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Controlling laminar-to-turbulent transition with superhydrophobic surfaces

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Tailoring bio-mimetic rough surfaces researchers are accessing new approaches reducing drag in wall bounded shear flows. Among them Underwater SuperHydrophobic Surfaces (U-SHS) have proven to be capable of dramatically reduce skin friction of an overlying liquid turbulent flow, providing a stable, lubricating layer of gas bubbles trapped within the surface's nano-sculptures. As long as a specific set of geometrical and thermodynamical conditions are ensured, wetting transition is avoided and the no-slip boundary condition at the wall is relaxed; this so called 'Lotus effect' is typically achieved when the length scale of U-SHS roughnesses is several order of magnitudes smaller than the overlying flow, bringing out both experimental and numerical challenges.
In this framework we want to study, by means of numerical simulations, the influence of U-SHS in a closed channel, following the complete evolution from laminar, to transitional and fully developed turbulent flow. We report the results of transition over U-SHS taking into account the dynamics of each microscopic liquid-gas free-surface by means of a fully coupled fluid-structure solver and show that U-SHS can triple transition time to turbulence.
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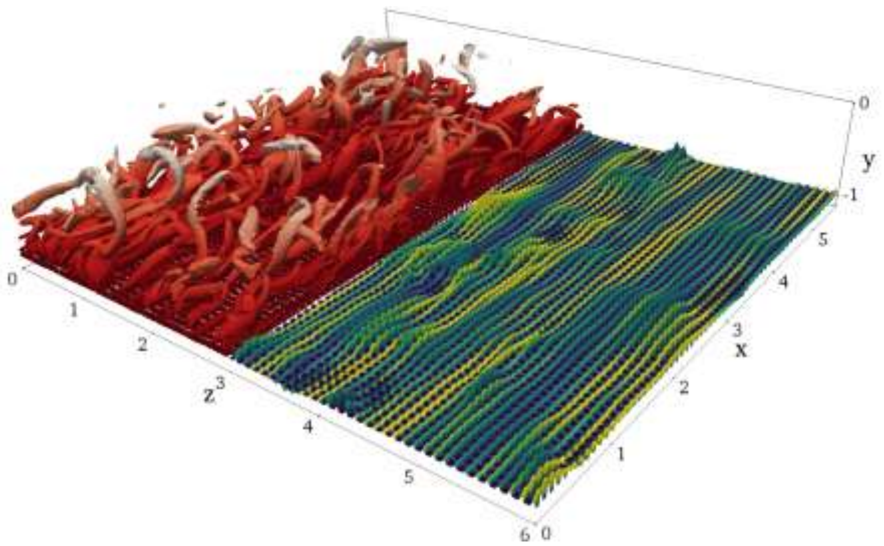

Figure 1: Direct numerical simulation of a transitional channel flow. The onset of coherent structures, here visualised as isosurfaces of the λ_2 criterion on the left is consequence of the laminar-turbulent transition. Here the phenomena is enhanced by the movement of the underlying U-SHS free-surface, on the right, interacting with the overlying transient flow. Note that, to be *wetting stable*, U-SHS roughnesses has to be much smaller than the turbulent structures that they must support.

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