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Stochastic Lagrangian Dynamics of Vorticity in Wall-Bounded Flows: Turbulent Channel-Flow[1] AKSHAT GUPTA[2], Technical University of Munich, GREGORY EYINK[3], TAMER TAKI, The Johns Hopkins University —
We exploit an exact stochastic Lagrangian formulation of Navier-Stokes to study vorticity dynamics in a turbulent channel-flow at $Re_\tau = 1000$. "Stochastic Cauchy invariants" are conserved on average backward in time along stochastic Lagrangian particle trajectories, even as individual vorticity vectors are advected, stretched and rotated. At close prior times, conservation requires delicate cancellations between vorticity contributions from particles in the interior of the flow and those which strike the wall and remain fixed there. Far back in time, interior vorticity is represented by an average over vorticity that originated entirely at the wall. As in superfluids, cross-stream transport of tangential vorticity generated at the wall is exactly related to drag. We show that the process of vortex-lifting in the buffer layer is not an abrupt lifting of discrete vortex lines but is instead distributed over 100's of viscous times and 1000's of wall units. Despite simple arrays of "hairpin" vortex-lines, the dynamics involves intense competition between nonlinear Lagrangian chaos that exponentially magnifies & rotates vorticity and strong viscous destruction. We discuss the Lighthill-Morton theory of vorticity generation from this stochastic Lagrangian perspective.

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