# Turbulence modeling in the QR space

Flavio Tuteri[1], Alexandros Alexakis[1], Sergio Chibbaro[2]

[1] Laboratoire de Physique de l'Ecole normale supérieure, ENS, Université PSL, CNRS, Sorbonne Université, Université de Paris, F-75005 Paris, France
[2] Sorbonne Université, CNRS, UMR 7190, Institut Jean Le Rond d'Alembert, F-75005 Paris, France
flavio.tuteri@phys.ens.psl.eu

Turbulence is omnipresent in dynamical description of fluids, a huge class of phenomena sharing the multiscaling complexity which results in a very large number of degrees of freedom. This has made it impossible to Directly Numerically Simulate systems of engineering interest and is the reason why modelling is the highway.

Starting from incompressible 3D Navier-Stokes, a standard approach is to apply a spatial coarse graining and solve the equation for the large-scale field. Closing the model means give a shape to the unsolved action of the small-scales. The energy local flux across scales is then given, so the problem is intimately related to the hundred-year mystery of the energy cascade.

The velocity gradient tensor, describing the flow local topology, has played a prominent role in recent developments [1]. As new instrument of investigation, we set the analysis conditioned to the $QR$ space, the invariants of this tensor. Fig. 1 provides an example of the information highlighted by this analysis: blue region are backscatter dominated in mean whereas red points are direct cascade. The same can be done for a modelled flux.

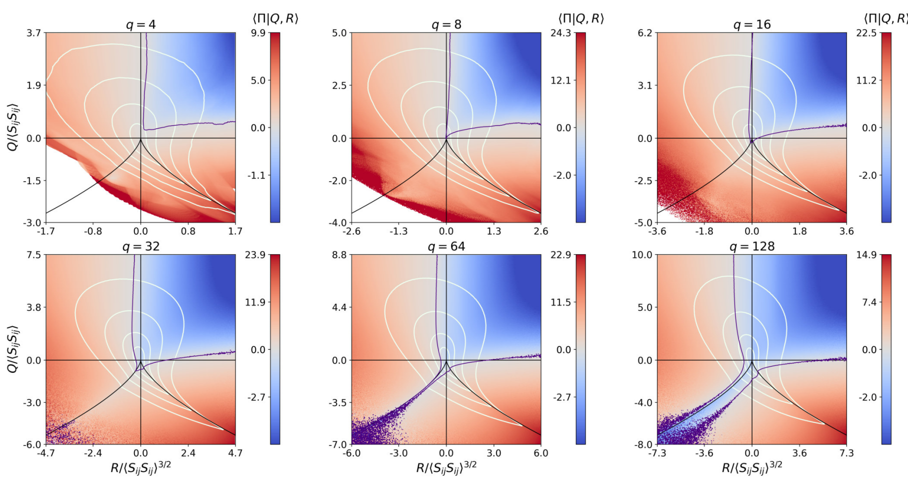


**Figure 1.** DNS mean flux $\Pi$ given invariants $Q$ and $R$ of the velocity gradient tensor for Gaussian coarse-graining at different scales $q$. Shown are isolines $p(Q,R) = 10^{-4}, 10^{-5}, 10^{-6}, 10^{-7}$ in white and $\langle \Pi | Q, R \rangle = 0$ in violet.

Of particular interest for this work is the Clark model, the local-in-scale approximation for a Gaussian filtering. Fluctuations from the mean are also studied.

## References

1. P. Johnson, On the role of vorticity stretching and strain self-amplification in the turbulence energy cascade, *J. Fluid Mech.*, **922**, A3 (2021).

© **Non-Linéaire Publications**, Bâtiment 508, rue John von Neumann, 91400 ORSAY