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Effective stress jump across thin permeable surfaces[1] GIUSEPPE ANTONIO ZAMPOGNA, FRANÇOIS GALLAIRE, EPFL — A reduced-order model, based on multi-scale homogenization, allows one to simulate the hydrodynamic interactions between a rigid membrane and a surrounding incompressible fluid flow. The model, intuitive, robust and computationally cheap, is able to provide a description of the micro- and macroscopic fluid behavior and consists of a constraint to be satisfied by the fluid velocity $\mathbf{u}$, imposed within the fluid domain, over a virtual smooth surface passing through the center of each membrane pore

$$\mathbf{u} = -\mathbf{M} : \mathbf{\Sigma}^{-} - \mathbf{N} : \mathbf{\Sigma}^{+},$$

where $\mathbf{\Sigma}^{\pm}$ denotes the upward and downward fluid stresses and $\mathbf{M}$, $\mathbf{N}$ the upward and downward Navier tensors, which can be computed once and for all at the pore-scale. The model shows that the membrane produces a jump in fluid stresses whose intensity and direction, evaluated solving problems at the microscale, depend on the external flow and on the pore geometry. To assert the validity of the macroscopic model developed, its solution is compared with the solution of the full-scale problem. Finally, known laws describing flows through porous media or over rough surfaces (like Darcy law or Navier slip condition) can be deduced from this model as particular cases.

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