# INTER-SCALE CAUSALITY IN NEAR-WALL TURBULENCE

Zengrong Hao[1] and Ricardo García-Mayoral[2]
*Department of Engineering, University of Cambridge, CB2 1PZ, UK.*
*E-mail: r.gmayoral@eng.cam.ac.uk*

This work aims to map how information is transferred between different lengthscales through the momentum equations in near-wall turbulence, with a particular focus on streamwise and spanwise lengthscales. For this we use direct simulations in streamwise-spanwise-periodic turbulent channels. In this setup, the flow can be viewed as a dynamical system where the state space variables $\phi = \{u, w, v, p\}$ are the streamwise ($x$), spanwise ($z$) and wall-normal ($y$) velocities and the pressure, which depend on the $x$- and $z$-wavenumbers $\mathbf{k} = (k_x, k_z)$, $y$, and $t$. The evolution equations for $\phi$ are the Navier-Stokes equations plus the continuity equation, which can then be written as

$$F(\phi_{\mathbf{k},y,t}) = N(\psi_{\mathbf{k}',y,t}, \psi_{\mathbf{k}+\mathbf{k}',y,t}),$$

where $F$ represents the linear part of the equations and $N$ the nonlinear terms, which are responsible for the transfer of information from other lengthscales into lengthscale $\mathbf{k}$. The objective of this work is to quantify the relative importance of the different terms in $N$. The aim is to obtain results such as: $w$ in wavelength $\lambda_1$ in combination with $\partial_z u$ in wavelength $\lambda_2$ play a significant role in the dynamics of $u$ in wavelength $\lambda_3$, and so forth – note that, in turn, $u$ in wavelength $\lambda_3$ and $\partial_z u$ in wavelength $\lambda_2$ do not appear combined in the momentum equation for $w$ in wavelength $\lambda_1$. While intimately connected to triadic interactions, which are obtained from energy considerations, this analysis, relying instead on the momentum equations, aims to add a layer of directionality (i.e. causality) to the triple interactions.