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Vortex-based penalized method for permeability estimation of real samples

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SUMMARY

The investigation of fluid flow at the pore scale, based on X-ray scans of real samples, is one of the most challenging problems in CFD. Flow simulation at this scale is difficult because of the inherent complexity of the geometry, which includes a fluid-solid interface with possible roughness. The high resolution needed to capture relevant geometrical details has to be handled without using tremendous memory resources, excluding traditional assembling methods like finite elements or finite volumes. In our study, we use a robust hybrid grid-particle method [1, 2] to solve the advection-diffusion problem. The complete problem writes in the domain Ω

$$\begin{cases} u = \bar{u} \text{ in solid domain,} \\ -\text{div}(2\mu(\alpha, u)D(u)) = f - \nabla P \text{ in fluid domain ,} \\ \text{div} u = 0 \text{ in } \Omega, \\ \partial_t \alpha + u \cdot \nabla \alpha - \eta \Delta \alpha = 0 \text{ in } \Omega, \end{cases} \tag{1}$$

where u is the fluid velocity, $D(u) = (\nabla u + \nabla u^T)/2$, μ is the fluid viscosity, f is the external force, P is the pressure, α is a transported quantity of interest and η is its diffusion coefficient. In [3], we use the penalized version of (1) to get existence and unicity of the solution. The numerical method that allows permeability prediction [4] is then built with a velocity/vorticity splitting for Stokes solution.

References

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