Towards implicit multi-scale wall-laws for Poiseuille flows in rugous straight geometries

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Abstract

Recent in-vivo experiments show that wired metallic multi-layer stents present bio-compatibilty features: endothelial cells form a deposit slowly integrating the device into a stable part of the artery. This phenomenon is widely multi-scale and multi-model. We consider the flow part, and we model stent's wires as a periodic rugous boundary perturbation of the Stokes problem (see [4],[1]). We construct high order boundary layer approximation. Then we show that there is now way to obtain high order wall laws by standard averaged wall-laws. We propose a new framework including multi-scale features into explicit and implicit wall-laws. We provide convergence rates wrt to ϵ, the rugosity's characteristic length, with periodic boundary condition at inlet and outlet of the domain. In the more realistic case of a pressure drop, we propose a new and general approach when considering vertical boundary layers. While in the periodic case high order wall-laws provide exponential convergence [2] we show that in the pressure drop case convergence rate locates between 2 and 2.5 (see [3]). Numerical simulations show the optimality of our estimates.

Keywords: Rugous boundary, perturbed poiseuille flow, boundary layer approximation, wall laws, convergence rates, Navier or Saffman-Joseph's wall laws.

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