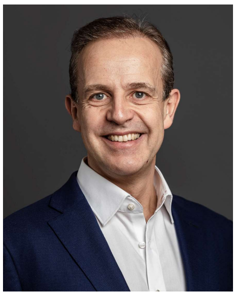
Material barriers to the transport of momentum and vorticity in turbulence

George Haller



ETH Zürich

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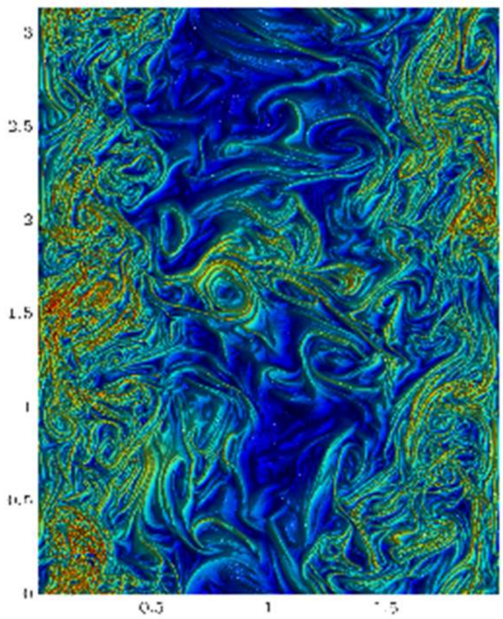
Abstract

I discuss a recent theory for material surfaces that maximally inhibit the diffusive transport of a dynamically active (i.e., velocity-dependent) vector field, such as the linear momentum, the angular momentum or the vorticity, in three-dimensional unsteady flows. These diffusion barriers provide physics-based, observer-independent boundaries of dynamically active coherent structures. Instantaneous limits of these Lagrangian diffusion barriers mark objective Eulerian barriers to short-term active transport. I show how active diffusion barriers can be identified with active versions of Lagrangian coherent structure (LCS) diagnostics. In comparison to their passive counterparts, however, active LCS diagnostics require no significant fluid particle separation and hence provide substantially higher-resolved Lagrangian and Eulerian coherent structure boundaries from shorter velocity data sets. I illustrate these results on two-dimensional turbulence and three-dimensional wall-bounded turbulence.



Short CV

George Haller received his Ph.D. in Applied Mechanics at the California Institute of Technology in 1993. He then spent a year as postdoc at the Courant Institute of Mathematical Sciences at New York University, prior to joining the Division of Applied Mathematics at Brown University as Assistant Professor in 1994. In 2001, he left Brown University as Associate Professor to join the Department of Mechanical Engineering at the Massachusetts Institute of Technology, where he became Professor in 2005. While still a professor at MIT, he became the first director of Morgan Stanley's Mathematical Modeling Center in Budapest, which he headed for three years. He then joined the Department of Mechanical Engineering at McGill University in 2009, serving as Department Chair till 2011. Over the period 2014-2018, he headed the Institute for Mechanical Systems at ETH Zurich, where he currently holds the Chair in Nonlinear Dynamics.