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Local thermal non-equilibrium processes in porous media: Comparison of different models from the pore- to the REV-scale

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Local thermal equilibrium, meaning an instantaneous heat transfer between different phases, is often assumed when modeling heat transfer in porous media systems. However, for some technical applications as well as environmental systems, such as self-pumping transpiration cooling [2], fuel cells [4] and geothermal systems [3], heat exchange processes between the different phases may be of great importance e.g. due to large temperature gradients or large differences in thermal properties of the respective phases. Therefore, when modelling those processes, local thermal non-equilibrium (LTNE) processes should be considered to evaluate the validity of the instantaneous heat transfer assumption.

In our presentation, we show a comparative study for conduction as well as conduction and convection processes between three different LTNE-models focusing on the influence of the interface between a solid and a single fluid phase. On the one hand, the pore-scale geometry including the solid-fluid interface will be resolved by the grid and the respective equations are solved for each phase and coupled through interface conditions. On the other hand, two additional models leading to averaged physical properties, such as the temperature, are taken into consideration. The dual network model ([5]) hereby takes the pore geometry still into account by approximating it with ideal shapes, while a model on the Representative Elementary Volume (REV) scale ([6]) accounts for the pore-scale geometry through averaged quantities. For the latter, different effective conductivity approaches (e.g. obtained through homogenization [1]) are considered, indicating the importance of the respective choice. Additionally, we will provide a short outlook on recent ongoing model developments regarding interfacial heat transfer, including a coupled porous-media free-flow model for local thermal non-equilibrium processes.

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