Experimental Physics 5a: Atoms, Molecules and Optical Physics (AMO)

Dozent (ich): Prof. Dr. Randolf Pohl
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JOHANNES GUTENBERG UNIVERSITÄT MAINZ
JG|U

Welcome everybody!

My Name is Randolf Pohl, and I am working on experimental atomic physics here.

I am mainly concerned with precision laser spectroscopy of simple atoms (hydrogen isotopes, lithium etc.) and in particular exotic (muonic) atoms.

From these we learn about fundamental physical constants,
Properties of the atomic nuclei (charge radii, magnetization, polarizability)
and test the theory of Quantum Electrodynamics (QED) and the Standard Model

More on this tomorrow.

Lecture

Lecture is **hybrid**, i.e.

Lecture in the Lorenzraum	Wed 16:15 – 17:00 Thu 12:15 – 13:45

And simultaneosly on Zoom

Zoom will be recorded and uploaded onto Panopto server.

Exercises only in presence (no Zoom)

Website

We‘re using various electronic ressources, like
LMS (Moodle), Panopto, Particify, Zoom, …..

Central point of information is my web site

https://www.agpohl.physik.uni-mainz.de/ex-5a-ws-22-23
and the LMS web site of JGU

My web site contains all Information, Links, Slides, …

(You can also find the older slides from my previous Ex-5a lecture)

Zum Inhalt

Inhalt der Vorlesung ist die Einführung in Physik, d.h.

- Mechanik von Massenpunkten
- Kräfte, Impuls, Energie, lineare Bewegung
- Mechanik komplexerer Systeme
  Schwerpunkt, Rotationen, Stöße
- Schwingungen und Wellen
- Optik
- Elektro- und Magnetostatik und -dynamik
- Gesetze von Coulomb und Ampere, Strom, Spannung, …
- Atom- und Quantenphysik

Topics

AMO physics (Atoms, Molecules, Optical physics)

- Structure of atoms: Hydrogen beyond Schrödinger
  - Dirac equation
  - Fine structure, relativistic corrections, nucelar effects
  - Lamb shift, QED, Feynman diagrams
  - Hyperfine structure
  - Alkali atoms
  - Helium atom
  - Zeeman effect, Stark effect
- Light-Atom-Interaction
  - 2-level systems – Bloch vector, Density matrix
  - Spontaneous emission and Optical Bloch equations
  - Spectroscopy, Laser cooleing and Trapping
  - Laser
  - Dipole matrix elements and selection rules
- Molecular physics
  - Born-Oppenheimer approximation
  - LCAO: H2+, H2 -
  - Rotations and Vibrations

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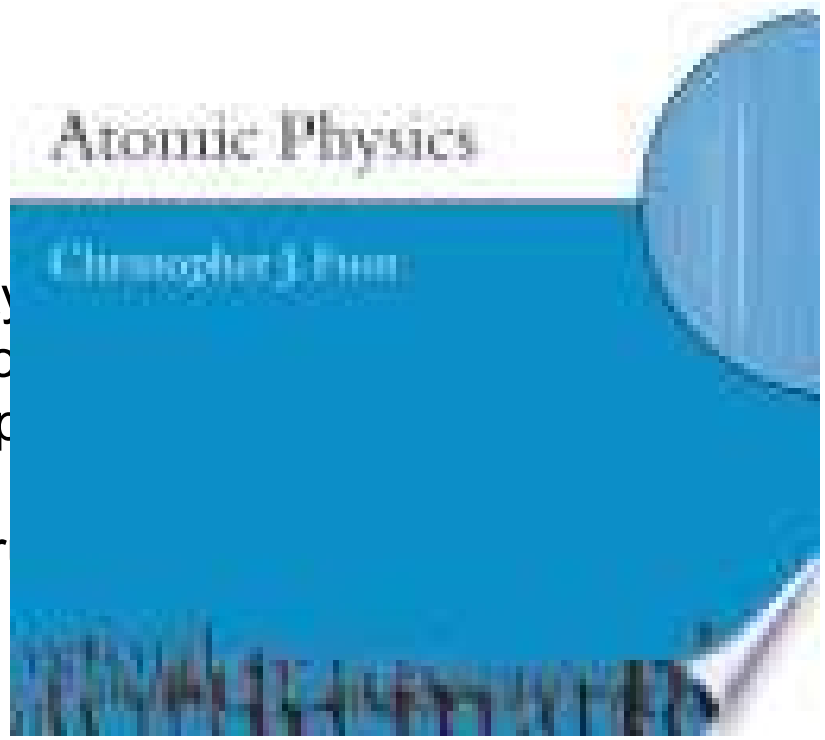
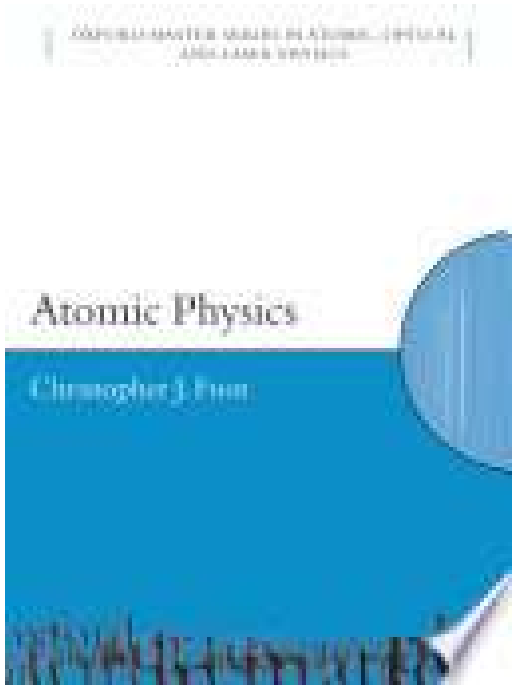
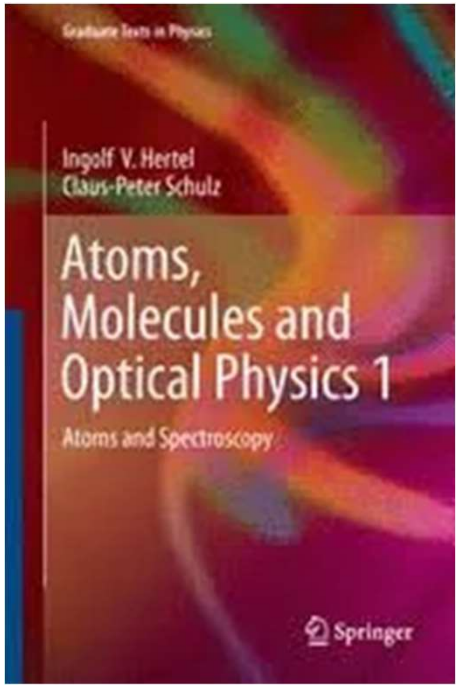
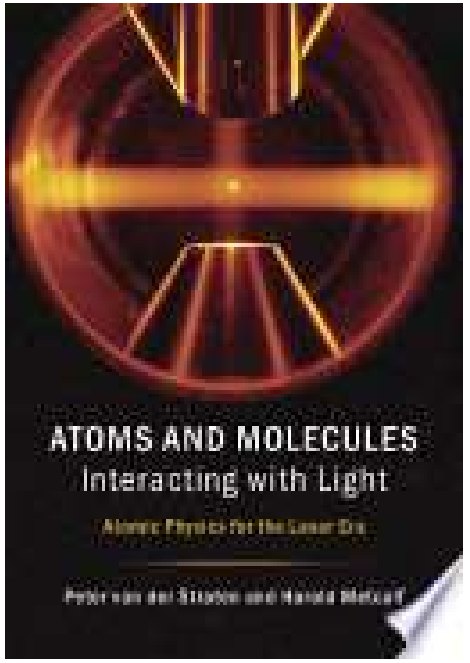


Christopher J. Foot, Atomic physics

Alternative Books







Foot: my favourite book, but not available at UB

Hertel, Schulz: VERY detailed, excellent for deeper understanding

Van der Straten, Metcalf: Very good, but rather dense

Flipped classroom

We‘re doing a „flipped classroom“

Flipped classroom

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So, you have to

READ and STUDY A BOOK

ON YOUR OWN (in groups)

Flipped classroom

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Atom- und Quantenphysik					
Modul-Kennnummer (JOGU-StINe) 08.128.050		Arbeitsaufwand (workload) 180 h	Moduldauer (laut Studienverlaufsplan) 1	Regelsemester (laut Studienverlaufsplan) 5-6 (BSc), 1 (MSc)	Leistungspunkte (LP) 6 LP
1.	Lehrveranstaltungen/Lehrformen Vorlesung mit Übung „Atom- und Quantenphysik“ (WP) Vorlesung (WP) Übung (WP)		Kontaktzeit 3 SWS/31.5 h 1 SWS/10.5 h	Selbststudium 138 h	Leistungspunkte 6 LP
2.	Gruppengrößen Vorlesung: unbegrenzt Übungen: 20				

138 hours of self-study in 14 weeks (28 lectures) = 10 hours / week

Why flipped

Classical Lecture = Frontal teaching, School a la 1980

Lecture: Teacher writes something new to the blackboard
(copying a book)
all students copy the stuff to their papers
the few who can follow may ask a question, maybe

Homework: „How was this exactly in the lecture?!?!“
Grab a book, read, teach yourself.

Next lecture: New topic.

Flipped classroom: 21st century

Study a book yourself (30 pages in 3 days)
Answer some quizzes for your own control
Exercises should be in context of book chapter

Lecture: I answer your questions, try to explain things better or in another context.
We do quizzes using a clicker
I talk about some experiments, and stuff that goes beyond the book

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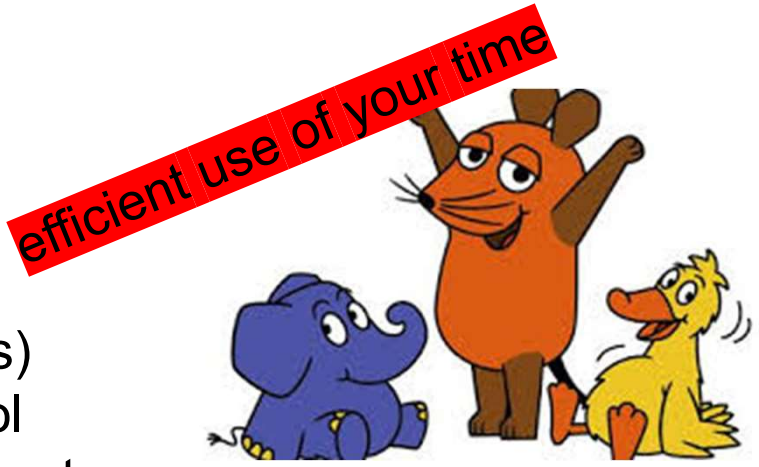

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The goal

Flipped classroom should make learning
As easy and efficient as possible.

We just shift the self study phase to the beginning of the week (before the lecture), not afterwards.

You can then ask informed questions, and I can help you to understand the things that were difficult in the book.

Please work in groups of 3 people!

More fun, more success.

How does it work

We‘re doing a „flipped classroom“

- 1st week:
- Monday: new problem sheet.
- Reading assignemtnt (ca. 30 pages)
- Self-tests
- Exercises
- Wed+Thu: Lecture
- You ask, I answer
- Quizzes
- Repeat the topic, give deeper insights, discuss experiments, …

- 2nd week
- Monday noon: Hand in the exercises (LMS)
- Exercises will be graded by us

- 3rd week:
- Exercises will be discussed

The Semesterplan

Week	Date		
0	26/27.10.	Intro, My work	
1	2./3.11.	Hydrogen: Bohr to Schrödinger	1, 2.1
2	9./10.11.	Hydrogen transitions, fine structure	2.2, 2.3 + paper
3	16./17.11.	Helium	3
4	23./24.11.	Alkali metals	4
5	20.11./1.12.	L-S coupling	5
6	7./8.12.	Hyperfine structure, Isotope shift	6
7	14./15.12.	Interaction with radiation	7
8	21./22.12.	Lasers, coatings	paper
9	11./12.1.	Laser spectroscopy	8
10	18./19.1.	Laser cooling and trapping	9
11	25./26.1.	Molecules 1	???
12	1./2.2.	Molecules 2	???
13	8./9.2.	spare	

preliminary!

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Mo	Di	Mi	Do	Fr	Sa	So	Mo	Di	Mi	Do	Fr	Sa	So	Mo	Di	Mi	Do	Fr	Sa	So
Bl. 1	Study		VL				Hand in	Exercises graded						Exercises						
							Bl.2	Study		VL				Abgabe	Exercises graded					
														Bl.3	Study		VL			

How to flip

The „flipped classroom“ NEEDs interactivity!

- Questions and answers
- Teamwork
- Quick quizzes → Particify https://ars.particify.de/p/63103355

Particify (a.k.a ArsNova)

03355

Exercises

Exercises are designed for 45 minutes.

This is a stupid choice by the Modulhandbuch (ECTS idiocy)

Usually we offer 90 minutes exercises, so you don‘t have to rush through the problems and have sufficient time for discussions.

OK? -> Particify

Slots: Wed 10-11
Wed 11-12
Wed 17-18

Atomic physics

What do YOU want to learn from this lecture?