Advanced Statistical Physics

WS 2007/2008

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I. Microscopic and macroscopic degrees of freedom

1. Thermodynamics and entropy

1.1 Boltzmann entropy

1.2 Ensembles and fluctuations

1.3 Entropy and information

2. Diffusion

2.1 Simple random walks

2.2 Other universality classes

 a) Lévy flights

 b) The self-avoiding walk

2.3 Collective diffusion

2.4 Driven diffusion

II. Phase transitions and critical phenomena

1. Phenomenology of phase transitions

1.1 Simple fluids

1.2 The van der Waals gas

1.3 Lattice models of ferromagnetism

2. Critical behavior of the Ising model

2.1 Mean field approximation

2.2 The Ising chain

2.3 Energy barriers and domain walls

2.4 The two-dimensional Ising model

3. Landau theory and Gaussian fluctuations

3.1 The Landau free energy

a) Opacity bound
b) Causality bound
c) Tip growth

3.3 Laplacian fractals and Laplacian instabilities
a) The continuum limit of DLA
b) The Mullins-Sekerka instability
c) The Saffman-Taylor instability
d) Dielectric breakdown

4. Self-affine growth processes

4.1 Self-affinity

4.2 Stochastic growth models with local rules
a) The Eden model
b) The single step model

4.3 The Kardar-Parisi-Zhang equation
a) Normal growth
b) Langevin equations for kinetic roughening
c) Solution of the Edwards-Wilkinson equation
d) Relevance of the nonlinear term
e) Galilean invariance

Recommended reading:

- J.P. Sethna: *Entropy, Order Parameters, and Complexity* (Oxford University Press 2006)
- N. Goldenfeld: *Lectures on Phase Transitions and the Renormalization Group* (Westview Press 1992)
- M. Plischke and B. Bergersen: *Equilibrium Statistical Physics* (3rd edition, World Scientific 2006)
- D. Sornette: *Critical Phenomena in Natural Sciences* (2nd edition, Springer 2004)

Problem sheets and supplementary information:

`http://www.thp.uni-koeln.de/krug/` ⇒ Teaching