12-31-2008

Detecting Topological Features of Chaotic Fluid Flow

Nicholas T. Ouellette
Yale University

Jerry P. Gollub
Haverford College; University of Pennsylvania, jgollub@haverford.edu

Follow this and additional works at: http://repository.upenn.edu/physics_papers

Part of the Physics Commons

Recommended Citation

Suggested Citation:

© 2008 American Institute of Physics. This article may be downloaded for personal use only. Any other use requires prior permission of the author and the American Institute of Physics. The following article appeared in Chaos and may be found at http://dx.doi.1063/1.2997332.

This paper is posted at ScholarlyCommons. http://repository.upenn.edu/physics_papers/94
For more information, please contact repository@pobox.upenn.edu.
Detecting topological features of chaotic fluid flow

Nicholas T. Ouellette¹ and J. P. Gollub²,³

¹Yale University, New Haven, Connecticut 06520, USA
²Haverford College, Haverford, Pennsylvania 19041, USA
³University of Pennsylvania, Philadelphia, Pennsylvania 19104, USA

(Received 17 September 2008; published online 31 December 2008)

DOI: 10.1063/1.2997332

Traditionally, fluid flows are characterized by studying their velocity fields. New experimental techniques based on following the motion of tracer particles give us more information and allow us to study the geometric and topological properties of the flow. In particular, we can use the curvature of particle trajectories to help us locate the primary topological feature of the flow.

By driving electric current across a layer of conducting fluid positioned above an array of permanent magnets, we produce quasi-two-dimensional flow.¹² A square lattice of alternating north and south poles produces a square vortex lattice at low Reynolds number (Re) that becomes disordered as Re increases, as shown in Fig. 1.

We measure the instantaneous curvature for each of our thousands of simultaneous particle trajectories and thereby construct a curvature field, as shown in Fig. 2. The local maxima of the curvature field indicate the topological singularities of the flow.¹² In two dimensions, these points are either hyperbolic (saddle points) or elliptic (vortex cores).

As Re increases, the hyperbolic and elliptic points make larger excursions from their forced locations, until they break free from the forced lattice. They also appear and disappear in pairs beyond the onset of spatiotemporal chaos.¹²

This work was supported by the National Science Foundation under Grant No. DMR-0405187.