The resistance of fluid flows is still an open problem in the fully-developed turbulent regime

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When fluid flows reach the fully-developed turbulent regime, one observes that the dissipation rate becomes independent of the fluid viscosity. We conjecture that, when the Reynolds number Re tends to infinite, viscous dissipation becomes negligible and turbulent dissipation, triggered by the nonlinear flow dynamics, takes over. To study this we consider the generic case of a jet hitting a wall. We perform direct numerical simulations of the two-dimensional Navier-Stokes equations in the vanishing viscosity limit, using volume penalization method to take into account the wall. We show that the energy dissipation first set up within a very thin vorticity sheet and then detachs from the wall and rolls up into a spiral where dissipation is maximal. We thus propose a new explanation of the d'Alembert's paradox, stated in 1752, which is based on turbulent dissipation rather than on viscous dissipation. Our observations are compatible with Kato's theorem, published in 1984, which proved that for dissipation to occur, anywhere in the flow and at any time, at least some dissipation had to occur in the vanishing viscosity limit within a very thin boundary layer whose thickness is proportional to Re^{-1}.

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