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Multiscale Modeling of Soft Matter Friction: Computational Framework and Elastic Boundary Layers

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A computational contact homogenization framework is established for the modeling and simulation of soft matter friction. The main challenges towards the realization of the framework are (i) the establishment of a frictional contact algorithm which displays an optimal combination of accuracy, efficiency and robustness, and which plays a central role in (ii) the construction of a micromechanical contact test within which samples of arbitrary size may be embedded and which is not restricted to a single deformable body. The former minor challenge is addressed through the extension of mixed variational formulations of contact mechanics to a mortar-based isogeometric setting where the augmented Lagrangian approach serves as the constraint enforcement method. The latter major challenge is addressed through the concept of periodic embedding, with which a periodically replicated C^1-continuous interface topography is realized across which not only pending but also ensuing contact among simulation cells will be automatically captured. Two- and three-dimensional investigations with unilateral/bilateral periodic/random roughness on two elastic micromechanical samples demonstrate the overall framework and the nature of the macroscopic frictional response.