Extreme events of inertial dissipation in a turbulent swirling flow

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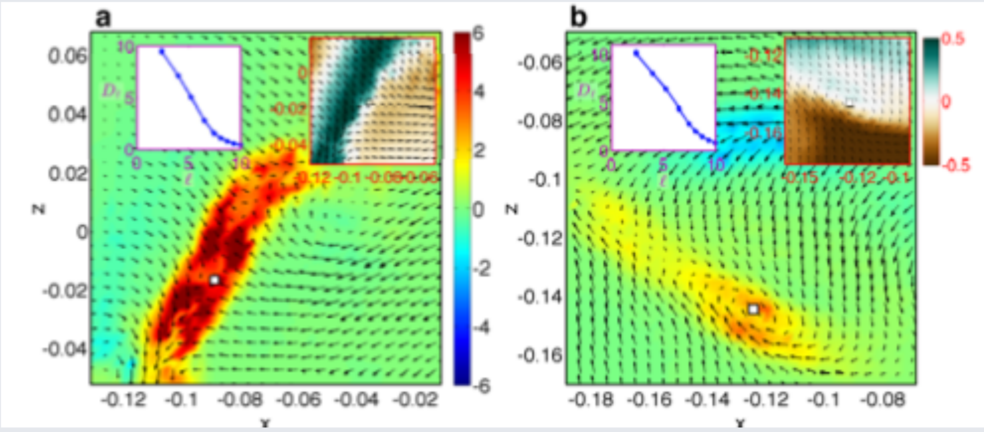
Many phenomena in nature involve motion of viscous flows, which are widely believed to be described by Navier-Stokes equations. These equations are used for instance in numerical simulations of flows in astrophysics, climate oraeronautics. In most of these areas, a central question is the description ofenergy dissipation. Indeed, it is a well-known experimental fact that the energydissipation rate of turbulent flows remains constant in the limit of vanishing viscosity. In the late 40's, Onsager suggested to connect this observation to the appearance of singularities of the Navier-Stokes equations, the existence of which have been postulated by Leray in 1933. However, mathematicians have failed so far to prove rigorously such a conjecture but show that that singularities, if exist, could only be rare events, Moreover, they may induce additional energy dissipation by inertial (non viscous) means.



Using measurements at the dissipative scale, we provide the first experimental estimate of such inertial energy dissipation in a turbulent swirling flow. Our methodology is directly based on a mathematical analysis of the Navier-Stokes equations by Duchon and Robert. We identify local events of extreme values. We characterize the topology of these extreme events and identify several main types. Most of them appear as fronts separating regions of distinct velocities, while events corresponding to focusing spirals, jets and cusps are also found. Our results highlight the nontriviality of turbulent flows at sub-Kolmogorov scales as possible footprints of singularities of Navier-Stokes equations.

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