

## **Random numbers**

- Random number generators
- Problems (e.g. Marsaglia effect)
- Random numbers with different distributions

## **Boundary conditions**

- Periodic boundary conditions
- Periodic boundary conditions deformed box
- Distance

## **Molecular dynamics**

- Algorithm
- Applications
- Forces
  - Pair
  - Frictional
- Find pairs
  - Bucketing algorithm
  - k-space solution
- Integration
  - Euler method
  - Runge-Kutta method
  - Leapfrog method
  - Verlet method
  - Multiscale
- Temperature

– Nosé-Hoover thermostat

### **Event driven algorithm**

- Algorithm
- Application
- Inelastic collapse

### **Contact dynamics**

- Algorithm
- Application
- Iterative solver
- Elasticity

### **Kinetic Monte Carlo**

- Algorithm
- Application

### **Parallelization**

- How, why?
- Algorithm

### **Percolation**

- Definition
- Hoshen-Kopelman Algorithm
- Percolation on networks (graphs)
- Algorithm percolation on networks (graphs)
- Determine  $p_c$

### **Ising-model**

- Definition
- Importance sampling
- Characteristic time
- Metropolis algorithm

### **Finite size scaling**

- Finite size effects
- Algorithm
- Fit

### **Ising-model**

- Multi-spin
- Cluster algorithm
  - Swendsen-Wang algorithm
  - Wolff algorithm
- Kawasaki dynamics

### **Optimization**

- Gradient based optimization
- Steepest descent algorithm
- Conjugate Gradient Method
- Modified Newton's method

### **Glassy behavior**

- Metastability
- Nucleation
- Frustration

- Simulated annealing
- Genetic algorithm

### **Growth models**

- DLA
  - Algorithm
  - Optimization
  - Noise reduction
  - Anisotropy
- Dielectric breakdown model
- Eden model
- Ballistic deposition
- KPZ-equation

### **Discrete models**

- Directed percolation
  - Exponents
- Numerical renormalization group
  - Fix points
- Neural networks

### **Complex networks**

- Random Networks
  - Erdős-Rényi graph
  - Configurations model
  - Barabási-Albert model
- Percolation and attack on random networks

## Clustering

- Definitions, local, global
  - Modularity
  - k-means clustering
  - Hierarchical clustering
  - LFK method
  - Clique percolation

## Random walk on networks

- Random walk master eq.
- Solution on uncorrelated network
- Page rank

## Disease spreading

- SIR model
- Algorithm
- Bit coding

## Opinion models

- Ising  $T = 0$
- Voter model
- Bounded confidence model
- Hegselmann-Krause model

## Game models

- Rock-paper-scissors
- Prisoner's dilemma
- Chicken, hawk-dove game

## **Self-Organized Criticality**

- Definition
- Bak-Tang-Wiesenfeld model
- Forest fire
- Bak-Sneppen model of evolution

## **Traffic models**

- Nagel–Schreckenberg model
- Emergence of traffic jams
- Asymmetric simple exclusion process