Mean Impulse Response in a Turbulent Channel Flow

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The linear response of a turbulent channel flow to an impulsive body force is measured through direct numerical simulations. The linear response can be used for many different purposes, such as the design or optimization of flow control techniques acting through body forces like plasma actuators, the understanding of how perturbations propagate in turbulent flows, or to assess turbulence models for the closure of the Reynolds-averaged Navier–Stokes equations.

Focusing on flow control applications, the impulse response is an effective tool to perform a sensitivity analysis, capable to determine in a statistical sense *where* and *in which direction* a volume force exerts its maximal influence in a turbulent flow. Moreover the time evolution of the response can also describe in detail *where* and *at which delay* the effects of the volume force affect the flow.

In this work we provide for the first time a detailed and complete space-time description of the impulse response of both laminar and turbulent flows to an impulsive volume force. Particular attention is given to the wall-normal distance at which the body force is applied, which is an important parameter in flow control applications based on plasma actuators.

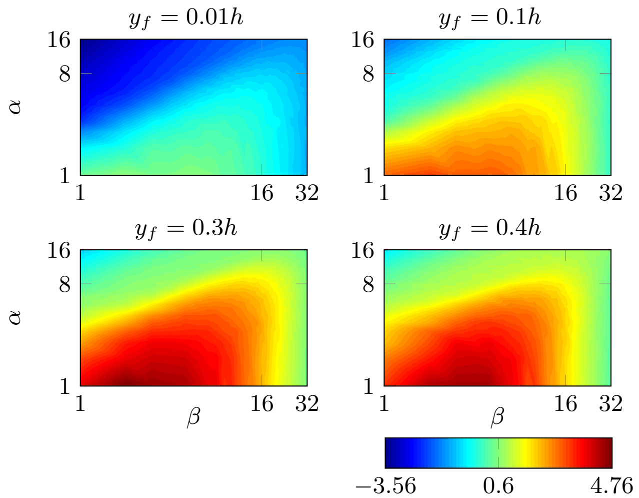

Figure 1: *

Dependence of the norm of the impulse response $\mathcal{H}_{zu}$ on the forcing location y_f from the lower wall. The colormaps show the intensity of $\|\mathcal{H}_{zu}\|_2$ as a function of the wavenumbers α and β which describe the homogeneous directions of a plan channel flow. Among the nine components of the impulse response $\mathcal{H}_{zu}$ shows the effects of a forcing in the spanwise direction f_z on the streamwise velocity u.

Andrea Codrignani is currently postdoctoral researcher at the Institute of Microsystems Engineering at the University of Freiburg in Germany, where he mainly works on the numerical modelling of tribological phenomena and the optimization of textured surface for sliding contacts. He obtained a master degree in Aeronautical engineering at Politecnico di Milano in 2014 and subsequently earned his doctorate in Mechanical engineering at the Karlsruhe Institute of Technology in 2018.