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The logarithmic layer of wall-bounded turbulent flows[1]

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The relatively high Reynolds numbers now available in numerical simulations of wall-bounded turbulence allow us to study the flow dynamics well above the viscous wall layer. In particular, we can now observe, manipulate, analyze, and follow in time, the hierarchy of eddies linked to the range of wall distances usually associated with the logarithmic velocity profile. At sufficiently high Reynolds numbers, most of the velocity drop in a boundary layer happens in that region, and the practical large-eddy simulation of attached turbulent flows requires that the dynamics of those self-similar "logarithmic" eddies should be understood well enough to be able to synthesize boundary conditions well above the viscous layer. This talk surveys what has been learned in the last decade. We will see that the logarithmic layer is populated by several self-similar families of eddies connecting the viscous wall structures with the largest outer ones. They have internal Reynolds numbers of the order of thousands, are themselves turbulent, and are better characterized by their energy and Reynolds stresses than by their vorticity. They can be followed in time in full simulations, or in isolation in small numerical boxes, and their dynamics is dominated by a quasi-periodic bursting cycle with a well-defined life history that has much in common with those observed in other shear flows. Those bursts carry most of the Reynolds stresses, and do not appear to be particularly associated with the wall or with the outer flow. They continue to be created and maintained even when either of those "end points" is strongly disturbed. As an example, we will show that it is possible to synthesize a reasonably normal logarithmic layer by applying artificial turbulent off-wall boundary conditions; the key ingredient seems to be the correct modeling of the change of the length scales with the distance to the wall.

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