The Chaos Revolution!

1970s and 1980s

Transitions in fluids (and population biology, chemical reactions, circuits, …)

Deterministic equations can behave chaotically.

Turbulence/chaos can arise from a small number of transitions.

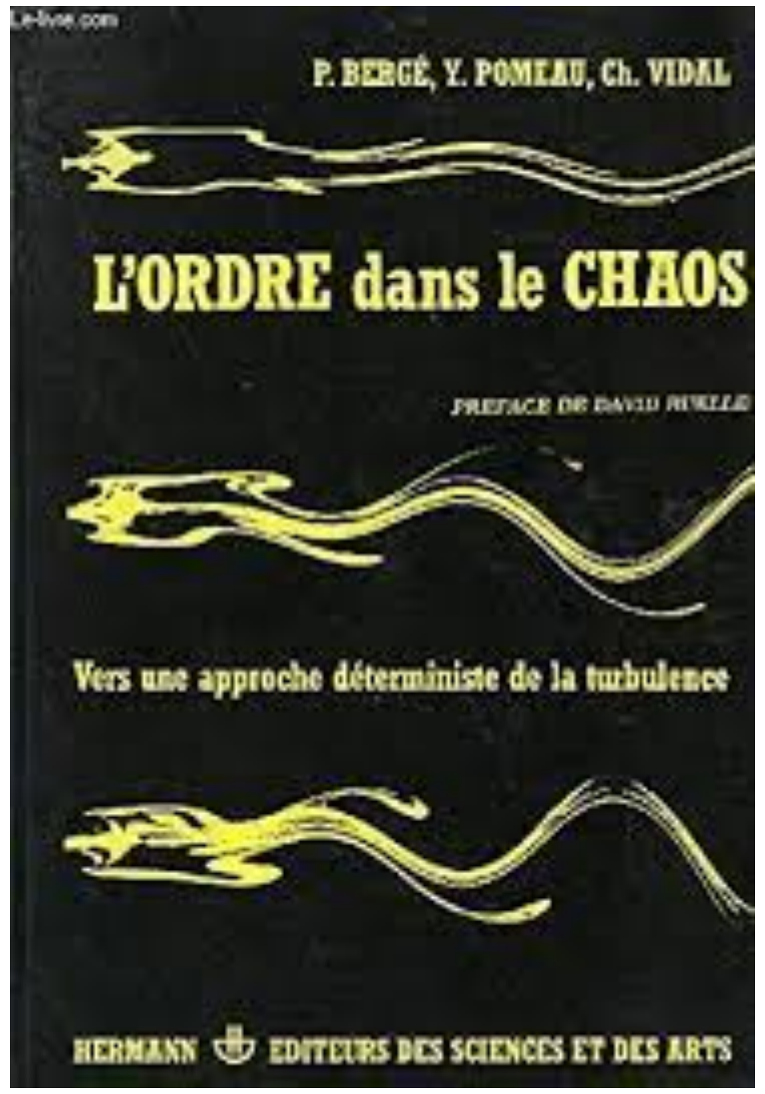
France: Paris, Nice, Saclay, Bordeaux

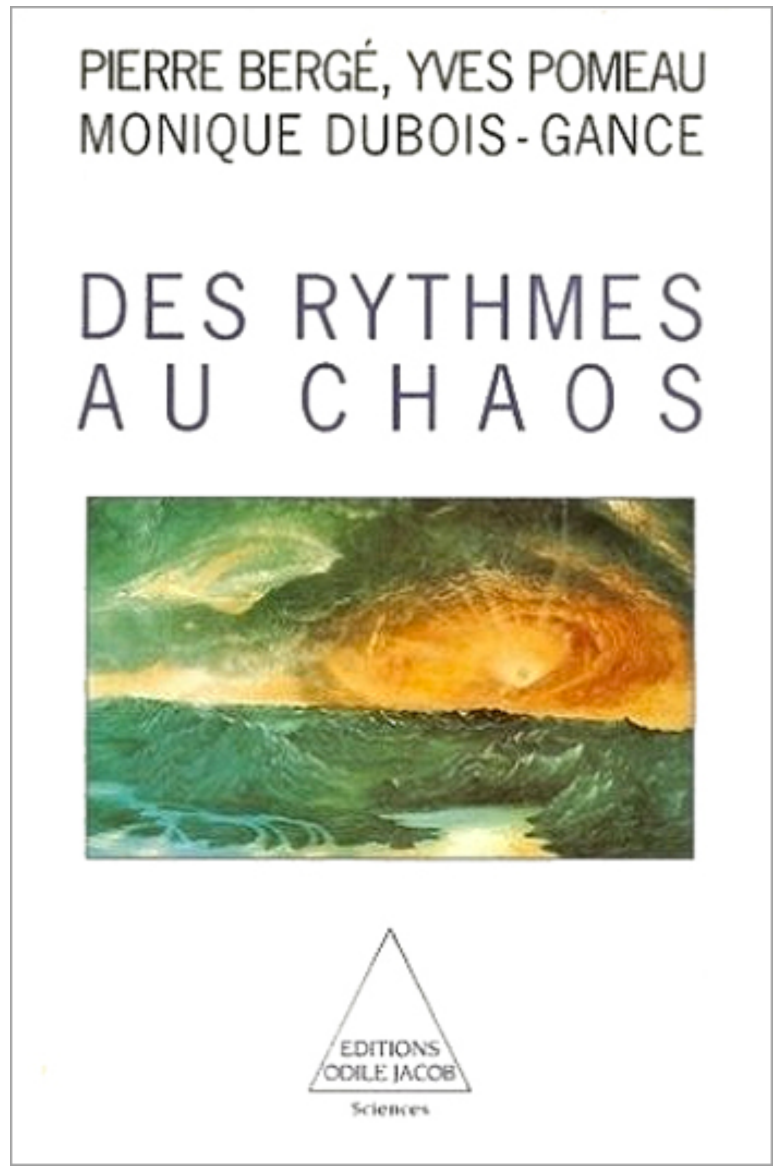
US: Texas, Chicago, Los Alamos, Cornell

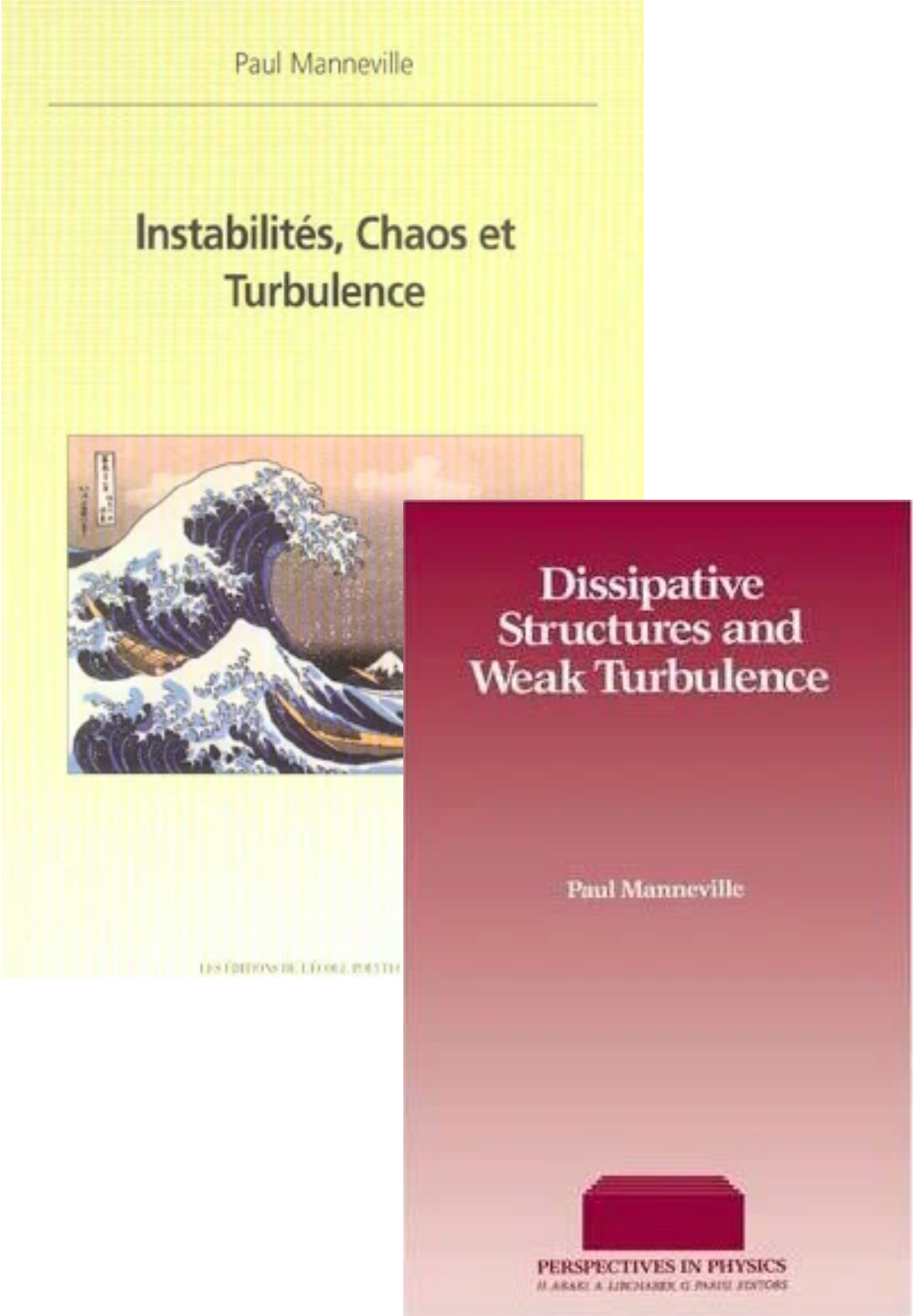
—> interest in hydrodynamic transitions, particularly convection

Paris: Libchaber, Fauve **Nice: Coullet, Tresser, Hénon**

Saclay: Bergé, Dubois, Manneville, Pomeau







Saclay: Wesfreid, Croquette, Le Gal, Pocheau, Beysens, Tuckerman

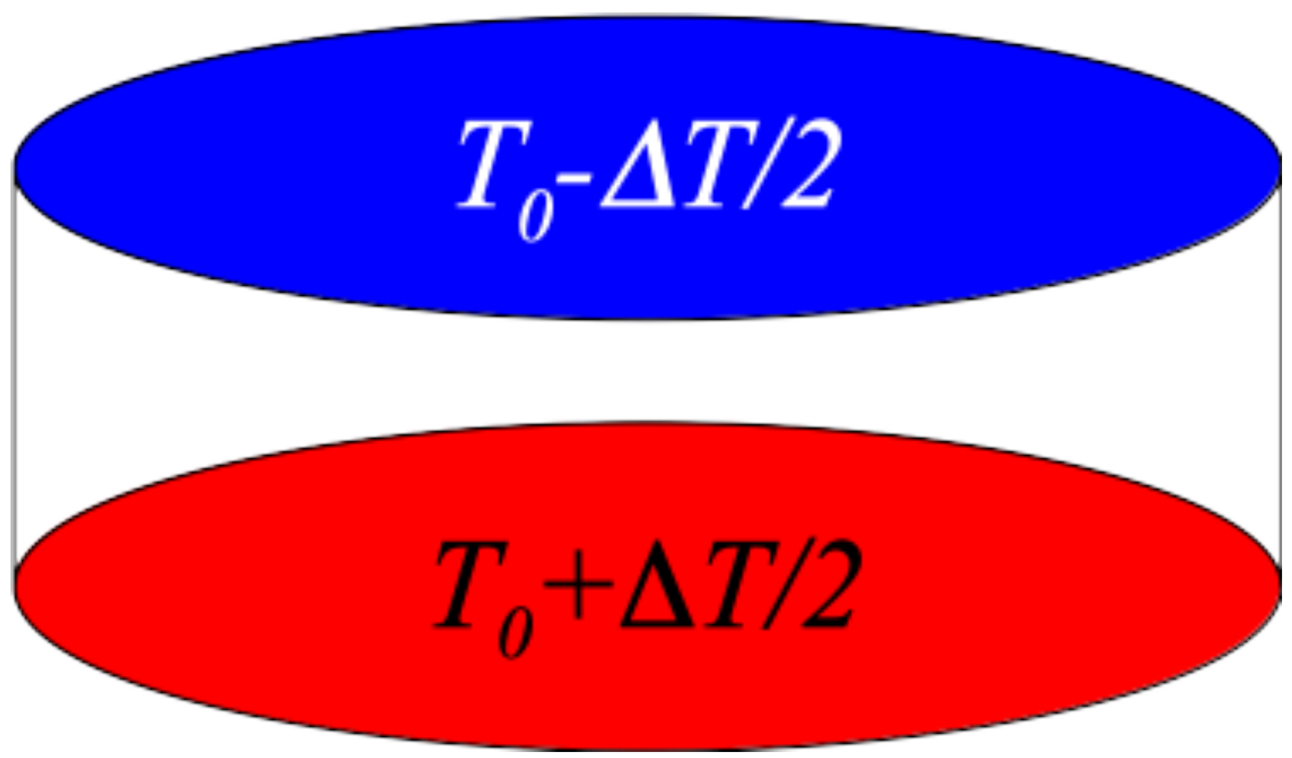
Instability: fluid (or system) wants to do something

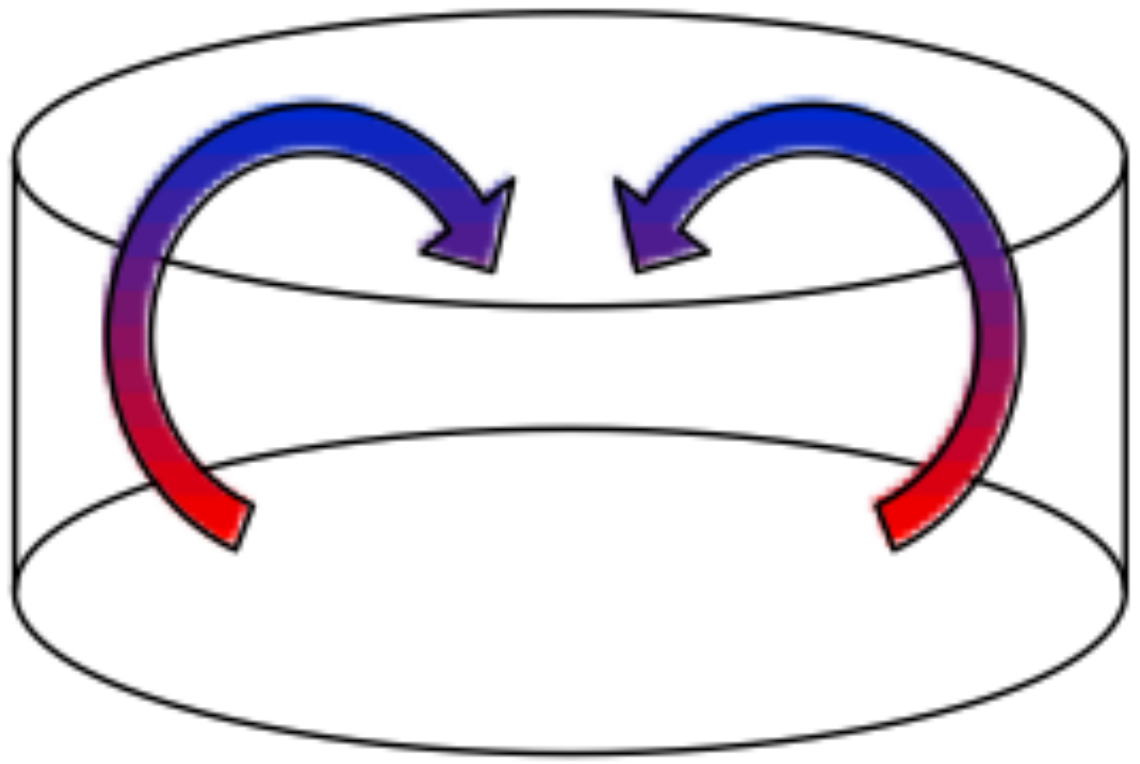
convection: **light/hot** (**heavy/cold**) fluid wants to **rise** (**fall**)

Taylor-Couette: fluid with **high** (**low**) angular momentum wants to move radially **outwards** (**inwards**)

shear flows: want to homogenize, confining shear to boundary layers

BUT: fluid cannot move up/down, in/out at same location —> **PATTERN**



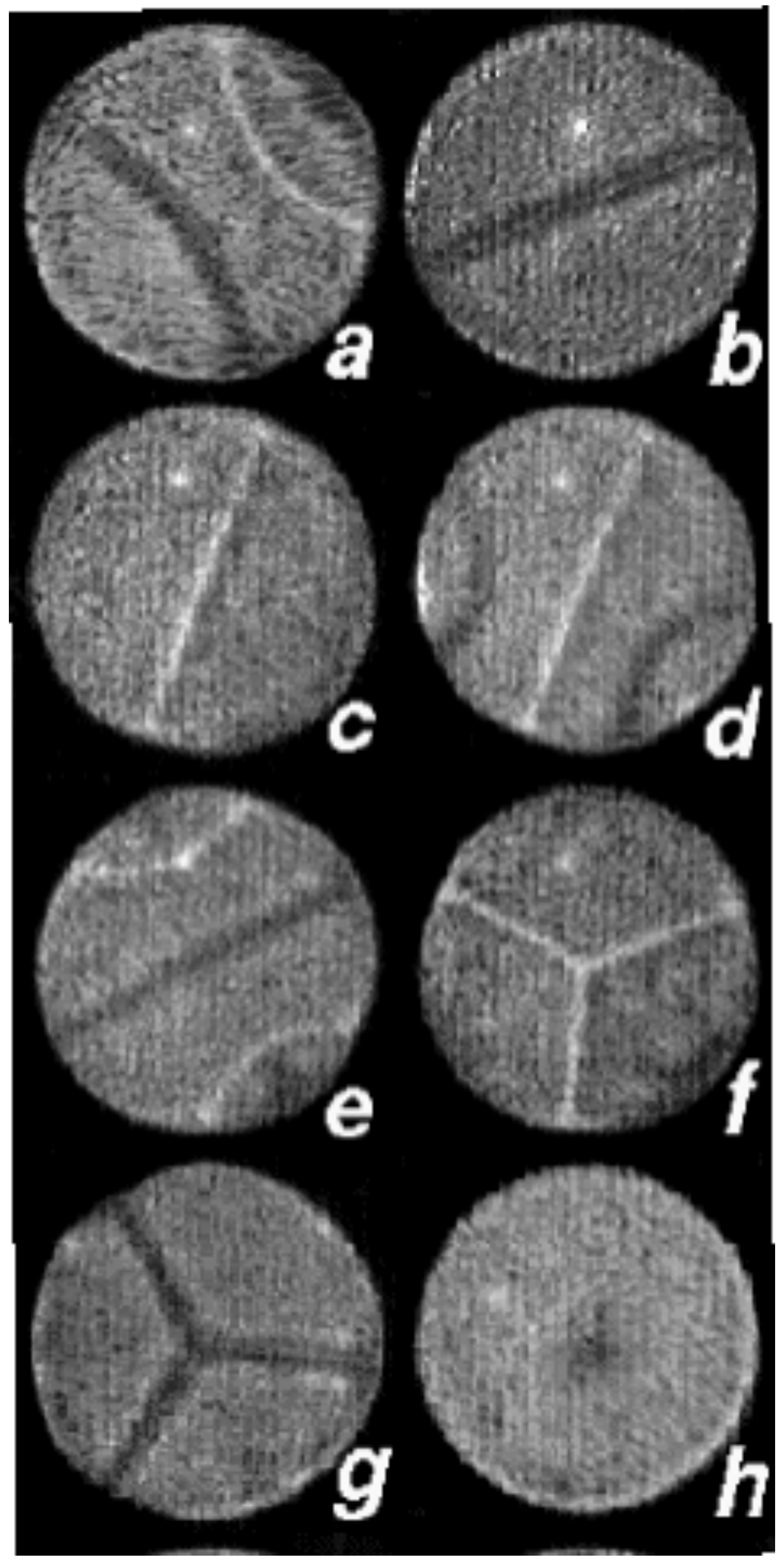


Convection in a cylinder with radius/height = 2

Experiment

Hof, Lucas & Mullin

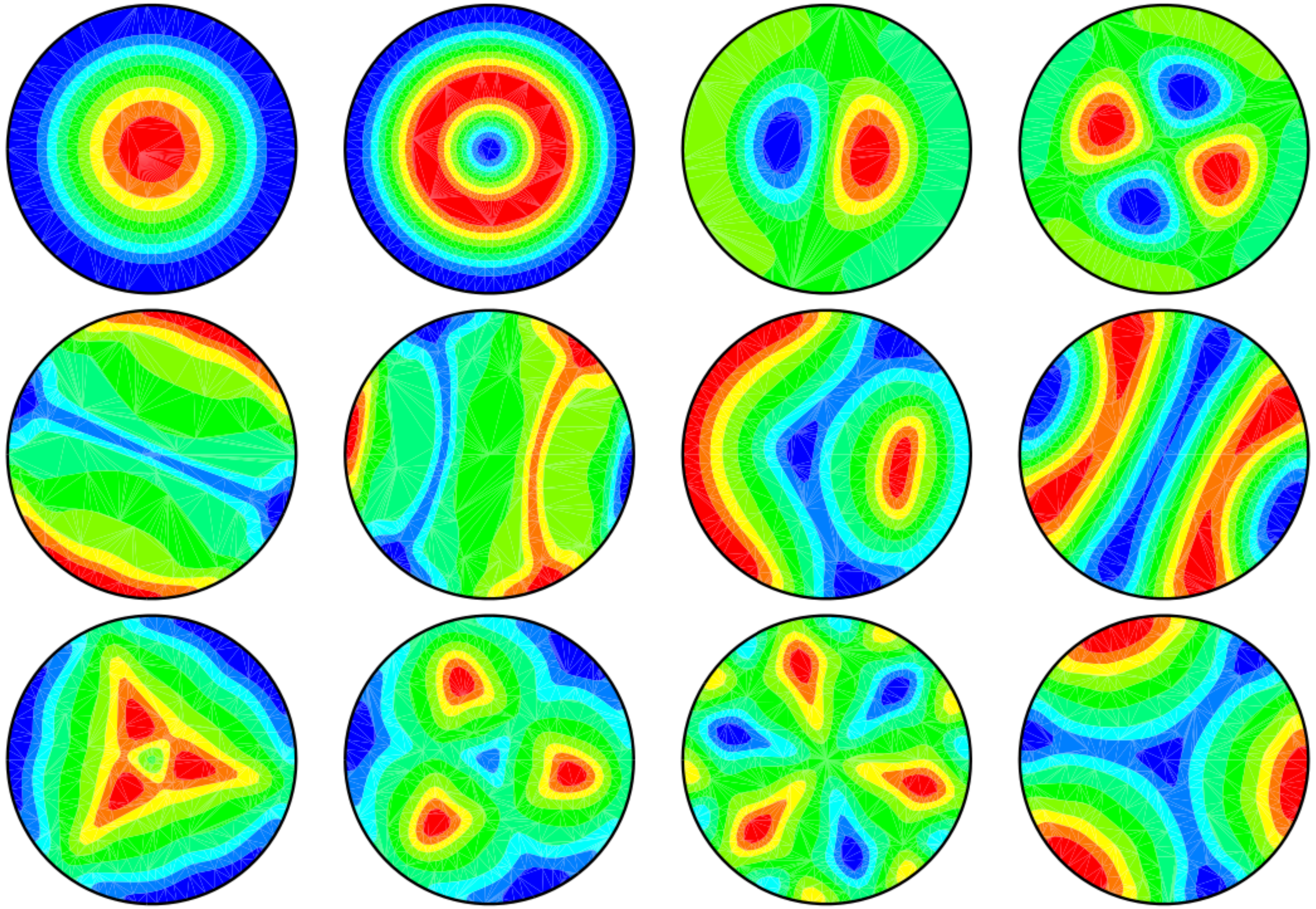
(*Phys. Fluids 1999*)



Numerical simulations

Phys. Rev. E 2010

L.S. Tuckerman, K. Borońska



Tome 39 N° 7 JUILLET 1978

LE JOURNAL DE PHYSIQUE-LETTRES

Classification
Physics Abstracts
47.25Q

CRITICAL EFFECTS IN RAYLEIGH-BÉNARD CONVECTION

J. WESFREID (*), Y. POMEAU (**), M. DUBOIS (*), C. NORMAND (**) and P. BERGÉ (*)

DPhT/DPh-G/PSRM, CEN Saclay, BP n° 2, 91190 Gif sur Yvette, France

Tome 39 N° 12 DÉCEMBRE 1978

LE JOURNAL DE PHYSIQUE

Classification
Physics Abstracts
44.25 — 47.25Q

NON BOUSSINESQ CONVECTIVE STRUCTURES IN WATER NEAR 4 °C

M. DUBOIS, P. BERGE and J. WESFREID

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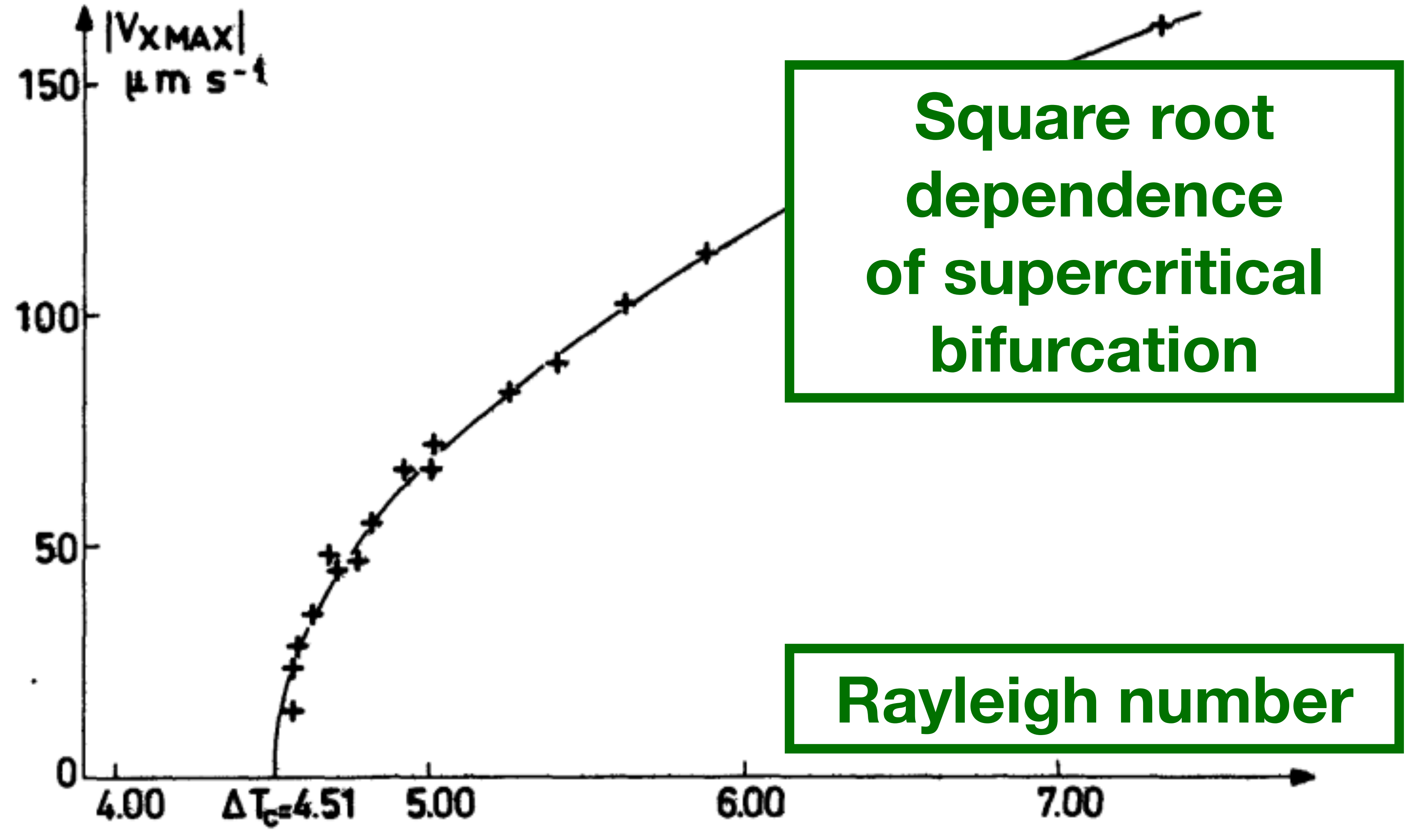

FIG. 1. — Dependence of the maximum velocity V_x max *versus* ΔT (ΔT is the temperature difference applied to the layer).

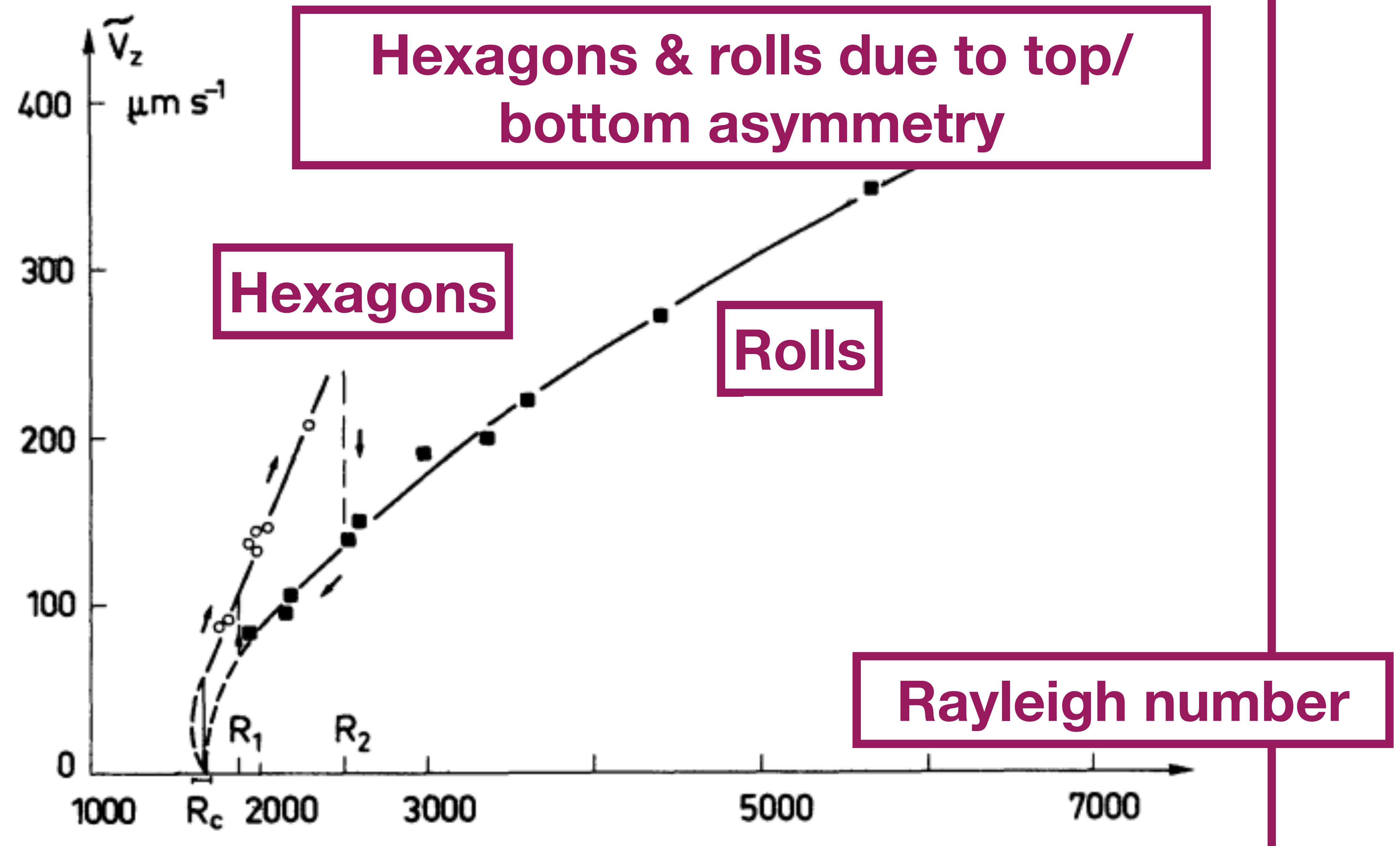

FIG. 4. — Behaviour of the maximum velocity amplitude, $\tilde{V}_z$, *versus* Rayleigh number for hexagons and rolls.

J. Fluid Mech. (2000), *vol.* 416, *pp.* 217–237. Printed in the United Kingdom

The normal field instability in ferrofluids: hexagon–square transition mechanism and wavenumber selection

By BÉRENGÈRE ABOU[1]†,
JOSÉ-EDUARDO WESFREID[1] AND STÉPHANE ROUX[2]

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[2] Laboratoire "Surface du Verre et Interfaces", UMR CNRS 125, 39 quai Lucien Lefranc, 93303 Aubervilliers Cedex, France

Hexagons

Squares

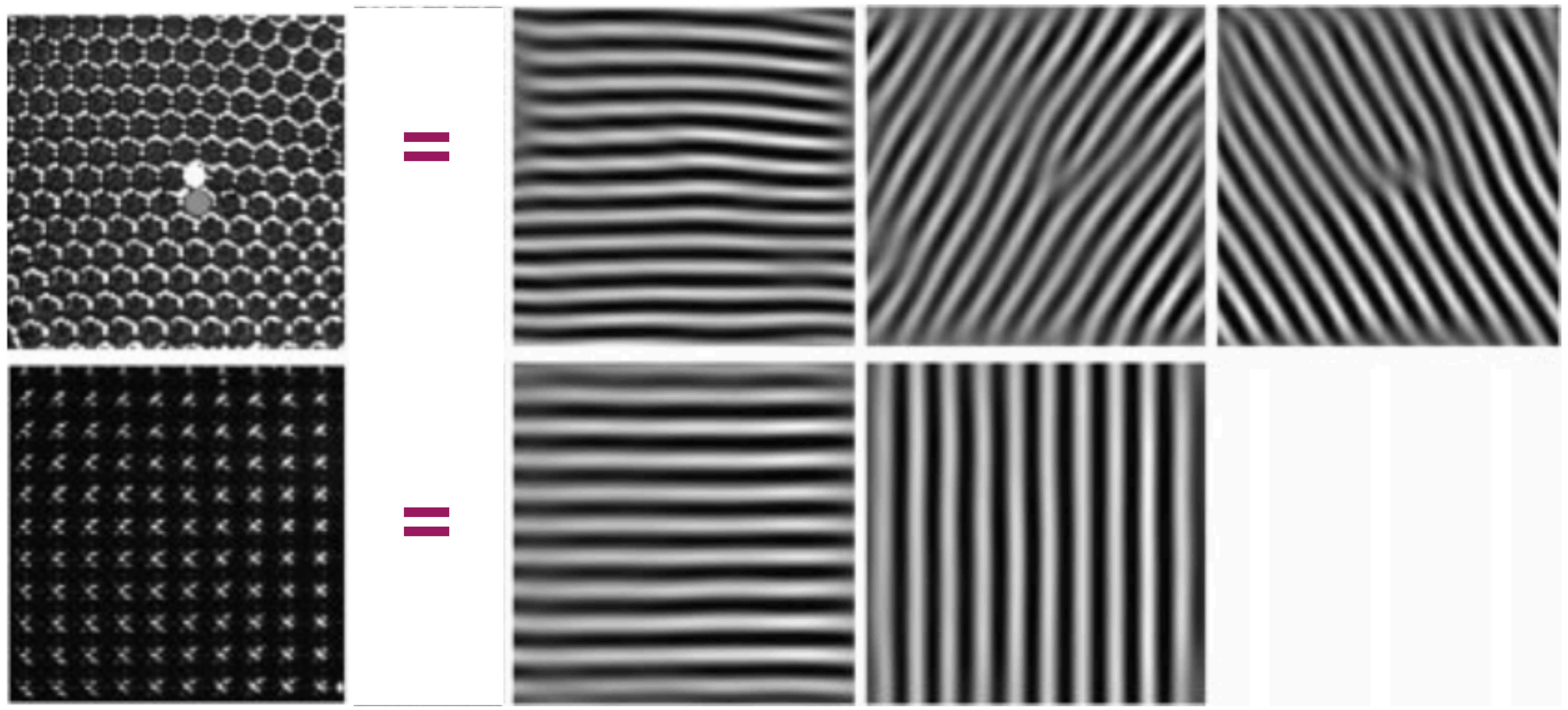
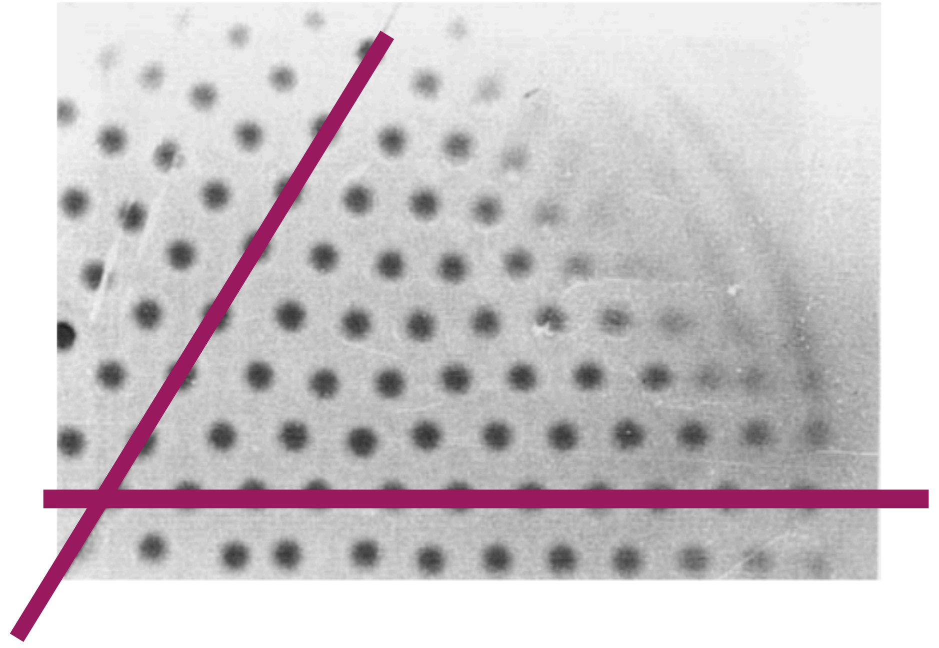
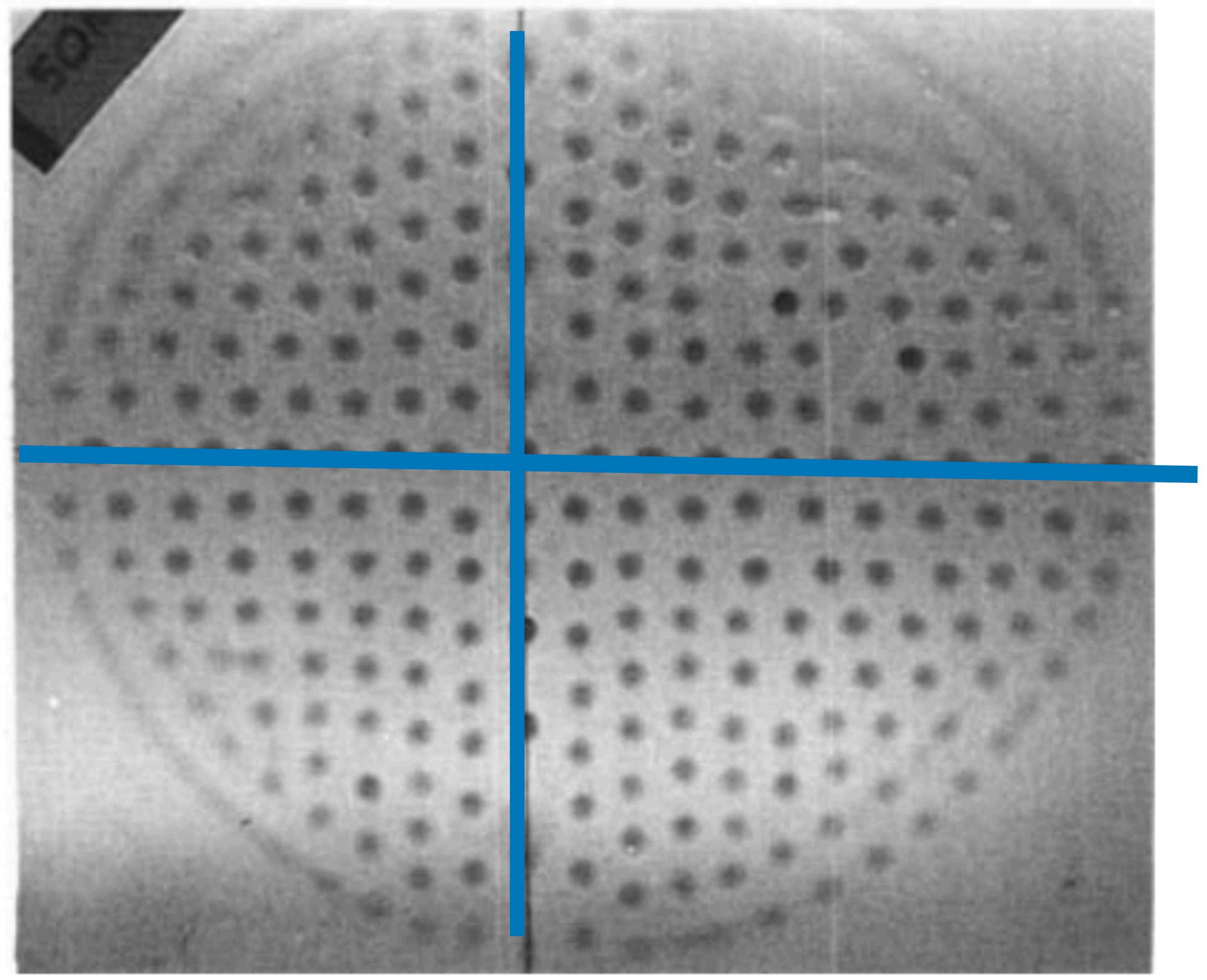


FIGURE 9. (*a*) the hexagonal pattern with a penta–hepta defect and its three modes obtained from Fourier filtering the initial image; (*b*) the square pattern formed from the hexagonal pattern in (*a*) by increasing the magnetic field, and its two modes reconstructed from Fourier filtering. The non-altered mode of the penta–hepta defect is conserved during the transition.

Hexagons vs Squares in Rayleigh-Taylor instability (heavy fluid above light fluid)



Wires induce hexagonal pattern



Wires induce square pattern

J. Fluid Mech. (1992), *vol.* 236, *pp.* 349–383 349
Printed in Great Britain

Two-dimensional patterns in Rayleigh-Taylor instability of a thin layer

By M. FERMIGIER[1], L. LIMAT[1,2], J. E. WESFREID[1], P. BOUDINET[1] AND C. QUILLIET[1]

[1] Laboratoire d'Hydrodynamique et Mécanique Physique, Ecole Supérieure de Physique et Chimie de Paris, 10, rue Vauquelin, 75231 Paris Cedex 05, France

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Interacting falling fluid columns

Phase diffusion in the vicinity of an oscillatory secondary bifurcation

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(Received 17 March 1997; revised manuscript received 29 October 1997)

The phase dynamics of a one-dimensional cellular pattern is studied on a regular array of liquid columns formed below an overflowing horizontal cylinder. When a uniform wavelength dilation is imposed by static boundaries, an oscillatory secondary bifurcation is observed (''optical mode''). The case of a moving boundary (sinusoidal motion) allows us to observe three dynamical states: phase diffusion, phase diffusion coupled with the oscillatory state, and propagation of dilation waves. The dependence of the phase diffusion coefficient D upon the pattern wavelength is investigated for different flow rates: D is nearly constant until the appearance of the oscillations and jumps to a larger value when the optical mode is excited. This unusual behavior is recovered by an analytical treatment of Coullet-Ioss equations. [S1063-651X(98)12002-0]

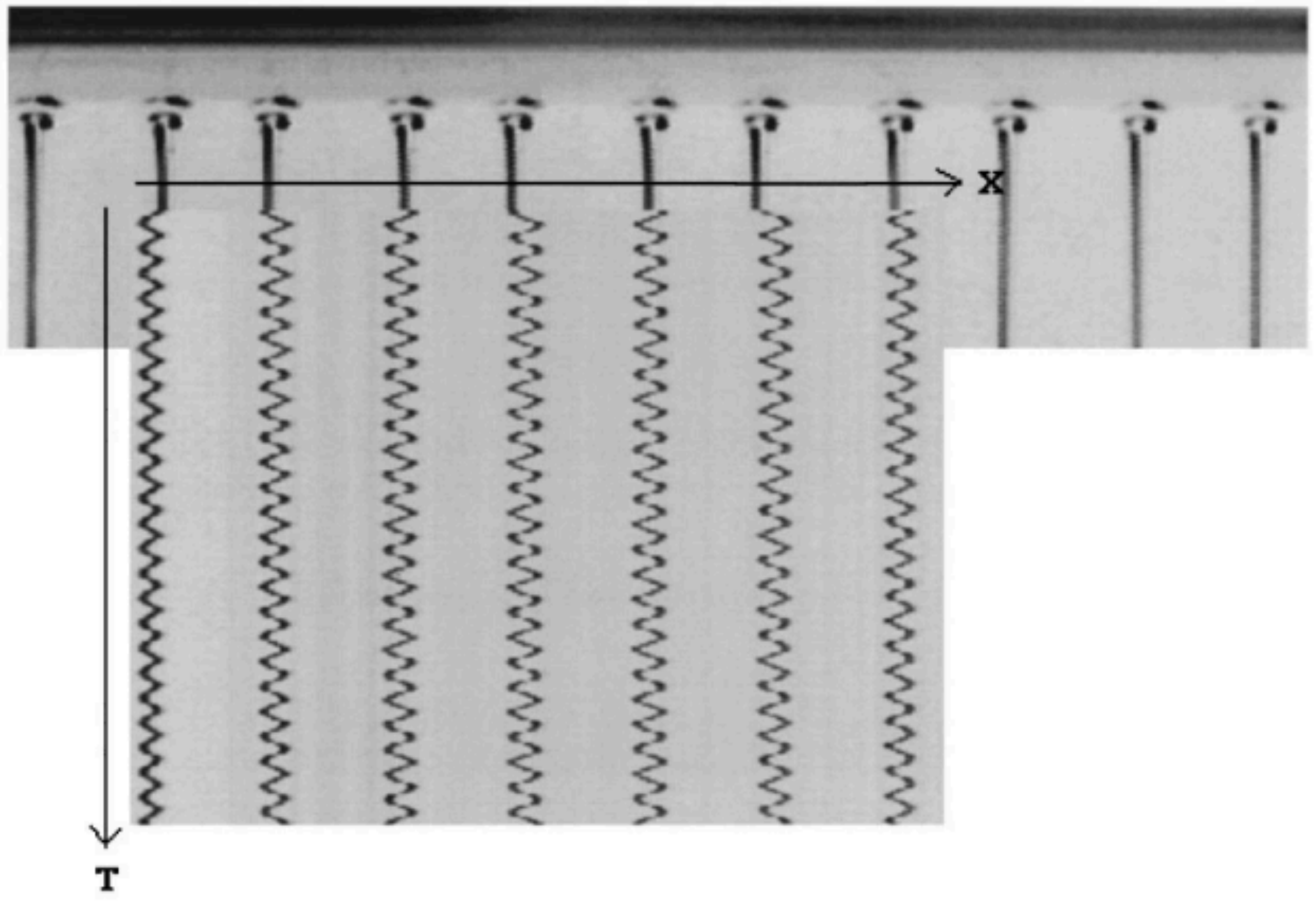
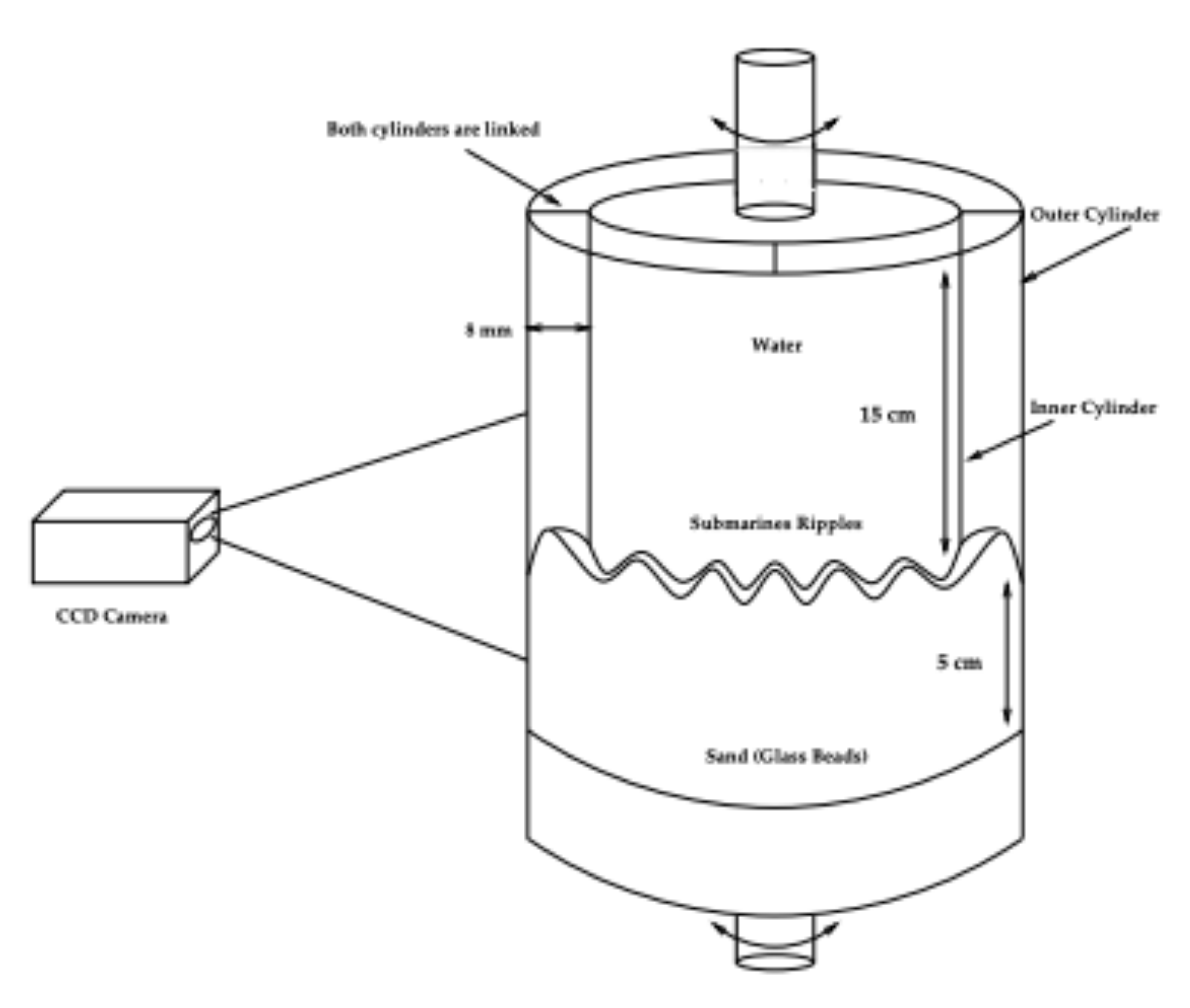


FIG. 1. Array of liquid columns observed below a horizontal cylinder along which a liquid is flowing from top to bottom at a constant rate. Inset: space-time diagram of the array of liquid columns for fixed boundary conditions (optical mode).

Sand Ripples



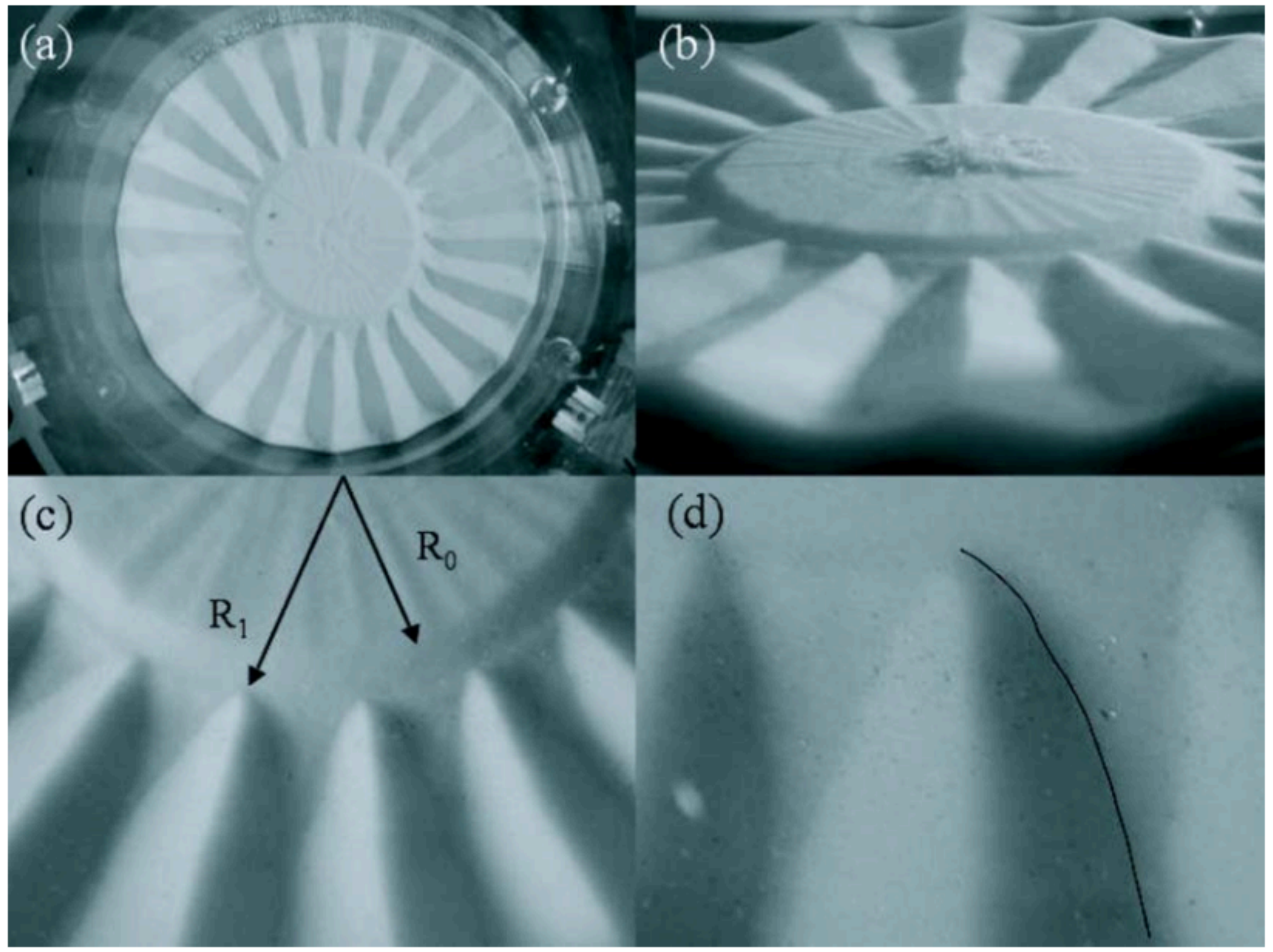


FIG. 2. (Color online) Description of the final state after 18 h: (a) threshold for movement, (b) dust in the center of the tank, (c) zoom on both internal radii, and (d) zoom on the internal part of a ripple.

PHYSICAL REVIEW E **78**, 016302 (2008)

Oscillation-induced sand ripples in a circular geometry

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Laboratoire J.-A. Dieudonné, Université de Nice–Sophia Antipolis, UMR 6621 CNRS-UNSA, Parc Valrose, 06108 Nice Cedex 02, France

Joachim Kruithof,[†] Patrice Jenffer,[‡] and José Eduardo Wesfreid[§]
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Buckling of thin elastic sheet

J. Physique Lett. **45** (1984) L-413 - L-418 1er MAI **1984**, PAGE L-413

Classification
Physics Abstracts
46.30L — 03.40D — 47.20

Role of boundary conditions on mode selection in a buckling instability

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(*Reçu le 2 février 1984, accepté le 7 mars 1984*)

Résumé. — En variant les conditions aux bords chargés, on sélectionne de façon différente les modes instables accessibles. La sélection de modes est reliée à des analyses non linéaires de ces problèmes. Une comparaison est établie avec la sélection des modes dans des instabilités convectives.

Abstract. — We present an experimental study on the selection of the wave number in the buckling of a thin elastic rectangular plate, subjected to a compressive force while being held laterally. Boundary conditions act selectively through non-linear mechanisms to restrict the accessible states above threshold.

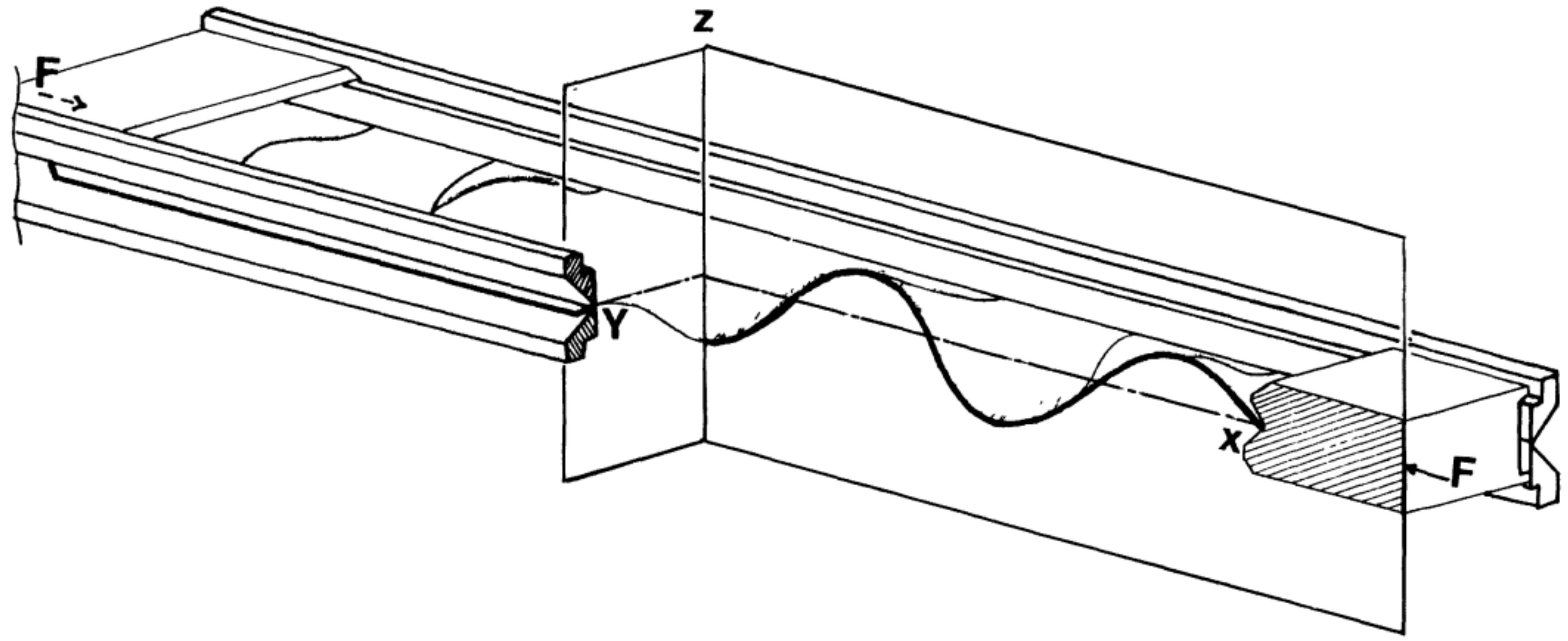
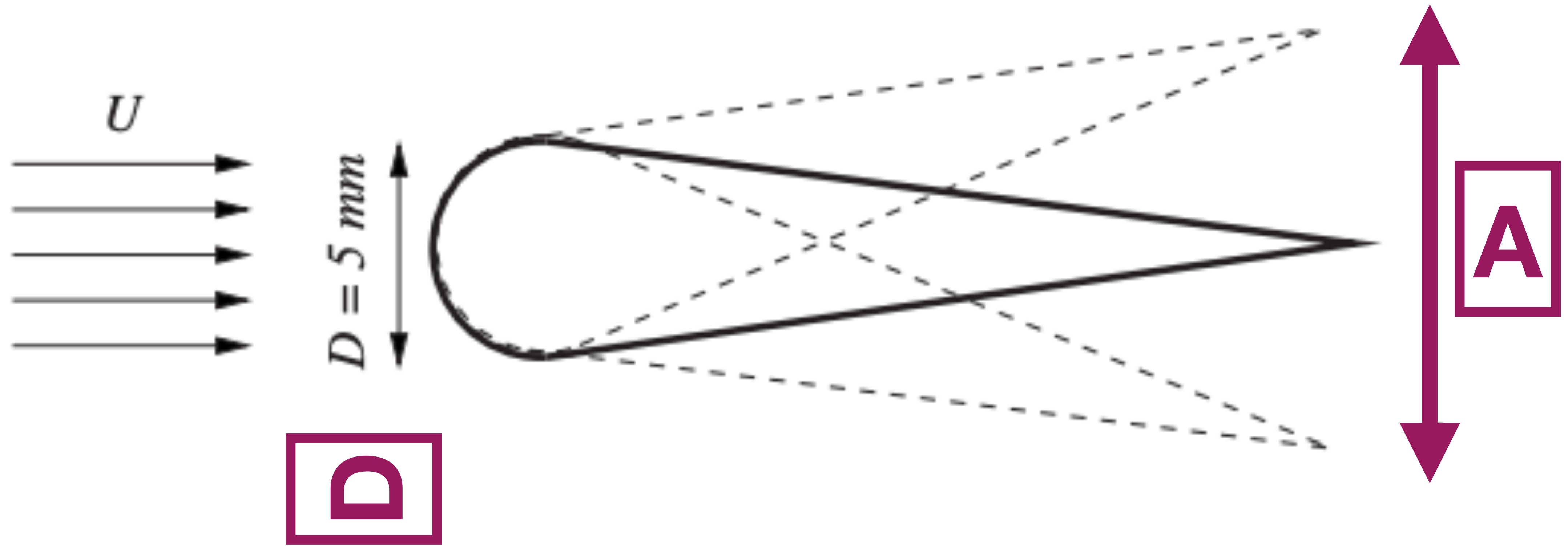


Fig. 1. — Experimental. The plate is held laterally along parallel lines $|y| = h/2$ and subjected to an uniaxial compressive force F along the x axis.

Flapping Foil



PHYSICAL REVIEW E **77**, 016308 (2008)

Transitions in the wake of a flapping foil

Ramiro Godoy-Diana,* Jean-Luc Aider, and José Eduardo Wesfreid
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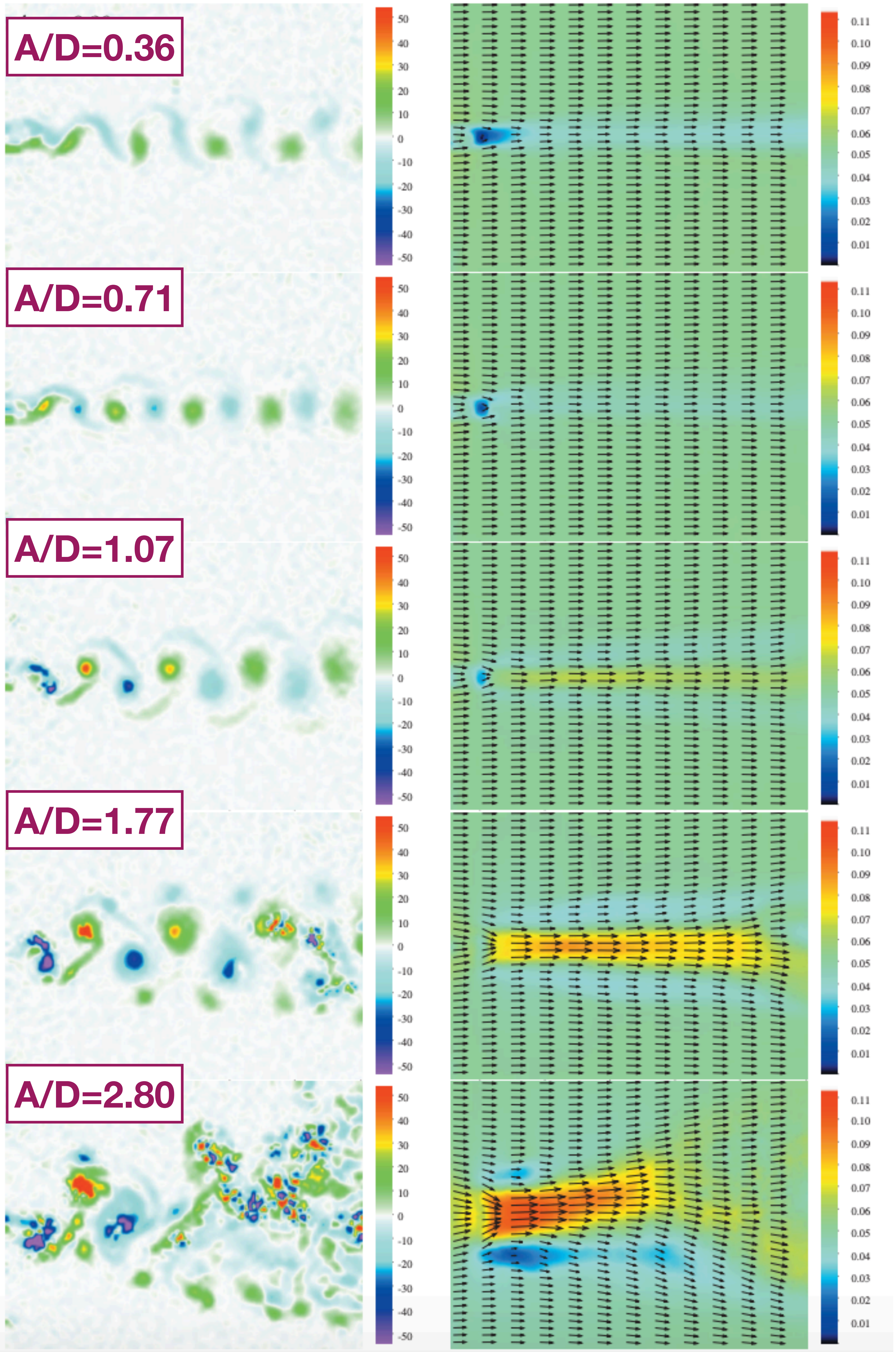
ESPCI, Paris 6, Paris 7, 10 rue Vauquelin, F-75231 Paris Cedex 5, France
(Received 19 February 2007; revised manuscript received 7 November 2007; published 24 January 2008)

We study experimentally the vortex streets produced by a flapping foil in a hydrodynamic tunnel, using two-dimensional particle image velocimetry. An analysis in terms of a flapping frequency-amplitude phase space allows the identification of (i) the transition from the well-known Bénard–von Kármán (BvK) wake to the reverse BvK vortex street that characterizes propulsive wakes, and (ii) the symmetry breaking of this reverse BvK pattern giving rise to an asymmetric wake. We also show that the transition from a BvK wake to a reverse BvK wake precedes the actual drag-thrust transition and we discuss the significance of the present results in the analysis of flapping systems in nature.

DOI: 10.1103/PhysRevE.77.016308 PACS number(s): 47.32.ck, 47.63.M−



J. Fluid Mech. (2012), *vol.* 710, *pp.* 659–669. © Cambridge University Press 2012 659
doi:10.1017/jfm.2012.390

Stabilizing effect of flexibility in the wake of a flapping foil

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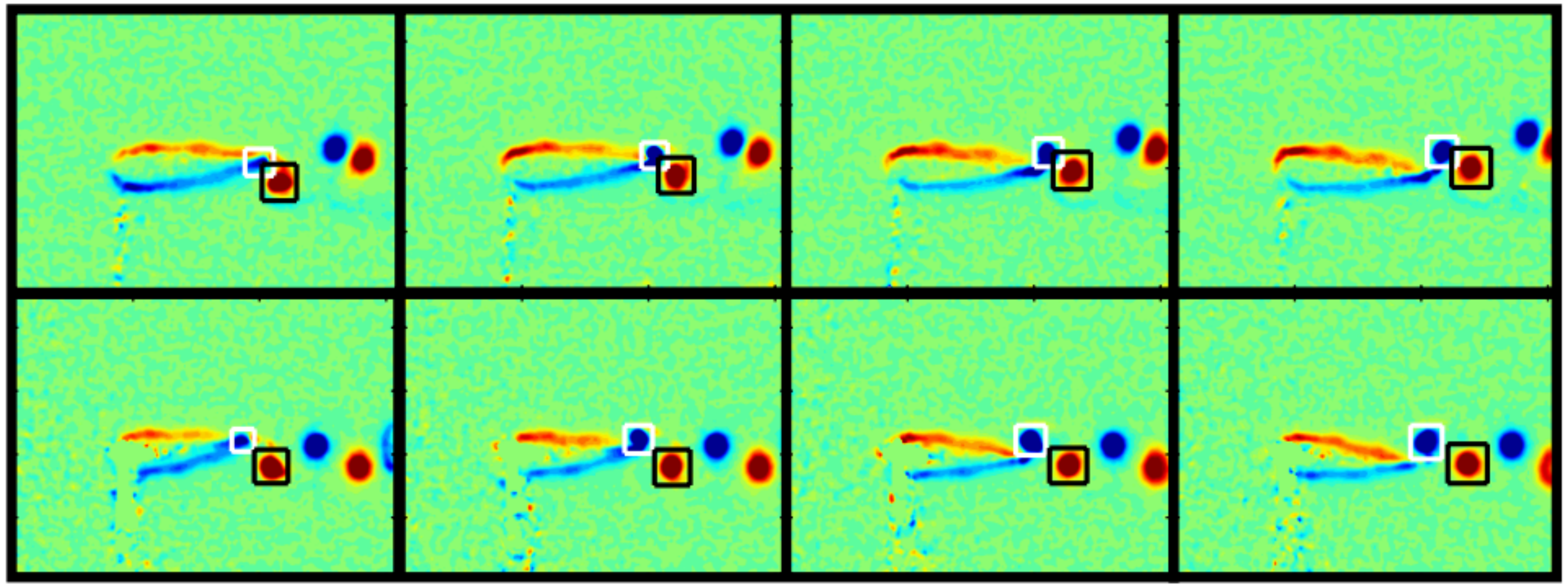
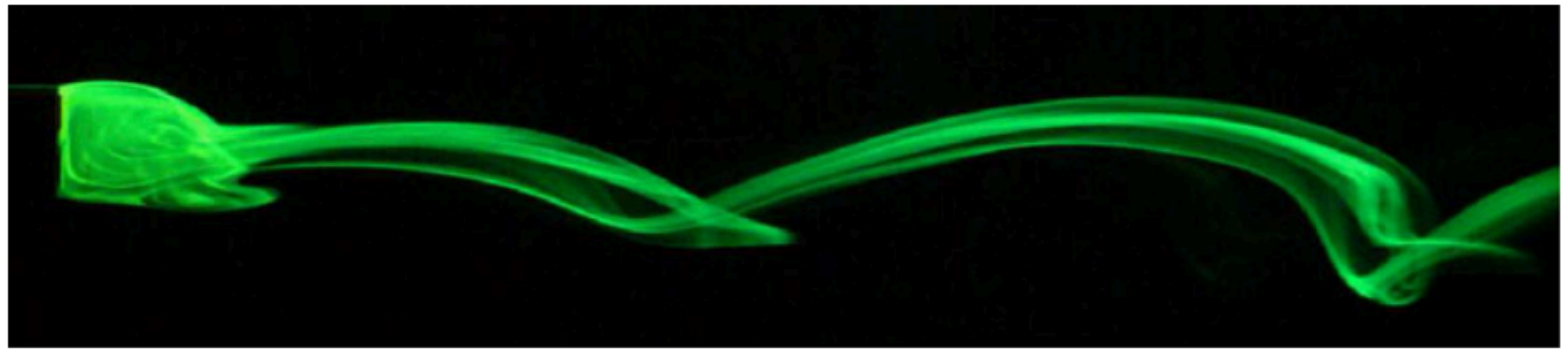
Rigid foil

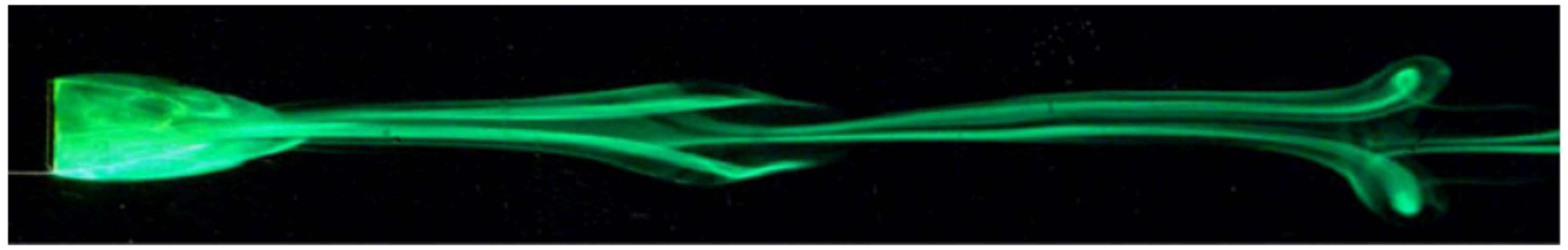


Flexible foil

(*e*) Side view



(*f*) Top view



Hairpin shedding regime

J. Fluid Mech. (2014), *vol.* 750, *pp.* 73–98. © Cambridge University Press 2014 73
doi:10.1017/jfm.2014.236

Experimental investigation of flow behind a cube for moderate Reynolds numbers

L. Klotz[1,2], S. Goujon-Durand[1], J. Rokicki[2] and J. E. Wesfreid[1,†]

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[2]Institute of Aeronautics and Applied Mechanics, Warsaw University of Technology, Nowowiejska 24, 00-665 Warsaw, Poland

SPATIO-TEMPORAL PROPERTIES OF CENTRIFUGAL INSTABILITIES

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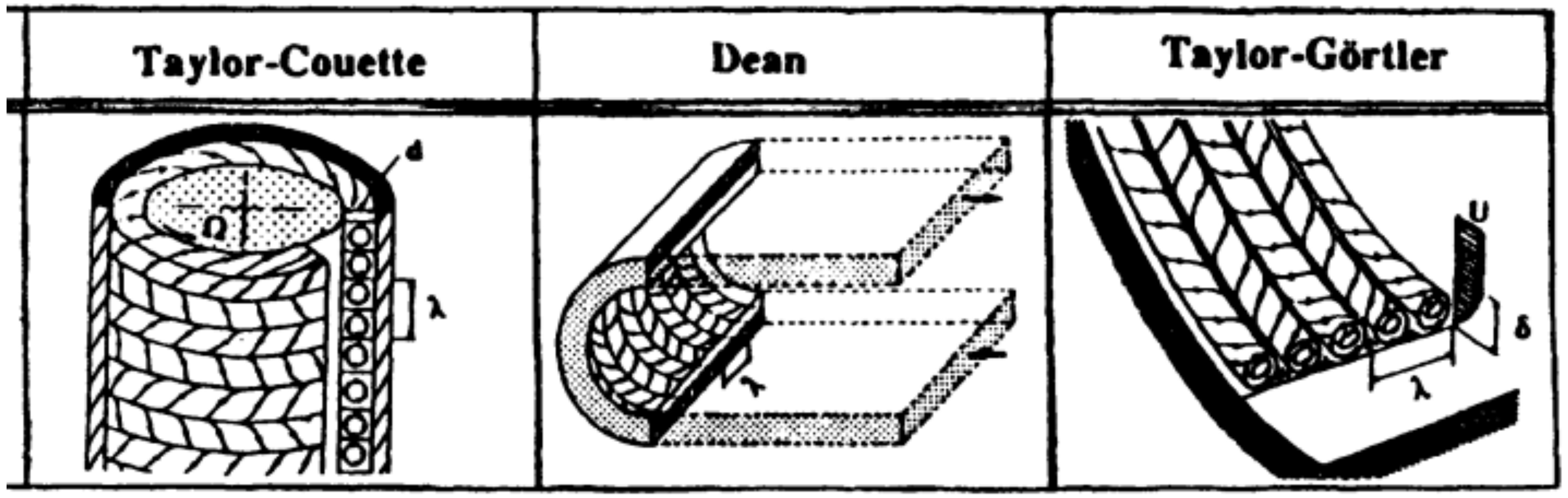
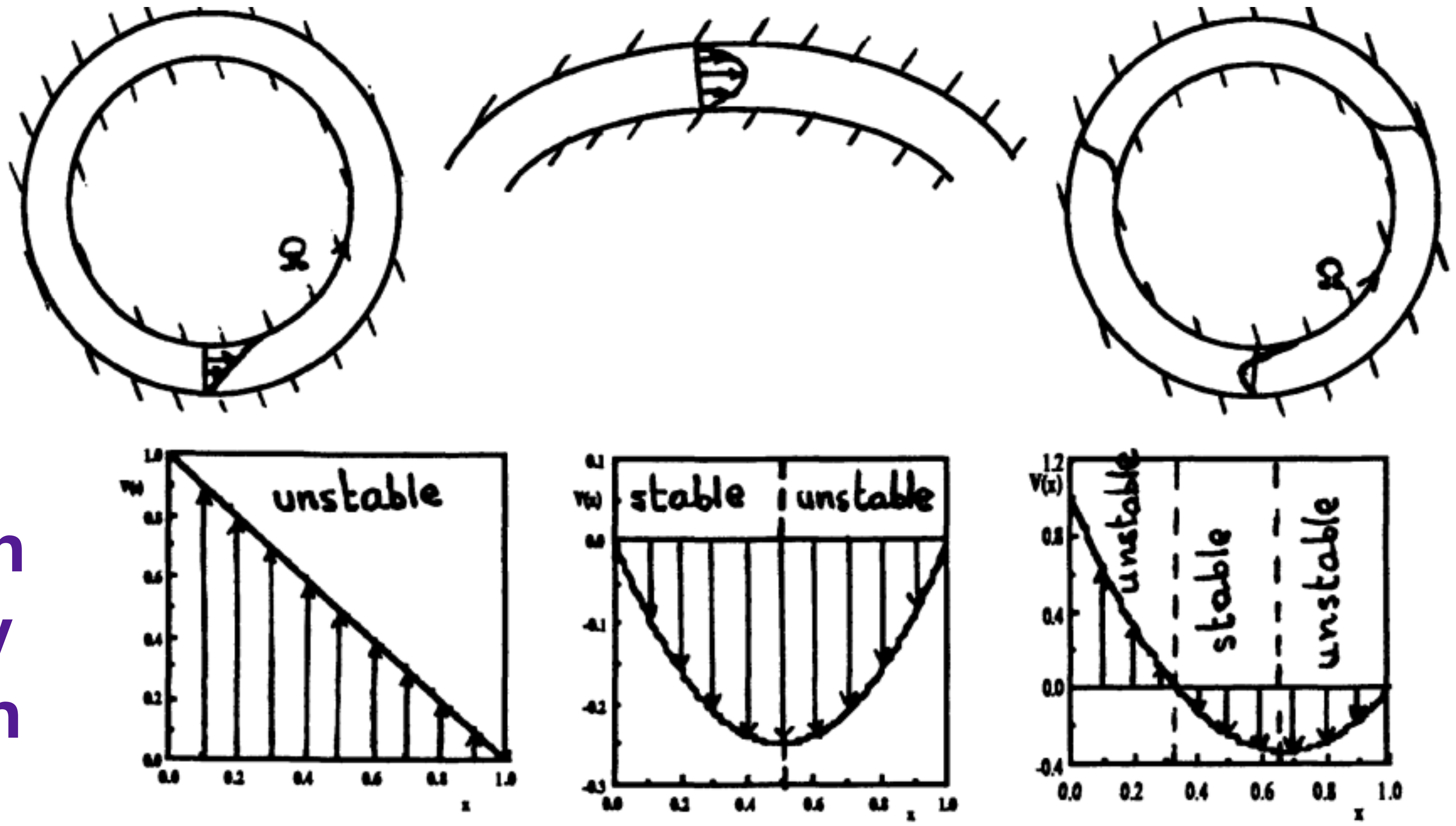
ESPCI (URA CNRS n°857)
10, rue Vauquelin, F-75231Paris Cédex 05, France



Couette Poiseuille-like Poiseuille-Couette

Rayleigh stability criterion



PHYSICAL REVIEW A VOLUME 38, NUMBER 9 NOVEMBER 1, 1988

Pattern formation in the flow between two horizontal coaxial cylinders with a partially filled gap

Innocent Mutabazi,* John J. Hegseth, and C. David Andereck
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Jose E. Wesfreid
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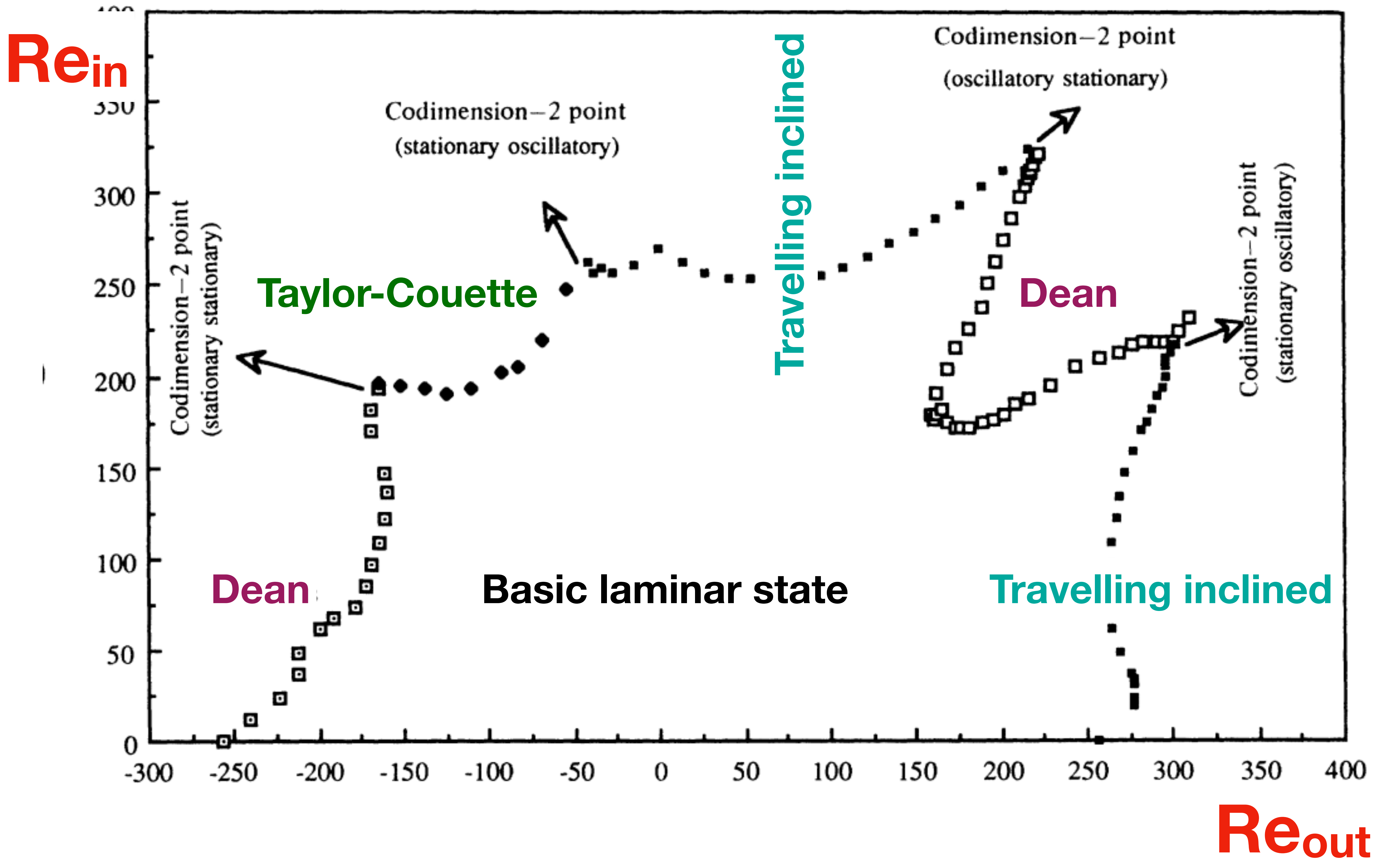
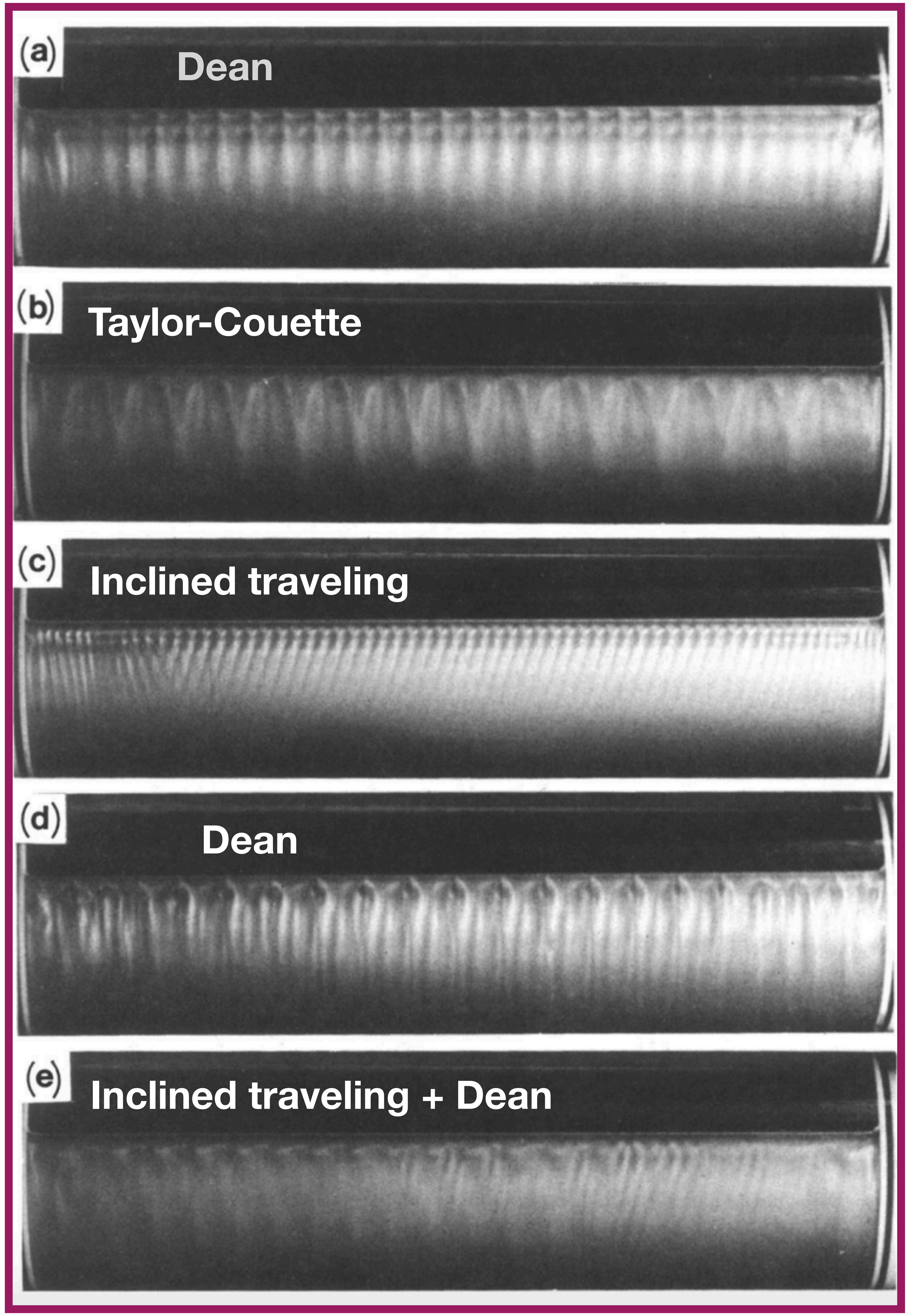
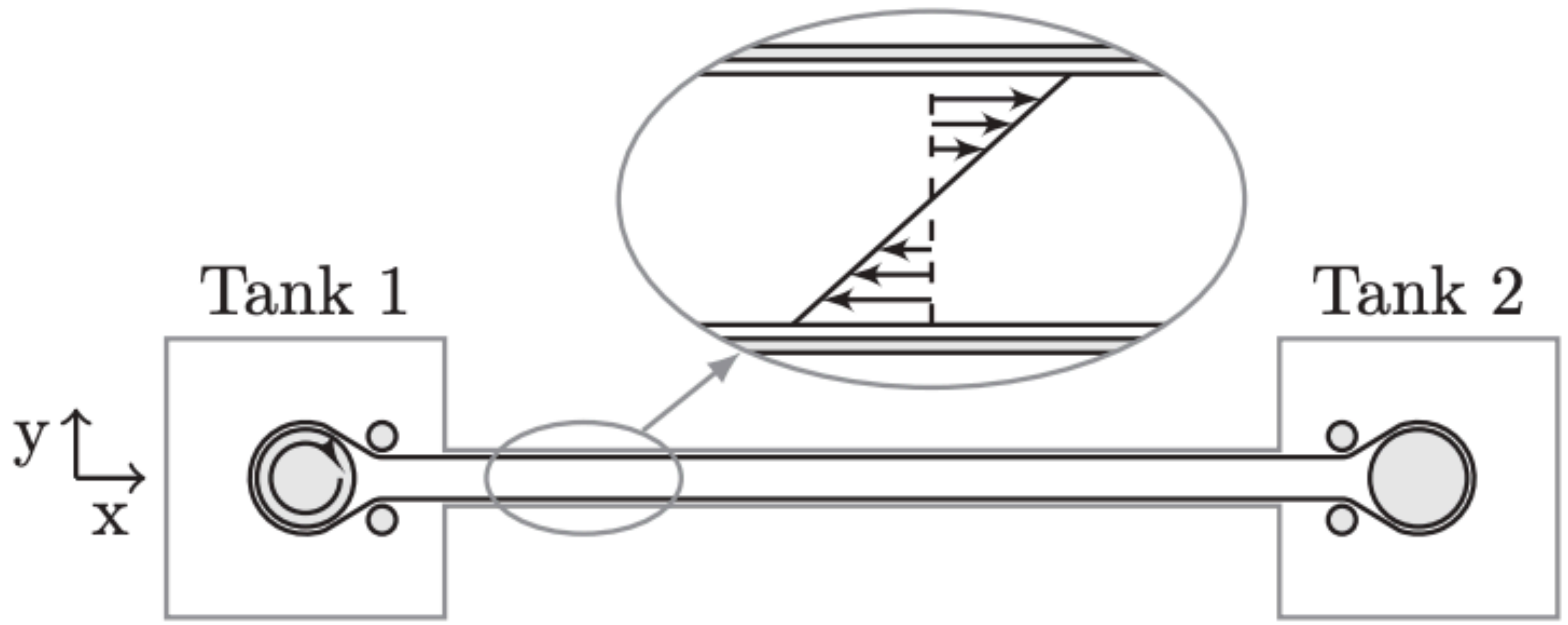




PHYSICAL REVIEW FLUIDS **2**, 043904 (2017)

Couette-Poiseuille flow experiment with zero mean advection velocity: Subcritical transition to turbulence

L. Klotz,[1,*] G. Lemoult,[2] I. Frontczak,[1,3] L. S. Tuckerman,[1] and J. E. Wesfreid[1,†]



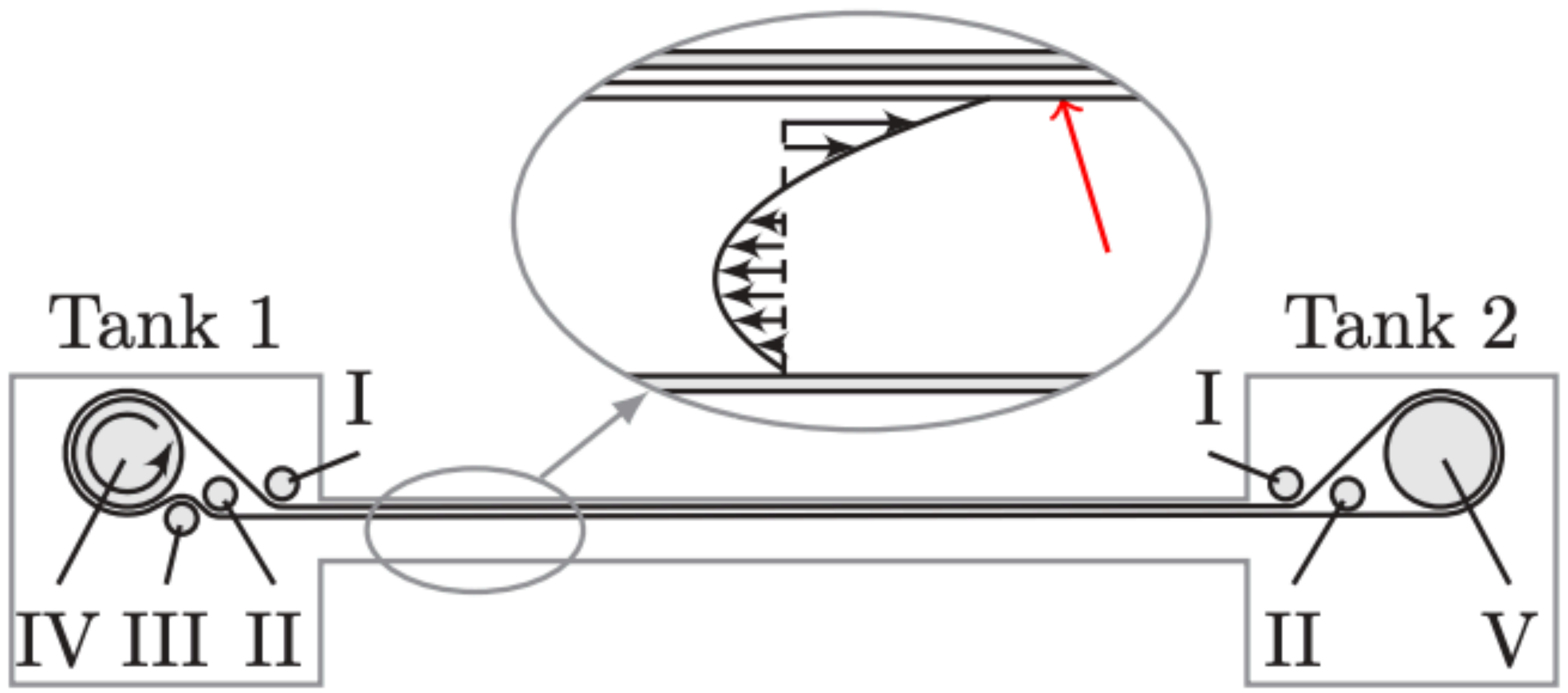
Looped-belt Couette

zero-mean-flow apparatus

of Tillmark & Alfredsson (1990)

used by Daviaud, Hegseth, Bergé (1992)

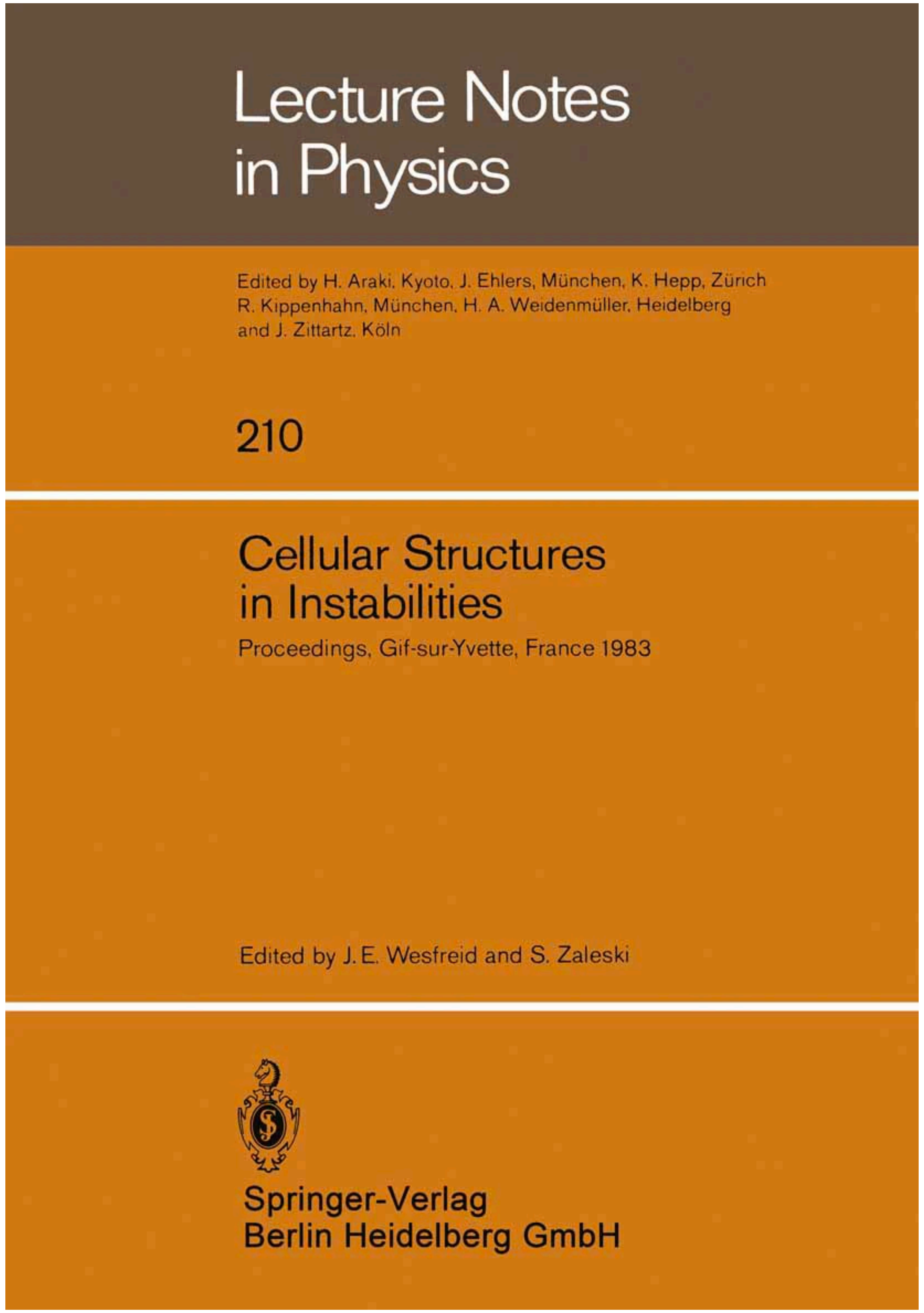
and Prigent & Dauchot (2002)



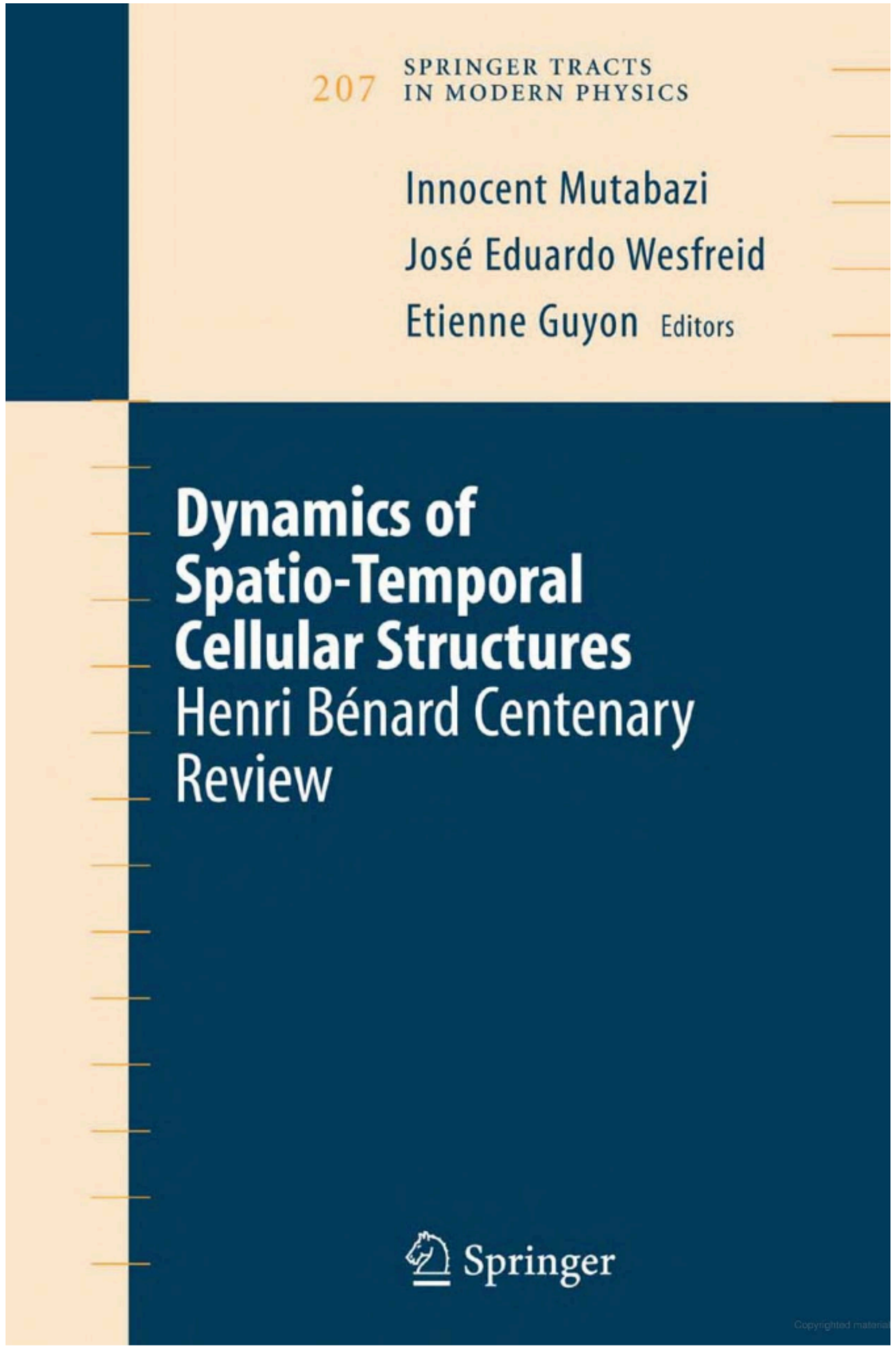
Looped-belt Couette-Poiseuille

zero-mean-flow apparatus

1983


Lecture Notes
in Physics
Edited by H. Araki, Kyoto, J. Ehlers, München, K. Hepp, Zürich
R. Kippenhahn, München, H. A. Weidenmüller, Heidelberg
and J. Zittartz, Köln
210
Cellular Structures
in Instabilities
Proceedings, Gif-sur-Yvette, France 1983
Edited by J. E. Wesfreid and S. Zaleski
Springer-Verlag
Berlin Heidelberg GmbH

2006


207
SPRINGER TRACTS
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Innocent Mutabazi
José Eduardo Wesfreid
Etienne Guyon Editors
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