Scale-space budget equations for inhomogeneous (quasi-)periodic turbulent flows

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Turbulent flows with periodic or quasi-periodic features are often encountered in fluid mechanics. Such coherent motions due to either an external periodic forcing or to some instability mechanism (e.g. the wake after a bluff body) interact with the stochastic turbulent fluctuations and affect their organisation.

To describe this interaction, this work derives the exact budget equations for the coherent and stochastic contributions to the second-order structure function tensor, extending the Anisotropic Generalised Kolmogorov Equations[1] (AGKE) with a triple decomposition of the velocity and pressure fields. While the original AGKE describe production, transport, redistribution and dissipation of the Reynolds stresses in the combined space of scales and positions, the new equations, named phi-AGKE, additionally feature the phase-by-phase interplay among the mean, coherent and stochastic fields.

The phi-AGKE are demonstrated by applying them to a turbulent channel flow forced by periodic spanwise wall oscillation[2]. The phase-by-phase action of the spanwise Stokes layer induced by the wall oscillation on the near-wall turbulent structures is brought to light, and the scale-space interaction between the mean, coherent and stochastic fields is described.

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[1] Gatti et al., *J. Fluid Mech.* **898**, A5 (2020).

[2] Jung et al., *Phys. Fluids A.* **4(8)**, 1605 (1992).

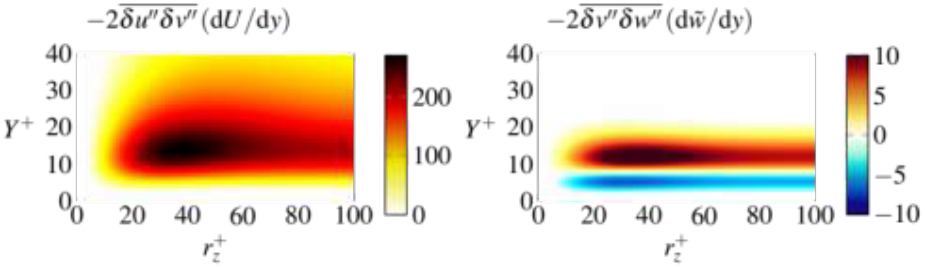

Figure 1: Mean production that feeds the stochastic field (left), and coherent production that feeds/drains the stochastic field (right); in both panels, production is drawn as a function of the distance from the wall (Y^+) and the spanwise scale (r_z^+), for a given phase of the wall oscillation.