High-resolution modelling for polymer transport in two-phase porous media flow

Supervisor: Johan Romate (Shell/TUD)

Problem background
Reservoir simulation is about the numerical solution of equations describing the transport of mass, momentum and energy of fluids moving through a porous medium. There may be one or more fluids and they may be also in different phases. For instance, in oil reservoir simulation water may be injected ("water flooding") for improving oil recovery from the reservoir, giving an oil-water two-phase flow system.
Here we consider water flooding in one space dimension. On one end water is injected and on the other end oil and water are produced. Under certain assumptions the flow of water and oil can be described by a transport equation for the water fraction (or *saturation*) S_w,

$$\frac{\partial}{\partial t}\left(S_w\right) + \frac{\partial}{\partial x}\left(\frac{q_T}{\phi} f_w(S_w)\right) = 0.$$

This is the Buckley-Leverett equation. Here ϕ is the porosity, q_T the given constant injection rate, and f_w the fractional-flow function.

Sometimes a small amount of particles or components (a *tracer*) are added to the injected water. This can be to follow the water movement, or to change the behaviour of the injected water. In a reservoir simulation model the movement of such a small amount of a tracer c can be modelled by adding a transport equation for c. For instance, in *polymer flooding* the transport of the added polymer tracer in the water phase can be modelled by

$$\frac{\partial}{\partial t}\left(cS_w\right) + \frac{\partial}{\partial x}\left(\frac{q_T}{\phi}\alpha c f_w(S_w)\right) = 0.$$

The added polymer makes the water more viscous, so that it influences the solution of the flow equations above.

Assignment
The numerical solution of the flow equations (for the saturations) and the transport equation (for the polymer tracer) could be done simultaneously, as they are coupled. However, in practice this is not always done. Existing reservoir simulators may have a built-in solver for the flow equations, and give the user the opportunity to add one or more transport equations, which are solved in a separate step.
The goal of the assignment is to develop a good numerical model for the transport of the tracer, with the flow solver for the oil-water saturations given. It is assumed that the flow solver is first order, and the goal is to derive a high-resolution (TVD) method for the tracer. The model needs to be developed first in the 1D case, and if possible extended to the 2D case.

The assignment roughly consists of the following parts:

1. Literature study.
2. Development of a high-resolution method for the tracer equation in 1D.

3. Extension to a system by including the flow equations.
4. Implementation and demonstration of the model.
5. Writing the thesis.