Regularized Interface Methods for Geometrically Nonlinear Navier-Stokes-Biot Interaction

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Abstract

We present recent advances in the existence theory for fluid-poroelastic structure interaction (FPSI) with nonlinear geometric coupling. The model couples incompressible Navier-Stokes flow in a moving domain to Biot's system for a poro(visco)elastic medium, with kinematic and dynamic transmission conditions on the a priori unknown interface. In a first step we study a multilayered configuration in which the free fluid and the Biot medium are separated by a reticular plate that carries inertia and elastic energy while remaining permeable to the fluid. A constructive Lie-splitting scheme yields finite-energy (Leray-Hopf) weak solutions to a regularized problem and a weak-classical consistency result as the regularization parameter vanishes.

We then introduce a regularized interface method for FPSI problems with low-regularity interfaces and direct fluid-poroelastic contact. The Biot displacement is smoothed by spatial convolution and we temporarily insert a thin elastic plate of thickness $h > 0$ at the interface. Uniform-in-h energy estimates together with compactness on time-dependent domains (Aubin-Lions type) allow passage to the limit $h \to 0$, producing weak solutions to the regularized interface problem with fully vector-valued interface motion.

References

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