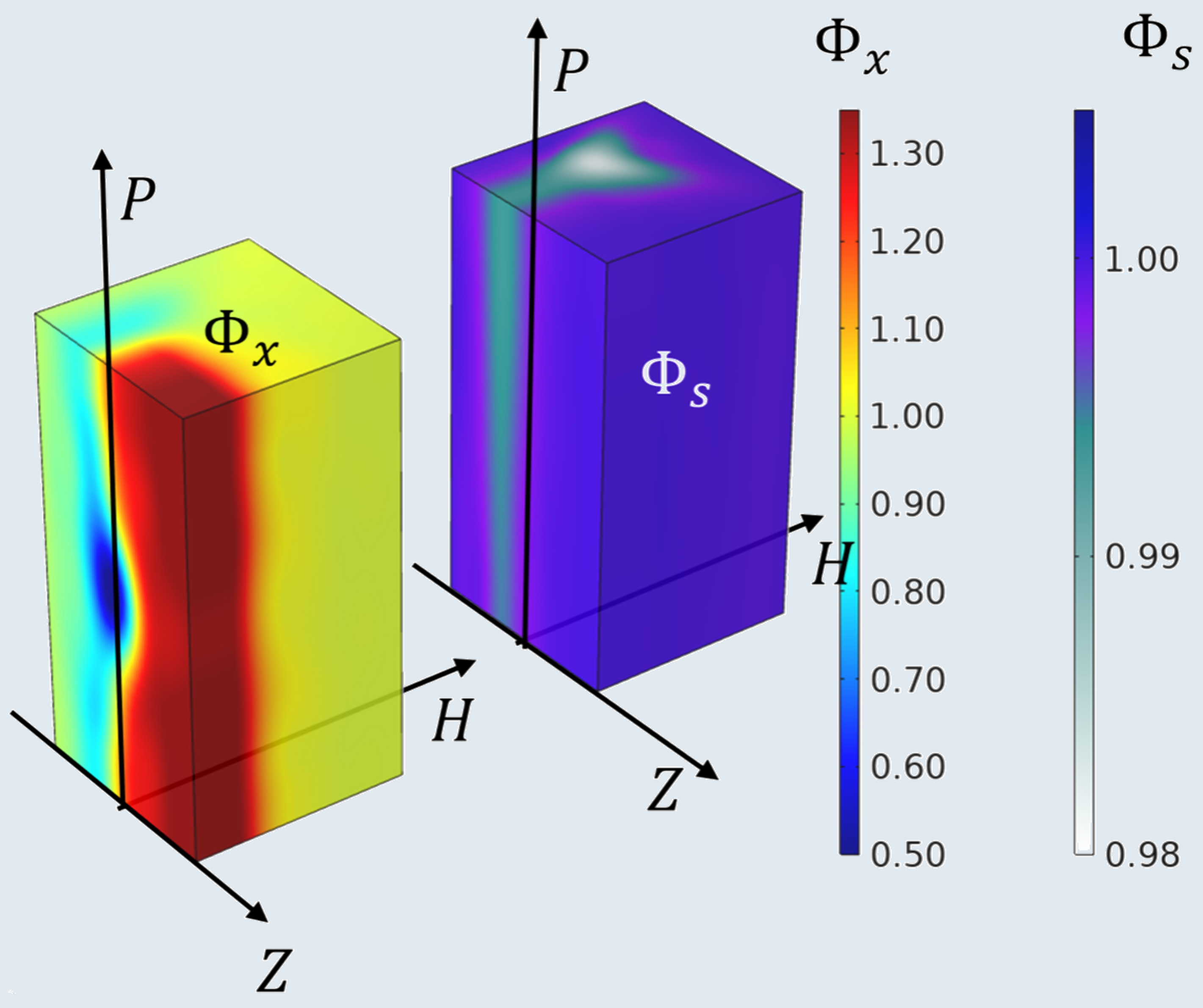

Lubrication of Industrial Contacts: Accounting for Roughness Contribution with a Reduced Order Model

Real life industrial contacts show rough surfaces, but lubrication models often consider ideal smooth surfaces instead: can homogenization method break the computation cost limit?

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Introduction and goal

The modeling of smooth concentrated contact lubrication has been achieved a few decades ago [1]. However, industrial contacts show rough surfaces where roughness amplitude compares with film thickness.

Most of the time, it is impossible to represent explicitly the roughness in the contact models because of the associated computation cost: this method is referred to as **explicit**. An alternative possibility consists in decoupling the roughness scale from the contact scale (see Figure 1) through homogenization method. Such method is developed and presented by Checo et al. [2], but the computation cost remains high.

In the present study, the roughness scale is computed first, and the precomputation results are gathered in a reduced order model (ROM). The contact model then calls the ROM at limited computation cost.

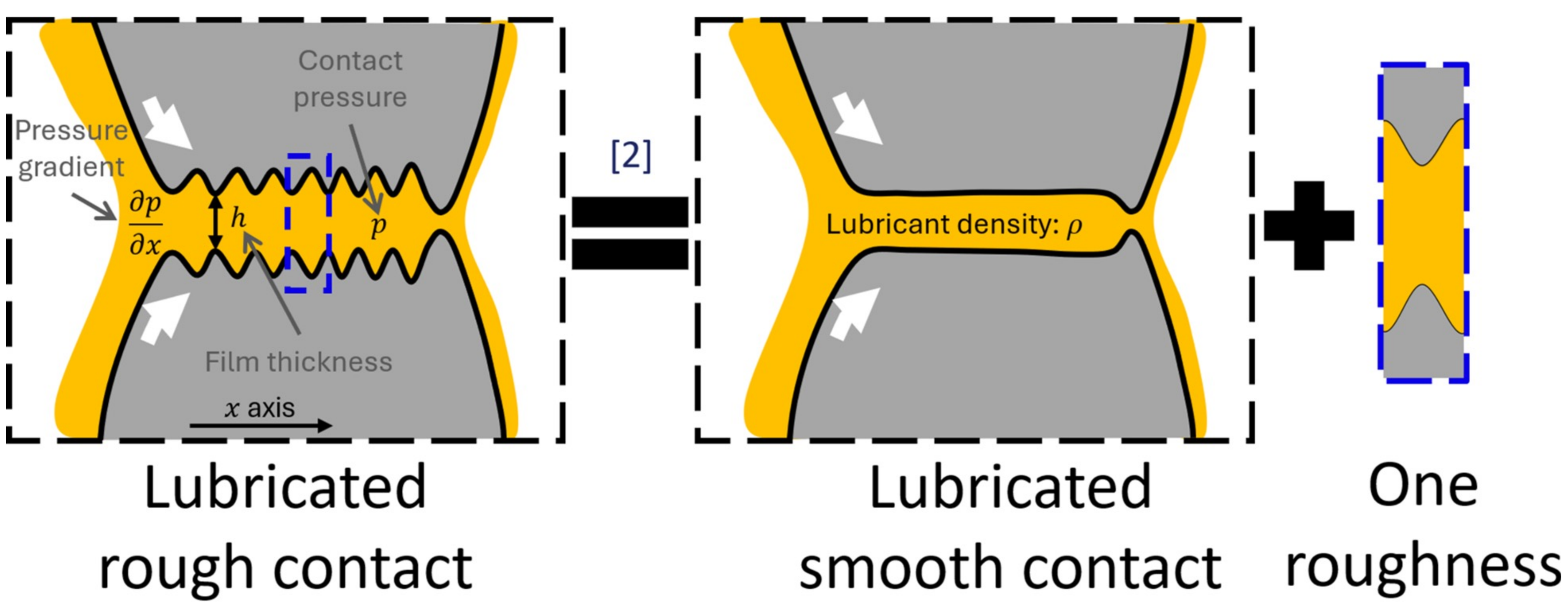

FIGURE 1. Homogenization method applied to lubricated contact

Methodology

The periodic homogenization method applied to a stationary Reynolds Equation (RE, a lower dimension Navier-Stokes equation) determines a contact scale RE:

$$\frac{\partial}{\partial x}\left(\frac{\rho h^3}{12\eta}\Phi_x\frac{\partial p}{\partial x}\right) - u_e\frac{\partial}{\partial x}(\rho\Phi_s h) = 0$$

where Φ_x and Φ_s are flow factors defined by the roughness scale computation results. Those depend on local condition h, p and $\partial p/\partial x$: the 3D space defined by the condition is explored through multiple computation in a machine learning method based on DACE MATLAB® library [3]. Subsequent ROMs are built and called *in fine* by the contact model.

Results

To build the Φ_x and Φ_s ROMs, the space of the conditions is mapped using dimensionless normalized variables H, P and Z (instead of respectively h, p and $\partial p/\partial x$). A few hundred roughness computations are run at a large computation cost, and the results are displayed in the introduction figure.

Based on these ROMs, the rough contact film thickness envelope is computed using **Homogenization (this study)** at a computation cost comparable to its **Smooth** equivalent. They are both displayed in Figure 2, together with the **Explicit** solution and the results from Checo et al. [2] method (**Homogenization FE²**). Roughness influences sensibly the film thickness and homogenization methods compare well with the **Explicit** solution. More developments are required to improve ROMs computation costs.

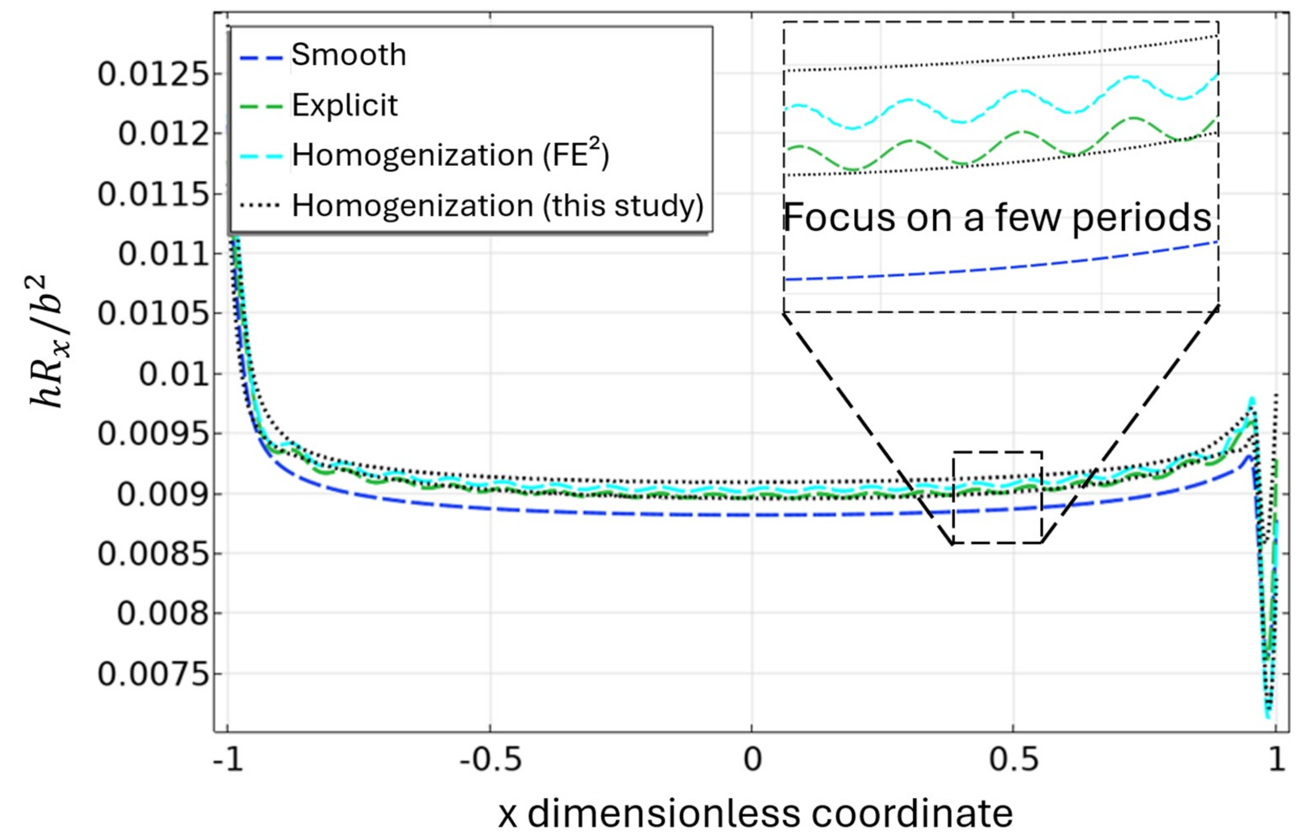

FIGURE 2. Film thickness prediction comparison

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