A local mechanism linked to the emergence of extreme events in the turbulent channel flow

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A potential precursor of extreme events is investigated using nonlinear optimization on the turbulent channel flow at $Re_\tau = 180$. An optimal perturbation to a generic three-dimensional turbulent field is searched using the direct-adjoint and gradient rotation method[1], to maximize the turbulent dissipation in a short time interval. The resulting optimal is localized in the near-wall region, displays the upstream tilting characteristic of the Orr's mechanism and is positioned along the interface between the streaks of the pre-existing turbulent velocity field. This perturbation leads to a breakdown of the pre-existing structures and engenders a strong peak in the global turbulent intensities. Thus, if the whole domain is perturbed, the flow exits from the turbulent attractor (Fig. 1(a)). However, the same mechanism can be recovered perturbing only a portion of the domain, showing that it is local in nature. The connection between this local instability of the streaks and the emergence of extreme events, suggested in a recent work[2], is addressed performing a statistical analysis on different realizations of the numerical experiment. As shown in Fig. 1(b), the probability density function distribution of the dissipation sampled in the perturbed zones displays a heavier tail with respect to the unperturbed flow, meaning a higher density of extreme events. Therefore, it is argued that the optimal perturbation captures a local mechanism which may be one of the causes of extreme events in wall turbulence.

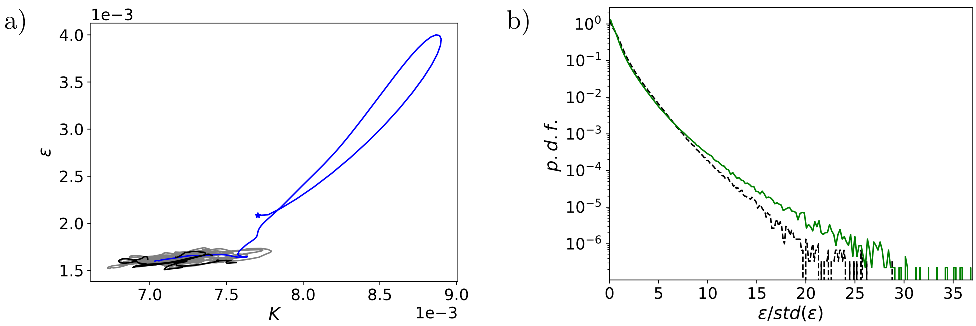

Figure 1: (a) Turbulent attractor projected in the TKE-dissipation ($K - \varepsilon$) space for the unperturbed flow (grey line), the fully perturbed flow (blue line) and the locally perturbed flows (black lines). (b) Probability density function distribution of the dissipation for the pertubed (solid green line) and the unperturbed (dashed black line) flows.

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[1]Foures et al., *J. Fluid Mech.* **729**, 672 (2013).
[2]Hack and Schmidt, *J. Fluid Mech.* **907**, A9 (2021).