Towards a link between time-irreversibility and singularity in turbulent flows

Adam Cheminet[1], Damien Geneste[1], Antoine Barlet[1], Yasar Ostovan[2], Tarek Chaabo[2], Valentina Valori[1], Paul Debue[1], Christophe Cuvier[2], François Daviaud[1], Jean-Marc Foucaut[2], Jean-Philippe Laval[2], Bérengère Dubrulle[1]

[1] SPEC, CEA, CNRS, Université Paris-Saclay, CEA Saclay, Gif-sur-Yvette, France
[2] Univ. Lille, CNRS, ONERA, Arts et Métiers ParisTech, Centrale Lille, FRE 2017-LMFL-Laboratoire de Mécanique des Fluides de Lille-Kampé de Fériet, F-59000, Lille, France
adam.cheminet@cea.fr

In a turbulent fluid, the time-reversal symmetry is explicitly broken by viscosity, and spontaneously broken in the inviscid limit. Recently, Drivas [1] proved the equivalence of two different local indicators of time-irreversibility: i) an Eulerian one, based on regularity properties of the velocity field [3]; ii) a Lagrangian one, based on symmetry properties of the trajectories under time reversal [2].

Drivas [1], rigorously proved that under suitable limits, the Eulerian and Lagrangian irreversibility indicators converge to the same quantity ϵ, the local energy dissipation. This result is interesting because it provides two different indicators, one Eulerian, and one Lagrangian, that discriminate between regions where the fluid is or is not time-irreversible. By tracking dynamically in time and space such regions, one may then get hints of the physical processes that are responsible for the symmetry breaking.

In this talk, I will first test the equivalence of the two indicators in an experimental turbulent Von Kármán flow at a resolution of the order of the Kolmogorov scale using a high resolution 4D-PTV technique. I will then use the equivalence to perform the first joined Eulerian-Lagrangian exploration of the dynamics leading to time irreversibility, and find that it is linked with vortex interaction, suggesting a link between irreversibility and singularity (Figure 1).

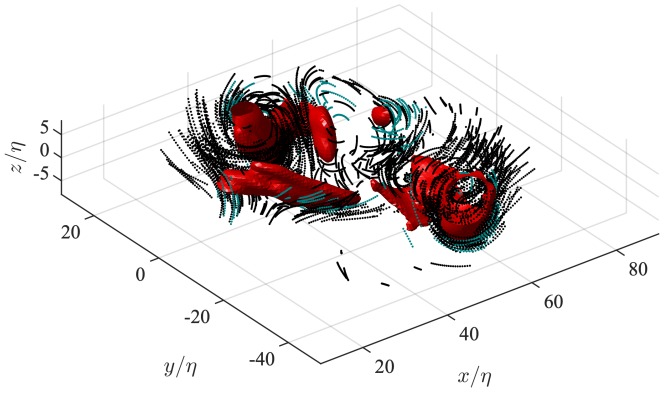

Figure 1: 3D visualization of Eulerian irreversiblity iso-surfaces (in red) and highly irreversible trajectories selected from the Lagrangian criterion in black (positive) and blue (negative).

References

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