Date: 12.11.2019

Condensed Matter Physics 2, 2019-2020

Week	**Tuesday** (13:15–15.00 & 15.15-17.00)	**Friday** (8:15–10.00 & 10.15-12.00)
1 (18+19/11) Note the dates.	Session 01: Monday 18/11 at 9.15-12.00 **Atomic physics I** Reading: Blundell Ch. 1 (1-15), App. C + E. Topics: Introduction to the course. Magnetic moments. The absence of magnetic materials in classical physics (Bohr-van Leuven theorem), the atomic origin of magnetic moments, reminder of quantum mechanics of spins, atoms in a magnetic field. Exercises: Magnetism problems: 1.1 (See Absalon). Blundell 1.1, 1.2, 1.9, 1.7. Note that we will have combined lectures + exercises.	Session 02: Tuesday 19/11 at 13.15-17.00 **Atomic physics II** Reading: Blundell Ch. 2 (18-36), App. C + E. [As optional supplementary reading you may consult S. Simon Ch. 19).] Topics: The Hamiltonian in a magnetic field, diamagnetism, paramagnetism, Curie law, magnetic susceptibility, Hund's rules, exchange interaction. Exercises: Blundell 2.1, 2.4, 4.5, 2.7, Exchange Exercise (See Absalon). Note that we will have combined lectures + exercises.
2 (26+29/11)	Session 03 **Magnetism I** Reading: Blundell Ch. 3 (45-71), Ch. 4 (74-81). Pages 52-71 can be read cursorily. Topics: Exchange interaction, Crystal fields, quenching, Jahn-Teller effect, various experimental techniques, different types of exchange interactions, Ising and Heisenberg models. Exercises: Blundell 3.1, 4.8. Magnetism problems: 1.2, 3.1.	Session 04 **Magnetism II** Reading: Blundell Ch. 5 (85-102). [As optional supplementary reading you may consult S. Simon Ch. 20.] Topics: Different kinds of magnetic order, ferromagnetism, antiferromagnetism, spin flop, helical order. Exercises: Blundell 5.1, 5.7, 5.6, 5.4.
3 (3+6/12)	Session 05 **Magnetism III** Reading: Blundell Ch. 6 (111-127) Topics: Spin waves. Bloch's $T^{3/2}$ law, general phase transitions, break-down of mean-field theory in low dimensions, the Mermin-Wagner theorem. Exercises: Blundell 6.1, 6.11. Mermin-Wagner spin-wave box p. 32-33 in the CMP2 notes. Monday 2/12, 9.00-12.00. Hand-in 1 help. Hand-in 1 is exercise 4.1 in CMP2 notes, i.e. box questions on pp. 12-14 in the CMP2 notes. I will start Monday 2/12 by going through CMP2 notes 1-14 and introduce the problem. Hand-in 1 is due 10/12.	Session 06 **Phase transitions** Reading: CMP2 notes (1-25). [As optional supplementary reading you may consult S. Simon Ch. 22.] Topics: The concept of an order parameter, Landau expansions, mean field theory, first and second order transitions, critical temperature, critical exponents, diverging correlation length. Short intro to Hand-in 2. Exercises: Box question on p. 11 in CMP2 notes. Show Eqns. 52-57 in the CMP2 notes. Blundell 6.5.
4 (10+13/12)	Session 07 **Magnetism in metals I** Reading: Blundell Ch. 7 (140-148).[As optional supplementary reading you may consult S. Simon Ch. 23.] Topics: Finish criticality-discussion, the free electron gas, Pauli paramagnetism, itinerant magnetism, Stoner instability, Spin-density-waves. Exercises: 6.7,7.1,7.2 in Blundell. Monday 9/12, 9.00-12.00. Hand-in 1 or 2 help. Hand-in 2 is exercise 7.1, Box questions on pp. 25-27 in the CMP2 notes. Due 20/12.	Session 08 **Magnetism in metals II** Reading: Blundell Ch. 7 (148-163). Topics: Momentum dependence of the susceptibility, RKKY interaction, Stoner excitations, Kondo effect. Short intro to Hand-in 3. Exercises: 7.4, 7.7, 7.8 in Blundell.
5 (17+20/12)	Session 09 **Superconductivity I** Reading: Ch. 3 from Annett book (Absalon). I will give a power point presentation of the basics of superconductivity. And we will play with real superconductors, and demonstrate levitation. Topics: Phenomenology of superconductivity, London equations, Meissner effect, hands-on superconductivity. Exercises: Problem 3.1, 3.2, 3.3 from the Annett book. Monday 16/12, 9-12. Hand-in 2 help.	Session 10 **Superconductivity II** Reading: CMP2 notes 40-46 Topics: Introduction to Ginzburg-Landau theory, local gauge invariance, characteristic length scales, type I versus type II, flux quantization, vortex lattices, Josephson junctions, macroscopic quantum coherence. Exercises: Box question on p. 43 in the CMP2 notes, and box question on p. 50 in the CMP2 notes. Hand-in 2 due 20/12. Hand-in 1 return.
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6 (3+7/1)	Session 11 **Superconductivity III** Reading: CMP2 notes 46-50, JS Ch. 26 section 26.4 (except 26.4.4, 26.4.6, and 26.4.7). As optional supplementary reading you may consult Ch. 4 from the Annett book. Topics: The Ginzburg-Landau equations, applications of Ginzburg-Landau theory, type I versus type II, flux quantization, the Little-Parks experiment. Exercises: Problems 3.4, 4.2, 4.3 from the Annett book. Monday 6/1, 9-12. Hand-in 3 help. Due 10/1.	Session 12 **Superconductivity IV** Reading: JS Ch. 26 section 26.5. Topics: Finishing the Ginzburg-Landau theory, surface energy, vortex lattices, Josephson junctions, SQUIDs. Exercises: Catch up on older exercises, discuss hand-in issues. If time allows: go through the Feynman approach to the Josephson effect; derive Eq. 26.5.11 and Eq. 26.5.50 in JS Ch. 26.
7 (10+14/1)	Session 13 **Landau diamagnetism and Hall Effect** Reading: JS Ch. 22.1.1-22.1.3, 22.1.6, 22.2, and 24.5 Topics: Landau diamagnetism, Hall effect and magneto-resistance, Landau levels, classical Hall effect, Landau diamagnetism. Exercises: TBA	Session 14 **Integer Quantum Hall Effect** Reading: JS Ch. 22.1.1-22.1.3, 22.1.6, 22.2, and 24.5 Topics: Landau levels, Integer quantum Hall effect, edge states. Exercises: TBA, Landau diamagnetism JS Ch. 22.1.3 and 22.2. Hand-in 3 return 14/1.
	We will have a question session Friday 17th 10.15-12.00 in Aud. 5 (HCØ)	
	Oral exam: 21, 24 Jan	

Place and Time Sessions (Lectures and Exercises)
Lectures: Tuesday 13:15-15:00 and Friday 8:15-10.00 (ATR, BMA).
Exercises: Tuesday 15:15-17:00 and Friday 10.15-12.00 (AP). In addition, we will use Mondays 9.15-12.00 for extra help with problems and hand-in assignments.

Rooms: Lectures take place in Aud. 2 (HCØ) on Tuesdays, and Aud. 7 (HCØ) on Fridays.
Rooms: Exercises take place in kursussal 3 (Zoo) on Tuesdays and Aud. 5 (HCØ) on Fridays. And in Aud. Syd (Idræt) on Mondays.

Course material
S. Blundell; “Magnetism in Condensed Matter”
B. M. Andersen, “Notes for CMP2”
J. Soloym, “Fundamentals of the Physics of Solids”, Chapters 22, 24, 26.
S. Simon; “The Oxford Solid State Basics”.
(free download through the course homepage on Absalon).

Teachers (lectures & exercises)
BMA Brian Møller Andersen (lectures)
ATR Astrid Tranum Rømer (lectures)
AP Andreas Simon Pøschl (exercises)

The course consists of Session 1-14 (lectures and exercises) plus self-study. The students’ mastery of the course subjects (equivalent of 7.5 ETCS points) is evaluated at the oral exam (mark given). The course contains three longer written hand-in problems, whose content and solution will be a natural part of the oral examination.

Prerequisites:
Completed courses in basic electromagnetism, quantum mechanics, and statistical physics. CMP1 provides a foundation for this course but it is not a strict prerequisite.

Other good textbooks:
Ashcroft and Merlin; “Solid state physics”.
C. Kittel: “Introduction to Solid State Physics”.
J. Singleton; “Band theory and electronic properties of solids”.
H. Ibach and H. Luth; “Solid-state physics”.
C. Kittel; “Quantum theory of solids”.
M. P. Marder; “Condensed matter physics”.