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Mathematical Modelling Towards the Open Problem of Incompressible Viscous Flow at a Fluid-porous Interface

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We discuss mathematical modelling and analysis of the incompressible viscous flow at the interface of permeable media. Since the pioneering work published fifty years ago by Beavers and Joseph (1967) where a slip condition of the tangential velocity is introduced semi-empirically, many efforts and attempts have been made to obtain physically relevant interface conditions at the macroscopic scale. Unfortunately, the results for the non-inertial viscous flow obtained semi-empirically and/or experimentally, with theoretical upscaling methods as multi-scale homogenization, matched asymptotic expansions or volume averaging, or also with filtered direct numerical simulations are till now mainly restricted to the unidirectional channel or shear flow, nearly parallel to the porous bed. Very recently, a simplified theory with asymptotic modelling and related approximations is extensively developed in [2] which provides physically relevant jump interface conditions for the two- or three- dimensional non-inertial flow at the interface of a permeable medium. This method not only supplies the general expression of the jump equations for both the stress and velocity vectors at the interface, but also gives correlations of the associated slip and friction coefficients with respect to porosity ϕ and depending on the chosen scaling. The results of well-posedness analysis proved in [1] for three problems issued from the asymptotic modelling and covering the whole porosity range $0 < \phi < 1$ will be described. Finally, some

perspectives are proposed to deal with the multi-dimensional inertial flow by the same asymptotic modelling which provides nonlinear jump interface conditions.

References

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