Topology of quasi-singularities in an experimental turbulent swirling flow

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Even though they are more than 150 years old, the incompressible 3D Navier-Stokes equations remain an open mathematical problem [1] : the existence of a solution was proven by Leray [2] but it is still unknown whether such a solution is unique and regular. The quest for singularities in Navier-Stokes equations is of fundamental interest but may also have more applied consequences, regarding the relevance of numerical simulation and small scale modelling for instance. In this work we aim at providing insight on what such singularities may resemble and how they may form by studying the distribution and topology of extreme events of energy transfer in a real turbulent flow. Indeed, a singularity is characterized by a refinement of scales and may result in a non-zero or diverging inter-scale transfer with decreasing scale, as suggested by Duchon and Robert [3].

Local inter-scale energy transfer terms are computed from 3D-3C velocity fields, experimentally obtained by tomographic particle image velocimetry (TPIV) implemented in a compact set-up involving 5 cameras. Extreme events are detected following the methodology described in a previous work of the group [4], with the improvement that we are now able to measure the gradients in the three directions and compute the full transfer terms. This also allows to study the topology of such events following the classification provided in [5] and based on the velocity gradient tensor invariants.

Références

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