Abstract Submitted
for the MAR08 Meeting of
The American Physical Society

Topology and the Transition to Spatiotemporal Chaos[1]

NICHOLAS OUELLETTE, Haverford College, J.P. GOLLUB, Haverford College and University of Pennsylvania — Locations in a vector field where the field magnitude vanishes have special topological significance. For the case of the velocity field of a two-dimensional incompressible fluid, these points come in two types: elliptic (in vortex cores) and hyperbolic (non-rotating stagnation points). Here, we show a novel method for identifying these special points in experimental data sets by considering the local curvature of fluid element trajectories in a thin layer of conducting fluid driven by electromagnetic forcing. By constructing a curvature field, we show that regions of locally high curvature indicate the presence of hyperbolic and elliptic points. By then tracking the motion of these points in time, we show that their dynamics shed light on the transition of the flow to a spatiotemporally chaotic state. When the driving is weak, the hyperbolic and elliptic points are pinned to locations determined by the forcing geometry; when the driving is strong, they wander over the flow domain and interact pairwise. By comparing the behavior of several base flows, we show that our methods are robust even for complex flow situations.

[1]Supported by NSF-DMR-0405187.

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Date submitted: 30 Nov 2007

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