# Extreme events and metastability in transitional shear flows

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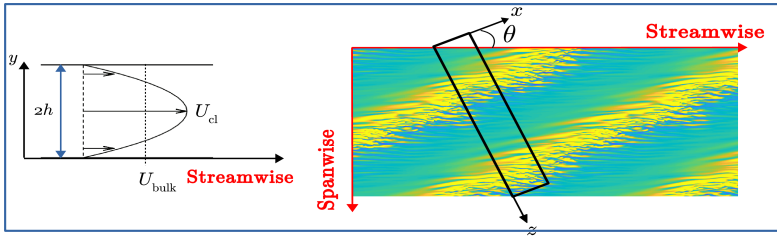
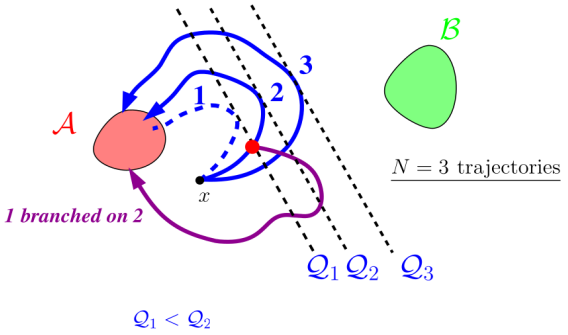



- Channel flow at low Re: intermittent, metastable, oblique turbulent-laminar patterns (bands)
- In a tilted geometry: independent bands can either proliferate (**split**) or collapse (**decay**) depending on Re.
- Lifetimes of bands are computable by DNS at high numerical cost : use of a rare event algorithm to stimulate transitions.



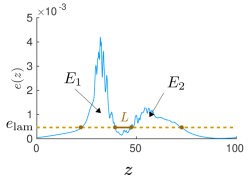

Cérou & Guyader, *Stoch. Anal. Appl*, 2007
Bouchet, Rolland & Simonnet, *PRL*, 2019

## The Adaptative Multilevel Splitting algorithm

- Generate N trajectories starting from A.
- Sort them via a score function Q (relative distance from A or B)
- Kill the worst trajectory and replace it by a clone of another random trajectory.

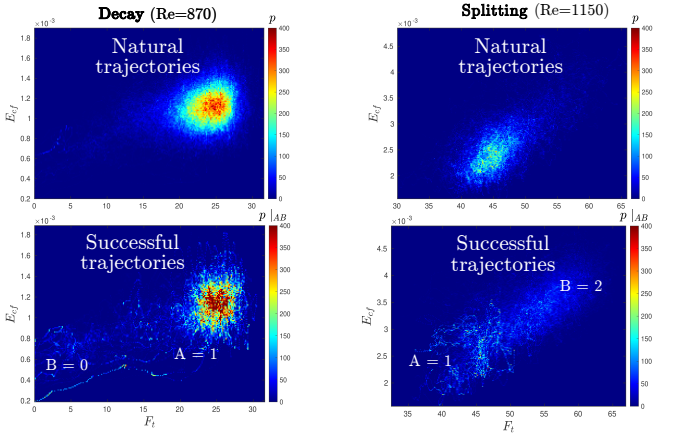
- A = 1 band, B = 2 or 0 bands
Q = improved turbulent fraction taking into account band localization.

$$\mathcal{Q} = F_t + L \times \left(\frac{E_2}{E_1}\right)^{\alpha}$$




## Instantons in the splitting or decay scenario

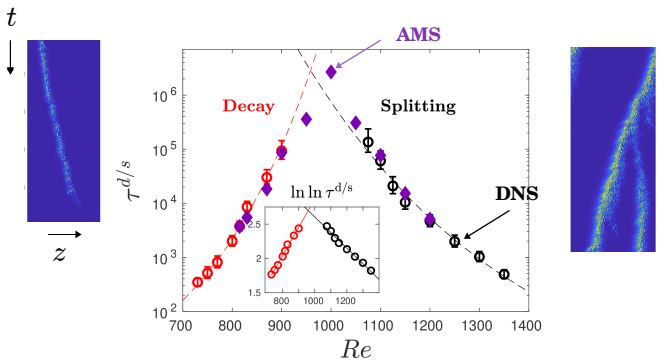
Successful trajectories concentrate into a reactive tube during decays or splits = signature of an **instanton**.




Grafke et al, *J. Phys. A*, 2015
Rolland, *PRE*, 2018

## Band lifetimes

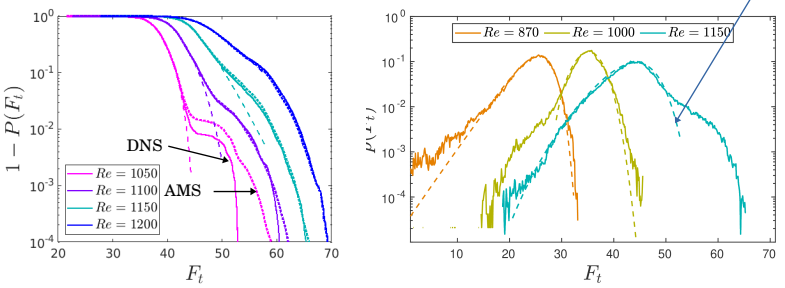
- Decay or splitting passage times are computed by both DNS and AMS.
- AMS and DNS show comparible estimates for the lowest time scales.
- Lifetimes depend super-exponentially on Re.




Gomé et al., *PRF*, 2020

## Extreme value theory

$$p = \gamma[1+\xi\gamma(\mu - F_t)]^{-\frac{\xi+1}{\xi}} \exp -(1+\xi\gamma(\mu - F_t))^{-1/\xi}$$




- Low tails of probability distributions are estimated with the AMS, at a lower cost than with DNS.
- Precursors to decay or split could be described by extreme value theory?

Goldenfeld et al, *PRE*, 2010
Nemoto & Alexakis, *JFM*, 2021