Asymptotic analysis of a fluid-structure-porous layer coupled model near contact

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The numerical simulation of systems involving fluid-structure-contact interaction raises many modeling, mathematical and numerical difficulties. It is in particular crucial for numerous biomedical applications such as the simulation of cardiac valve dynamics (native or artificial) for instance.

Fluid-structure interaction without contact is already challenging due to the moving geometries and the potential strong coupling between the solid and the fluid subsystems. If contact between solids is to be modeled as well, the complexity increases with additional difficulties among which:

- In some configurations and with no-slip boundary conditions, fluid-structure interaction models are unable to predict contact (see, e.g., [1, 4, 5]), this is the so called no collision paradox;
- The simple addition of a contact constraint (variational inequality) to a fluid-structure interaction model which allows for contact yields a mechanically inconsistent fluid-structure-contact interaction (see [6, 7]).

The first difficulty can be solved by modifying the boundary and interface conditions on the contact walls (see, e.g., [8, 9, 10]). However this is not necessarily enough to obtain a mechanically consistent model. An alternate approach considered in [6, 7] to circumvent these two issues is to consider a poroelastic modeling of the fluid seepage induced by the roughness of the contacting solid. Yet, very little is known on the mathematical foundations of this approache. In this work, we analyze the ability of such a model to encompass contact. We consider a 2D fluid-ball interaction problem and we build on the approach proposed in [4, 11] to evaluate the behaviour of the drag force with respect to the gap between the solid and the wall. The asymptotics of the model with respect to the porous layer parameters are also investigated. Finally, numerical evidence of these theoretical results is provided.

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