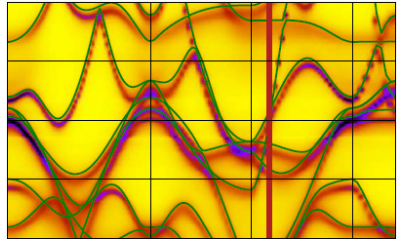
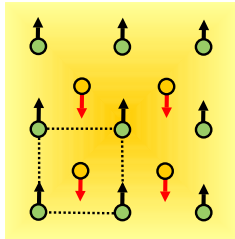


Introduction

Alexander Tsirlin

Division of Quantum Magnetism and Superconductivity
Felix Bloch Institute for Solid-State Physics



UNIVERSITÄT
LEIPZIG



Experimental Physics 5 – Solid-State Physics, WS 23/24

Prof. Alexander Tsirlin

alexander.tsirlin@uni-leipzig.de

Dr. Victoria Ginga

victoria.ginga@uni-leipzig.de

Crina Berbecariu

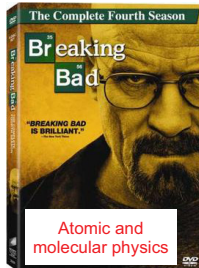
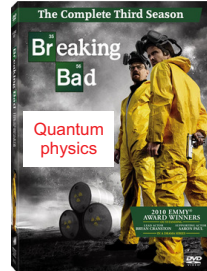
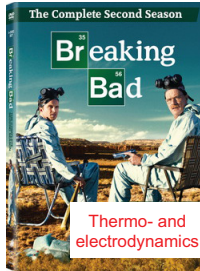
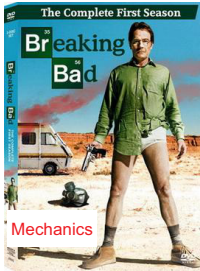
cb59bipu@studserv.uni-leipzig.de

Elizaveta Vostrecova

ev43vazy@studserv.uni-leipzig.de

You can also contact us via chat on Moodle,
or ask your questions after the class

Another season...



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Image credit: Cephas (CC-BY-SA)

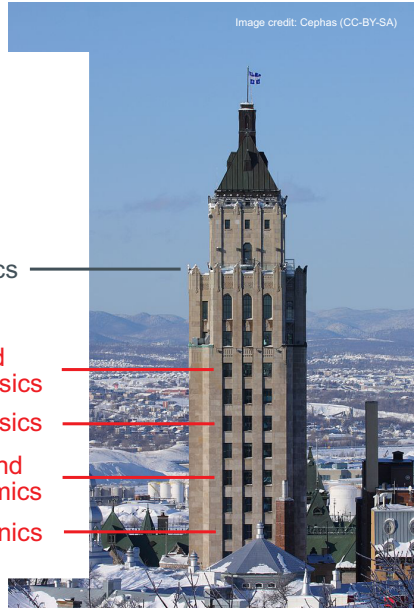
Solid-state physics

Atomic and
molecular physics

Quantum physics

Thermo- and
electrodynamics

Mechanics



Where and when?

W 11:15, kleiner Hörsaal

Th 9:15, kleiner Hörsaal

Where and when?

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Information:

<https://research.uni-leipzig.de/sum/ssp.html>

- *lecture slides*
- *supplemental material & reading suggestions*



Where and when?

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Information:

<https://research.uni-leipzig.de/sum/ssp.html>

- *lecture slides*
- *supplemental material & reading suggestions*



Lecture notes may be available later during the term
use textbooks otherwise

- **Ashcroft, Mermin. Solid State Physics**
seminal textbook, although it is nearly 50 years old translated into many languages
- Hunklinger. Festkörperphysik / Solid State Physics
recent English translation available
- Gross, Marx. Festkörperphysik
only the German version available
- any other solid-state physics textbook would work too
- don't overlook **supplemental material** (see the web page)

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More solid-state physics in the Advanced lecture (12-PHY-MWPE1), SS 24 or WS 24/25

Concepts, models, equations...

Concepts, models, equations...



Experimental technique

Concepts, models, equations...



Experimental technique



Material

Concepts, models, equations...



Experimental technique



Material



Person

- Retrieve the problem sheets
web page or Moodle
weekly on Wednesdays
- Enjoy your week and weekend
but remember to solve the problems
- Submit the solutions by the end of next week
- Solutions will be discussed during the tutorials:
Mo 15:15, kleiner Hörsaal
Tu 9:15, Theorie Hörsaal
Th 11:15, S 532



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Attending tutorials is your only chance to see the solutions



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Attending tutorials is your only chance to see the solutions



**50% of the solved problems
is a pre-requisite for taking the exam**

How to prepare?

- pen and paper / tablet and stylus
- all solutions in a single pdf-file

How to submit?

- via Moodle (closes after the deadline)
- if Moodle does not work, via email
- deadline should be respected

How to handle problems?

- an incomplete solution may still earn you some points
- many of the problems are based on real data, and you can find answers for a cross-check of your result

Questions about the grades: alexander.tsirlin@uni-leipzig.de



**50% of the solved problems
is a pre-requisite for taking the exam**

When?

provisionally, between February 12 and February 24, 2024
second attempt: end of March 2024

50% of the solved problems is a pre-requisite for taking the exam

When?

provisionally, between February 12 and February 24, 2024
second attempt: end of March 2024

How?

oral exam (30 minutes)

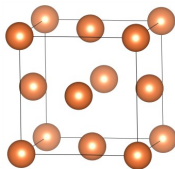
five questions from the database + any related questions

no need to remember everything, but be familiar with:

- main properties of solids
- how they are measured? (main experimental techniques)
- wherein they are relevant?

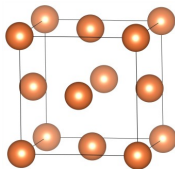
1. Structure of crystals

- direct lattice / reciprocal lattice
- symmetry
- crystal structure / structure factor



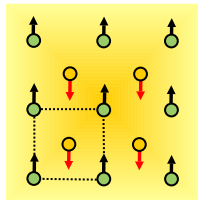
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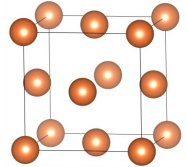
2. Atoms in crystals

- types of bonding
- elasticity and thermodynamics
- phonons (lattice vibrations)



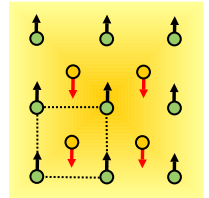
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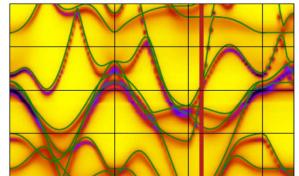
2. Atoms in crystals

- types of bonding
- elasticity and thermodynamics
- phonons (lattice vibrations)



3. Electrons in crystals

- free electron gas / Drude metal
- electronic band structure
- Fermi surface



Bravais lattice, or how to pack a crystal?



electron microscopy



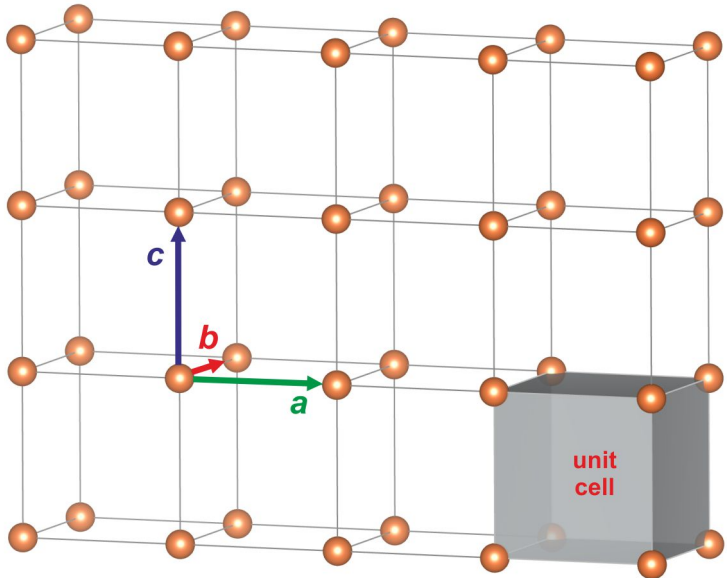
photonic crystals



remains for tomorrow



Lecture 1: October 11, 2023



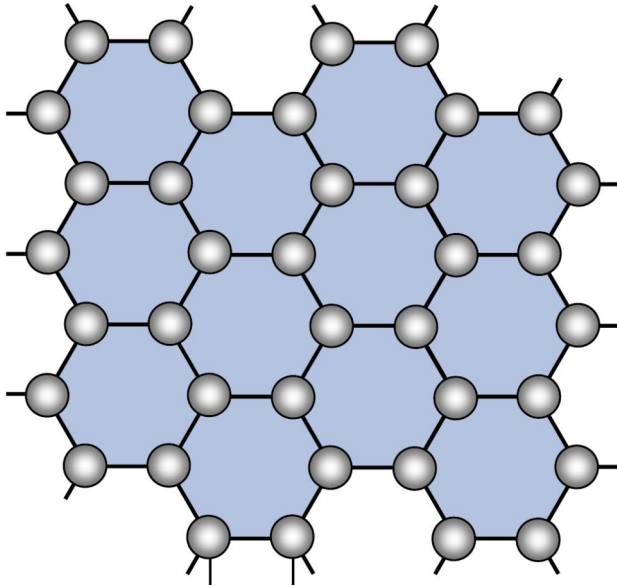


Image credit: Thomas Bresson (CC-BY-SA) and S. Hunklinger, Festkörperphysik

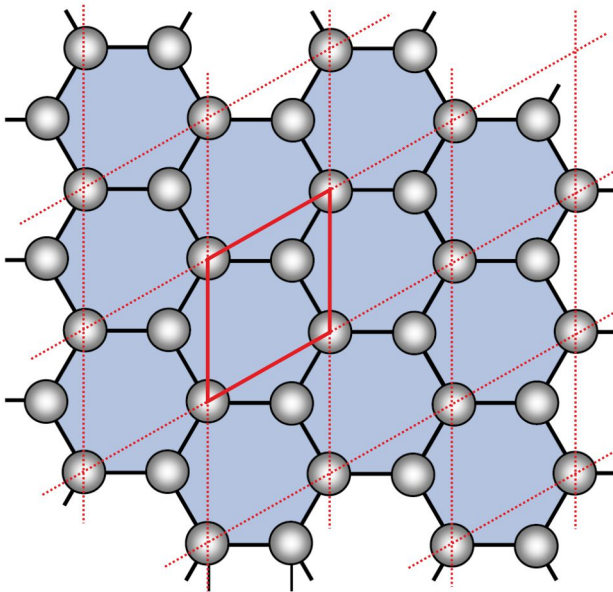


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Experimental technique

Electron microscopy

Transmission electron microscope (TEM)

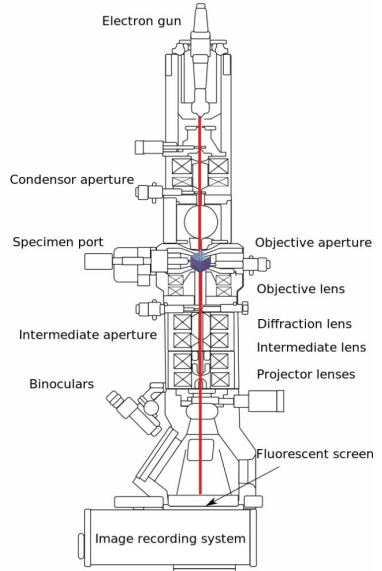
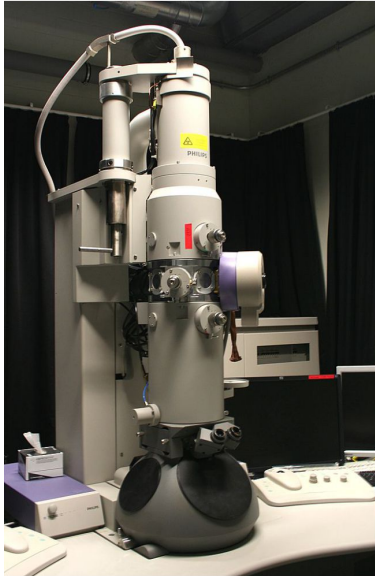
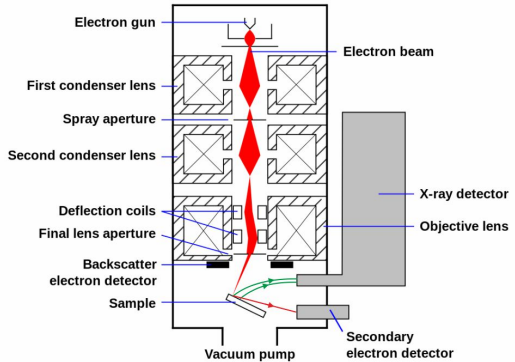
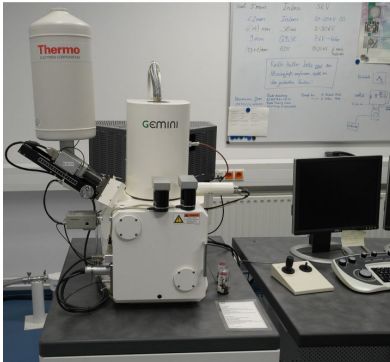


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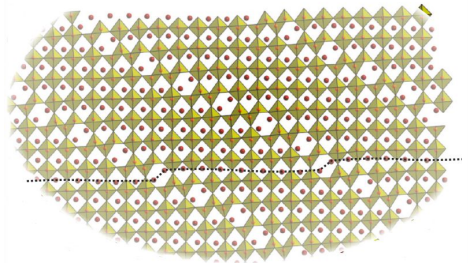
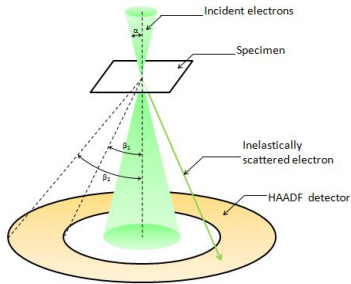
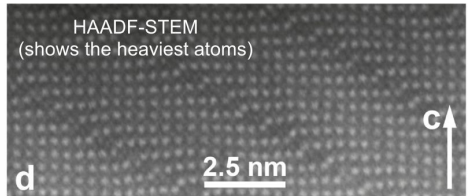
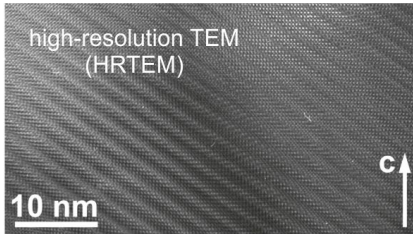
Scanning electron microscope (SEM)



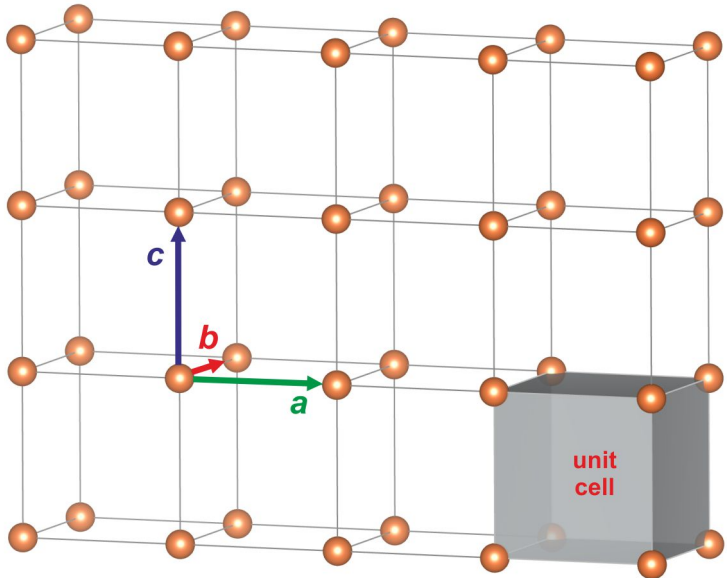
also known as REM = Rasterelektronenmikroskop
image formed by the scattered x-rays

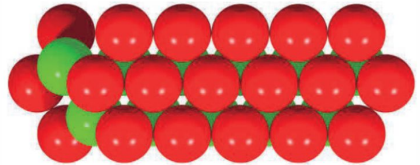
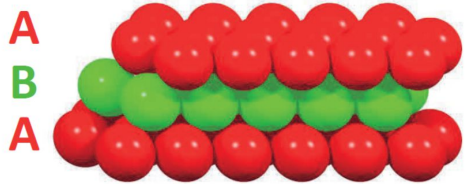
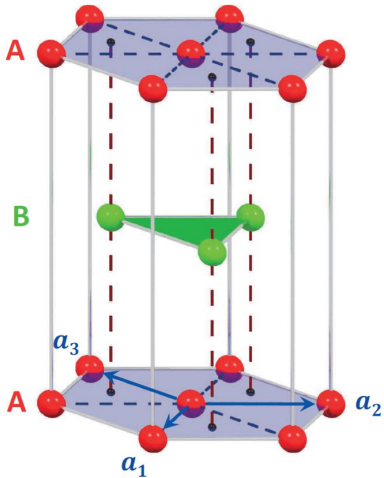
Image credit: Thctamm and Steff (CC-BY-SA)





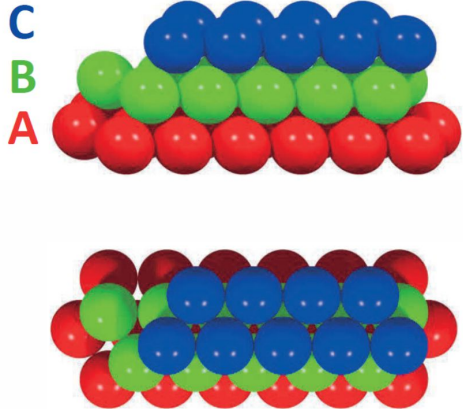
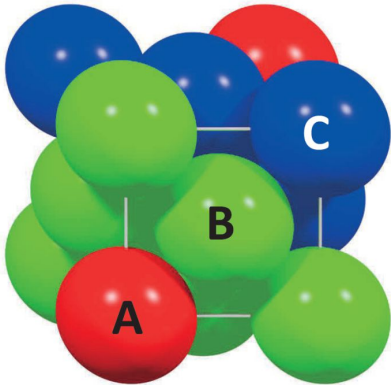
HAADF = high-angle annular dark-field





hcp (hexagonal close-packed) structure

Close packing: ABCABC



ccp (cubic closed-packed) structure
fcc (face-centered cubic) structure

Image from Gross and Marx, Festkörperphysik

Structures of metals

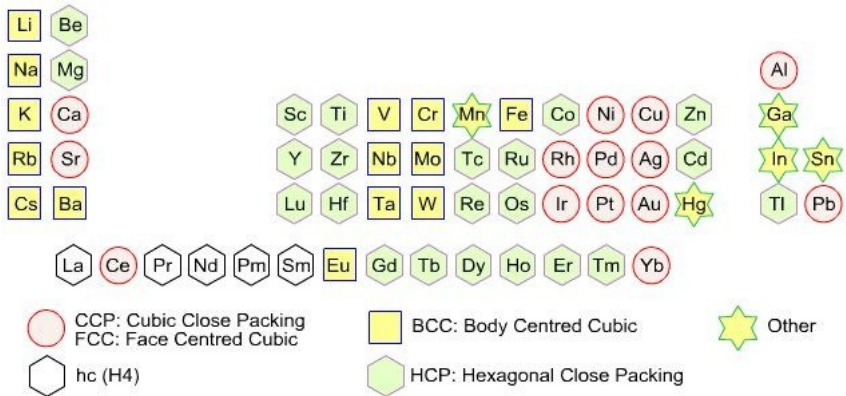
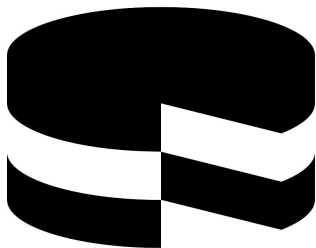


Image by Jeanne Paquette (fair use)



Material

Photonic crystals



Wall tiling at the Alhambra
(Granada, Spain)

Image credit: Gruban (CC-BY-SA), M. C. Escher (fair use)



Wall tiling at the Alhambra
(Granada, Spain)



M.C. Escher
*Study of the regular division
of the plane with reptiles*

Image credit: Gruban (CC-BY-SA), M. C. Escher (fair use)



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Packing on different length scales



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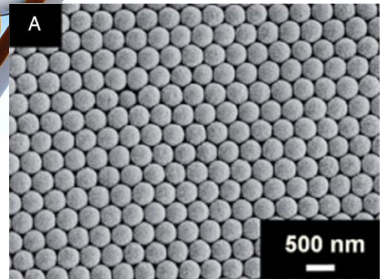
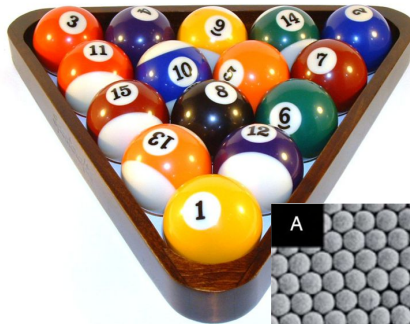
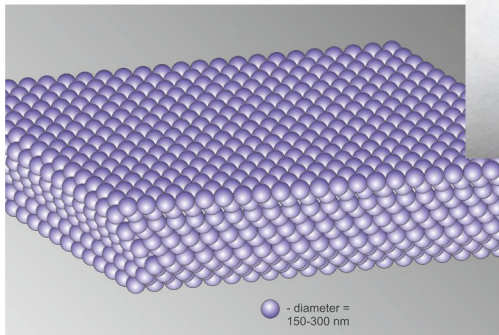


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Opal mineral ($\text{SiO}_2 \cdot x\text{H}_2\text{O}$)
consists of close-packed microspheres (*photonic crystal*)

Opalescence = “play of colors”

Image credit: Dpultzter, James St. John, James St. John (CC-BY)



Image credit: Vincent Paul S and Anaxibia (CC-BY-SA)

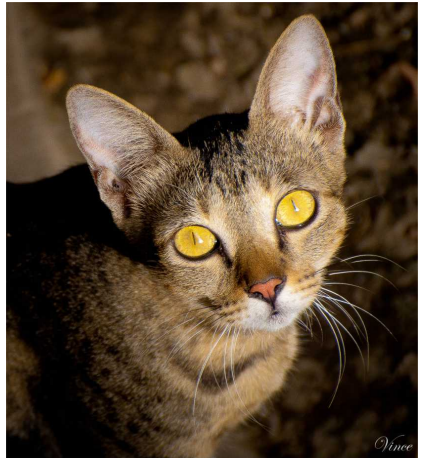


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