Technische Universität Braunschweig

MUSEN

A multi-scale approach for free-flow porous media interaction – explained using the example of water management in the fuel cell

Lecture of

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November 14th, 2024, 4:00 PM

Raum: PK3.0017 (Seminarraum des Instituts für Angewandte Mechanik), Pockelsstr. 3, Erdgeschoss

Flow and transport processes in domains composed of a porous medium and an adjacent free-flow region appear in a wide range of industrial, bio-medical and environmental applications. Industrial applications range from flow in fuel cells to drying processes; possible bio-medical applications include the interplay of distribution processes in blood vessels and in the surrounding tissue. Applications in environmental systems include infiltration of overland flow during rainfall, groundwater contamination due to infiltrating pollutants and evaporation from soil.

One of the key challenges for coupled free flow and porous-medium flow arises from the fact that the overall effective behaviour depends strongly on interface processes that occur on small spatial scales (pore scale), although the overall system of interest is often too large to resolve these processes explicitly in detail. REV-scale models are usually not able to capture all the relevant physical processes for such coupled systems. For the accurate description of interface phenomena, it is therefore necessary to develop model concepts that combine information gained through pore-scale and REV-scale models. The first part of the lecture includes the following items:

- an explanation of relevant processes of mass, momentum and energy transfer at the interface between a free-flow and a porous-media system
- a presentation of conceptual models for coupled single-phase free flow and two-phase porous-medium flow with a detailed description of the models in the free flow and in the porous medium for the pore and REV scale
- comparison studies to show the advantages and disadvantages in relation to classical approaches; the coupling concepts are discussed on the basis of different technical or environmental issues.

In the second part of my talk, I will present a multi-scale coupling approach for the water management in a PEM fuel cell. We obtain a numerical model which allows to predict the change in the macroscopic flow behavior caused by drops at the common interface. We compare the results of a simple test case with an experiment to validate our approach.