Advanced Statistical Physics  
Summer Term 2017  

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Requirements / organizational issues:

The lecture has as a main target group students in the Master program, plus beyond (including PhD students and postdocs). Students in the Bachelor program are welcome as well, as long as they are familiar with the content of prerequisite courses (standard statistical physics as well as mechanics). Exams will be done orally after the teaching term, probably not before September - unless the number of students is so large that a written exam is needed. Tutorial classes will take place every second week for 90 minutes each. Students are expected to solve the problems at home and to present them during the tutorials. They will be vital for a good understanding of the subject.

Contents:

The course presents some more advanced topics in statistical physics which are not dealt with in the basic course but which are at least useful (if not essential) for working in the field of statistical physics / soft matter at research level. We will cover both static and dynamic aspects of statistical physics.

Table of Contents:

A. Dynamics

A1. Stochastic processes (Markov processes, Langevin equation, Fokker Planck equation)

A2. Linear response theory

A3. Green-Kubo relations

A4. Kramers-Kronig relations

A5. Mori-Zwanzig formalism

B. Critical phenomena and phase transitions

B1. Ising model and critical exponents

B2. Mean-field theory of phase transitions (Landau theory, symmetry considerations and critical points)

B3. Ginzburg criterion and upper critical dimension

B4. Basic concepts of scale-invariance and renormalization group
B5. Sketch of field theoretical approach for phase transitions

C. Additional topics (if time permits)

C1. Introduction to liquid crystals (Landau-de Gennes free energy expansion, isotropic-nematic first order transition, Frank elastic constants)

C2. Introduction to hydrodynamics

Literature:

- Chaikin & Lubensky: Principles of Condensed Matter Physics (all topics)
- Risken & Frank: The Fokker-Planck Equation (stochastic processes)
- Balakrishnan, Elements of Nonequilibrium Statistical Mechanics (Langevin theory)
- Plischke and Berghersen: Equilibrium Statistical Physics (Linear response theory, Green-Kubo relations and critical phenomena)
- Forster, Hydrodynamic Fluctuations, Broken Symmetry, And Correlation Functions (Mori-Zwanzig formalism)
- Snook, The Langevin and Generalised Langevin ... (Langevin theory, Mori-Zwanzig)
- Frenkel and Smit, Understanding Molecular Simulation (Linear response theory)
- Hansen and McDonald, Theory of Simple Liquids (Langevin theory, Mori-Zwanzig, hydrodynamics)
- Goldenfeld, Lectures on Phase Transitions and the Renormalization Group
- Cardy, Scaling and Renormalization in Statistical Physics
- Kopietz, Bartosch & Schütz, Introduction to the Functional Renormalization Group
- De Gennes & J. Prost, The physics of liquid crystals
- Honerkamp and Roemer, Klassische Theoretische Physik (hydrodynamics)
- Guyon, Hulin, Petit & Mitesu: Physical Hydrodynamics
- Batchelor, An Introduction to Fluid Dynamics