Abstract

This thesis contains the derivation of two-scale models for multi phase and multi constituent flow in porous media. It will be achieved by using phase field models for the porespace together with formal asymptotic expansion. The equations describing the processes in the porespace are obtained by using the assumption of maximal entropy production rate, which was first developed and used by Rajagopal and Srinivasa. This method is able to yield thermodynamically consitent models in the bulk starting from constitutive assumptions on energy and on the rate of entropy production. In particular, the method will lead to a new point of view on phase field models and it will be possible to derive well known models like the Cahn-Hilliard-Navier-Stokes system, Korteweg's equation or the Allen-Cahn model of phase transition. In order to derive suitable boundary coditions, the assumption of maximum rate of entropy production is generalized to processes on the surface of a bounded domain and applied to phase field models. Finally, the same method is used to derive a thermodynamically consistent scaling of such multi phase and multi constituent systems. The resulting equations are homogenized via formal asymptotic expansion. This method will be applied to the air/water system in soil as well as to the active layer of permafrost soil consisting of the four constituents air, water, vapor and ice in the porespace. It will be shown that the resulting two-scale equations are true generalizations of existing models since the averaged behavior of the solutions of the two-scale model fits to the commonly used macroscopic equations. However, the two-scale models contain much more information and hence it is thinkable that they will provide much more accuracy in future simulations.