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Drag reduction in laminar and turbulent flows past superhydrophobic surfaces

JONATHAN P. ROTHSTEIN, University of Massachusetts Amherst

A series of experiments and direct numerical simulations (DNS) will be presented which demonstrate significant drag reduction for both laminar and turbulent flows of water through channels using superhydrophobic surfaces with well-defined micron-sized surface roughness. The surfaces are fabricated from PDMS to incorporate precise patterns of ridges or posts that can support a shear-free air-water interface. A flow cell is used to measure the pressure drop and velocity profile as a function of the flow rate for a series of channel geometries and superhydrophobic surface designs. DNS are performed for flow past superhydrophobic surfaces which both complement and extend the range of geometries and Reynolds number obtained in the experiments. We will show that drag reductions up to 75% and slip lengths up to 150μm can be obtained in turbulent flows past superhydrophobic surfaces. Additionally, we will show that slip along the air water interface forestalls the transition from laminar to turbulent flow. The drag reduction is found to increases with increasing post/ridge spacing and the fraction of air-water interface. In turbulent flows, the drag reduction increases with Reynolds number before eventually reaching a plateau. These results suggest that in turbulent flows, the drag reduction scales with the thickness of the viscous sublayer and not the overall channel height as in laminar flows.