It is antireductionistic: many concepts are needed

Historical periods



Conducting materials



Conductors

Copper

Semiconductors

Silicon

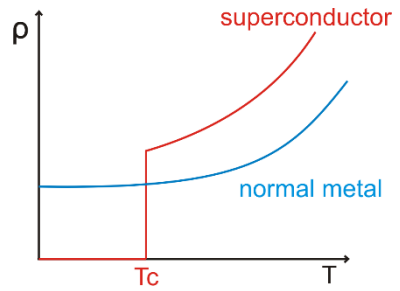
Superconductors

Nb_3Sn

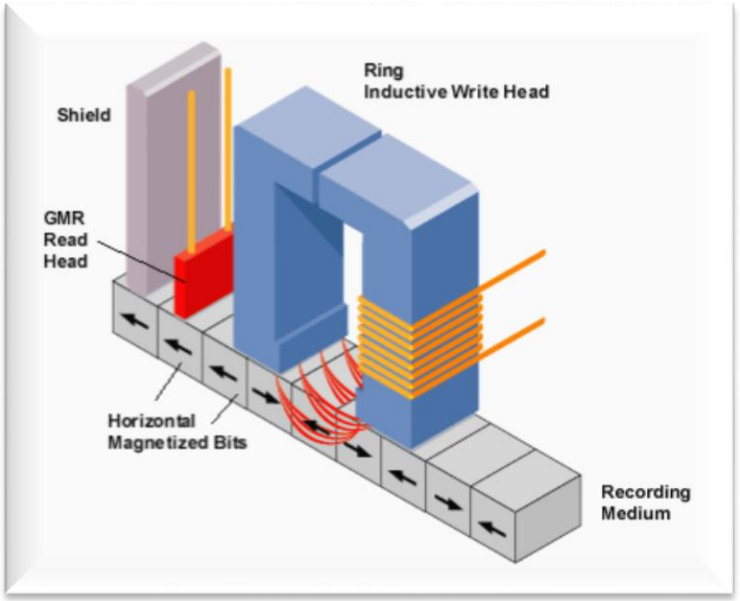
Interesting material properties

Superconductivity

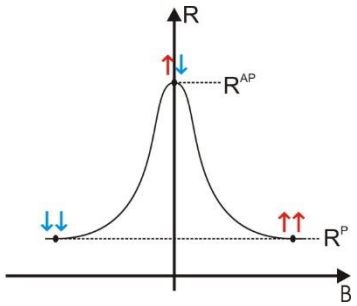
http://www.ccas-web.org/superconductivity/renewableenergy/



Magnetoresistance

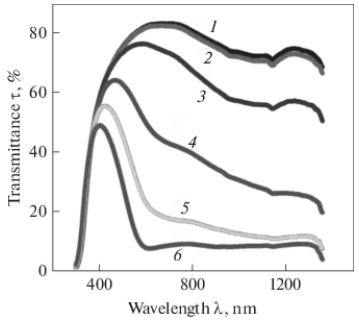


https://www.yourdictionary.com/magnetoresistance



Smart Insulators

https://phys.org/news/2012-09-intelligent-windows-future.html



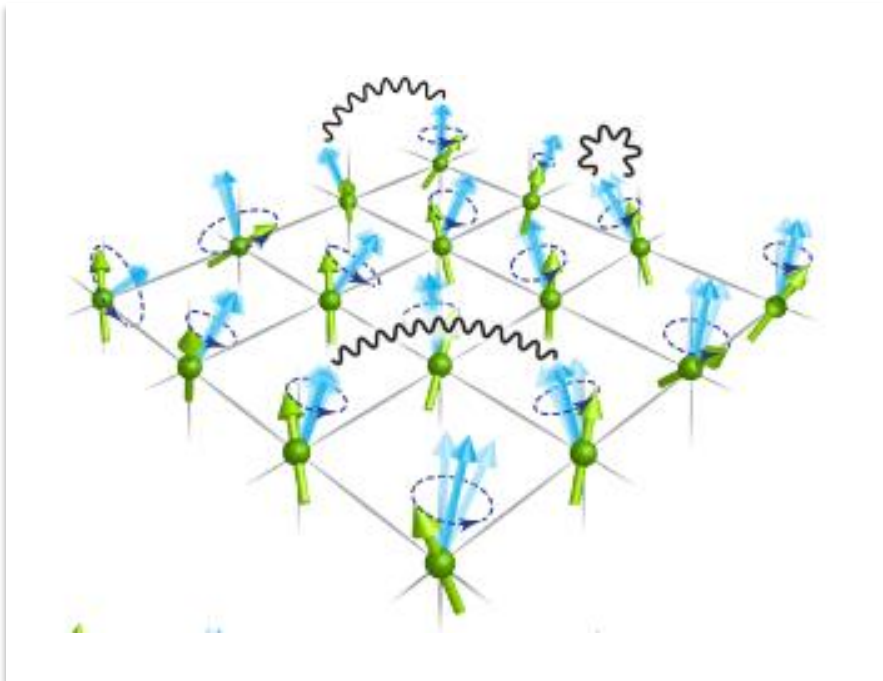
Why is condensed matter interesting?

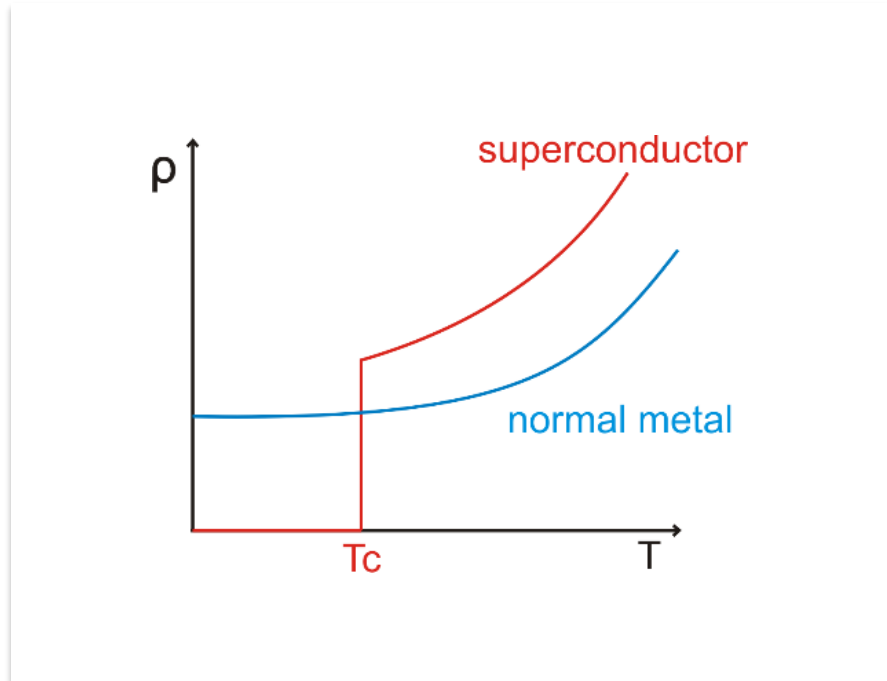
1. It is the world around us

2. It is useful

3. It is antireductionistic: many concepts are needed

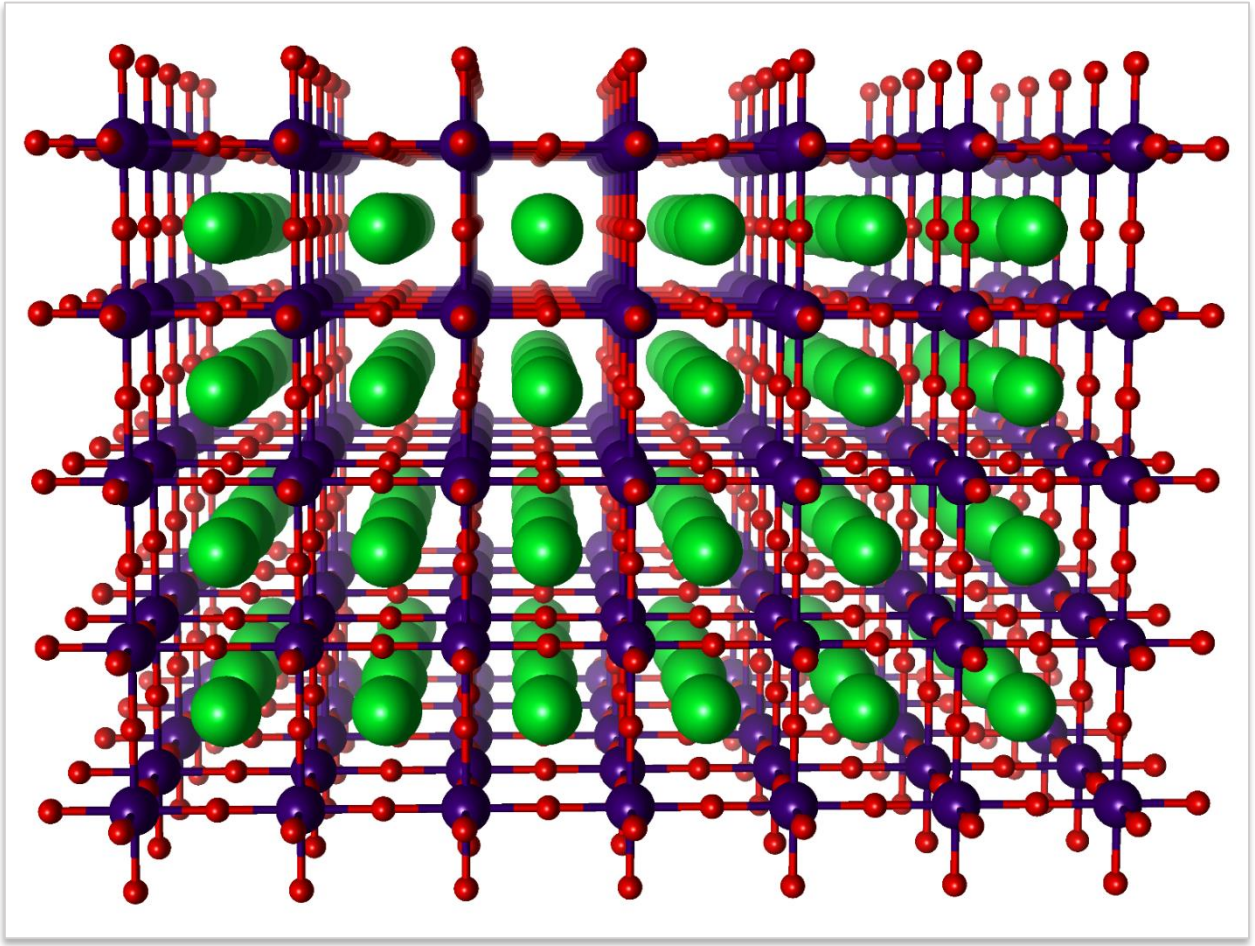
It is antireductionistic




ρ
superconductor
normal metal
Tc
T

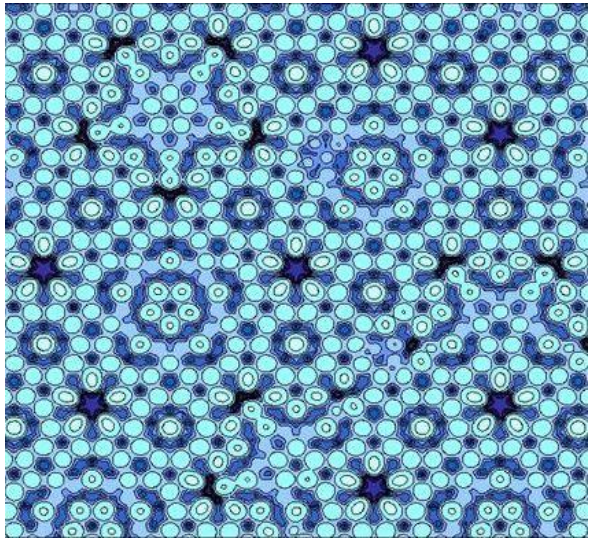
Solid State Physics

crystal



$\sim 10^{23}$ atoms / cm^3

amorphous solid



quasicrystal

Solid State Physics PHY210 - Course outline

- **Structure of solids:**
  - Crystal structure
  - Reciprocal Space
  - Scattering
  - Crystal Binding
  - Crystal vibrations

- **Electronic properties**
  - Free electron gas
  - Energy bands (i.e. metals *vs.* insulators)
  - Semiconductors

- **Additional topics** (if time allows)
  - Superconductivity
  - Magnetism