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Direct Numerical Simulation of weak-inertia single-phase flow in porous materials using SPH

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Instrinsic permeability of a porous material is a crucial material parameter in various application fields like e.g. geosciences, materials science and mechanical engineering. In these disciplines intrinsic permeability is a widley used input parameter for numerical simulations in the framework of continuum-scale models that employ Darcy's law. However, the assumption of linearity in constitutive relations for the momentum exchange is subjected to restrictions and only valid in the so-called creeping flow regime (Reynolds number Re < 1). We present an approach focusing on 3-D pore-scale-resolved computations of single-phase fluid flow through porous media from moderate to higher Re-numbers (1 < Re < 1000) aiming to show a smooth transition of effective properties from creeping flow to the weak inertia regime. While this has already been shown for 2-D artificial domains [4], we seek to generalize the phenomena by investigating spherepackings and natural porous materials with small to moderate porosities ($\varphi \leq 0.2$). For representative 3-D simulations based on XRCT-scans, with voxels in the order of 10003 massively parallel direct numerical simulation methods are required. Therefore, we choose fully-Lagrangian Smoothed Particle Hydrodynamics (SPH) as a simulation method to model pore-scale-resolved flow by means of the weakly compressible Navier-Stokes equations. The solver is implemented on top of the software framework HOOMD-Blue [1, 2] since this allows for massively parallel CPU and GPU computations. A sufficient scaling behavior as well as the numerical accuracy in the Darcy regime is demonstrated [3].

Participation

In-Person

References

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Primary author: Mr KRACH, David (University of Stuttgart)

Co-author: STEEB, Holger (Universität Stuttgart)

Presenter: Mr KRACH, David (University of Stuttgart)

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