# Outline course Upscaling and Stochastic Methods I
# András Bárdossy, Insa Neuweiler, Rudolf Hilfer

**Time:** from 31st July to 2nd August 2007 (each day from 9 am to appr. 5 pm)
**Place:** Seminarraum 2 and MultiMediaLab (Pfaffenwaldring 61)

## Part I Rudolf Hilfer: Upscaling and Stochastic Methods in Porous Media

**Time:** 31.07.2007 (from 9 am to appr. 5 pm)
**Place:** Seminarraum 2 (Pfaffenwaldring 61)

### Literature

R. Hilfer, Transport and relaxation phenomena in porous media
Adv. Chem. Phys. XCII, page 299 (1996)

R. Hilfer, Local Porosity Theory and Stochastic Reconstruction for Porous Media
Lecture Notes in Physics vol 554, Springer, Berlin, page 203 (2000)

### Contents

- Introduction to upscaling
- Pore scale equations of motion
- Geometric characterization
- Upscaling of geometric characteristics
- Local porosity theory
- Percolation theory
- Finite size scaling
- Effective medium theory

## Part II Insa Neuweiler: Perturbation methods and coarse graining

**Time:** 1.08.2007 (from 9 am to appr. 5 pm)
**Place:** MultiMediaLab (Pfaffenwaldring 61)

This part of the course will discuss upscaling methods, which are based on a stochastic description of a heterogeneous porous medium. The methods are therefore not only applied for upscaling, but also for stochastic modelling of flow and transport problems.

The stochastic averages and variances of a variable (such as the pressure head or a solute concentration) are often derived approximately using perturbation methods. The underlying assumption is that in a moderately heterogeneous parameter field, the solutions will also be only moderately heterogeneous.

In the first part the underlying principles and mathematical tools will be explained.

In the second part, different perturbation expansions will be discussed for the example of the single phase flow problem in a heterogeneous conductivity field. The derivation of the (second order) effective conductivity and of the head variance for the upscaled problem will be derived using perturbation methods.

In the third part the main ideas of coarse graining will be explained for the example of a single phase flow problem. The coarse grained flow problem is the flow problem for a filtered variable. The coarse grained problem is the starting point for renormalization methods. Renormalization will also be discussed shortly at the end of this part of the course.

## Part III András Bárdossy:

**Time:** 02.08.2007 (from 9 am to appr. 5 pm)
**Place:** MultiMediaLab (Pfaffenwaldring 61)

will be handed in later