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A theory for the drag reduction of superhydrophobic surfaces with surfactant in laminar three-dimensional flows[1] FERNANDO TEMPRANO COLETO, SCOTT SMITH, University of California Santa Barbara, FRANOIS PEAUDECERF, ETH Zrich, JULIEN LANDEL, University of Manchester, FRDRIC GIBOU, PAOLO LUZZATTO-FEGIZ, University of California Santa Barbara — In recent years, surfactants have been shown to have a crucial impact on the drag reduction of superhydrophobic surfaces (SHS) in laminar flows (Peaudecerf et al. PNAS, 2017; Song et al. PRF, 2018). Even trace amounts of these substances induce adverse Marangoni stresses that can negate the drag reduction of SHS. Including these effects in theoretical models is therefore essential to accurately predict the drag in realistic conditions, where surfactants are unavoidable. Our existing theory for SHS inclusive of surfactant (Landel et al. arXiv:1904.01194, 2019) considers a two-dimensional flow, which is sufficient to capture the streamwise accumulation of surfactant at the air-water interface. Here we build upon this model, expanding it to account for the drag of a fully three-dimensional laminar flow over an array of superhydrophobic rectangular gratings. This extended theory predicts the slip length and drag as a function of ten dimensionless numbers, including two novel ones that account for the spanwise geometry of the gratings. Finally, the performance of the model is tested against numerical simulations of the full problem.

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