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Tightly Coupled Hyperbolic Treatment of Buoyant Two-Phase Flow and Transport in Porous Media

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Buoyant incompressible multiphase flow and transport in porous media typically is simulated by coupling an elliptic flow equation with a hyperbolic transport description. The tight coupling between flow and transport either requires a fully implicit solution algorithm or very small time steps, if solved sequentially. In any case, however, a large linear system has to be solved each time step.

Here a new solution approach is devised, which relies on solving a coupled hyperbolic system of conservation laws with an explicit finite volume method. Consequently, only local operations have to be performed, which is a great advantage in case of massive parallel simulations and if GPUs are employed.

The devised method is based on the isothermal Euler equations with momentum source terms accounting for resistance due to the porous medium and buoyancy. In this system the pressure is proportional to the density and in case of very small Mach numbers and relative density changes, the computed velocity field is divergence free and converges towards the total volumetric flow in the porous domain. To account for saturation transport, the system was augmented by an additional hyperbolic equation. In order to obtain the numerical fluxes, a characteristic based approximative Riemann solver was developed and 2nd order accuracy in space and time is achieved by piecewise linear reconstruction.

Two-phase flow test cases with buoyant plumes and a lock exchange problem demonstrate that the devised hyperbolic approach recovers the correct incompressible solutions. Numerical experiments also demonstrate that the method is accurate and efficient.

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References

Time Block Preference

Time Block A (09:00-12:00 CET)

Participation

In person

Primary authors: Prof. JENNY, Patrick (Swiss Federal Institute of Technology, Switzerland); Mr HASANZADE, Rasim (Stanford University, USA); Prof. TCHELEPI, Hamdi (Stanford University, USA)

Presenter: Prof. JENNY, Patrick (Swiss Federal Institute of Technology, Switzerland)

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