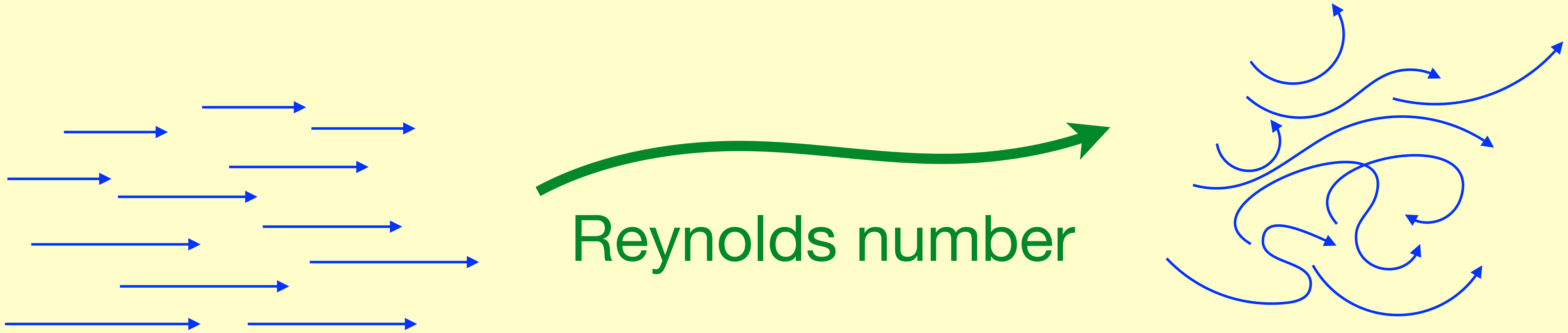
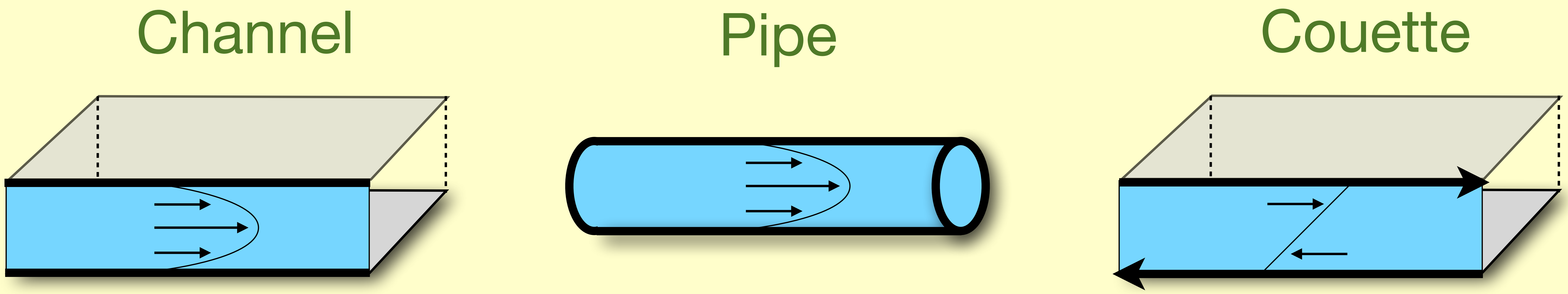
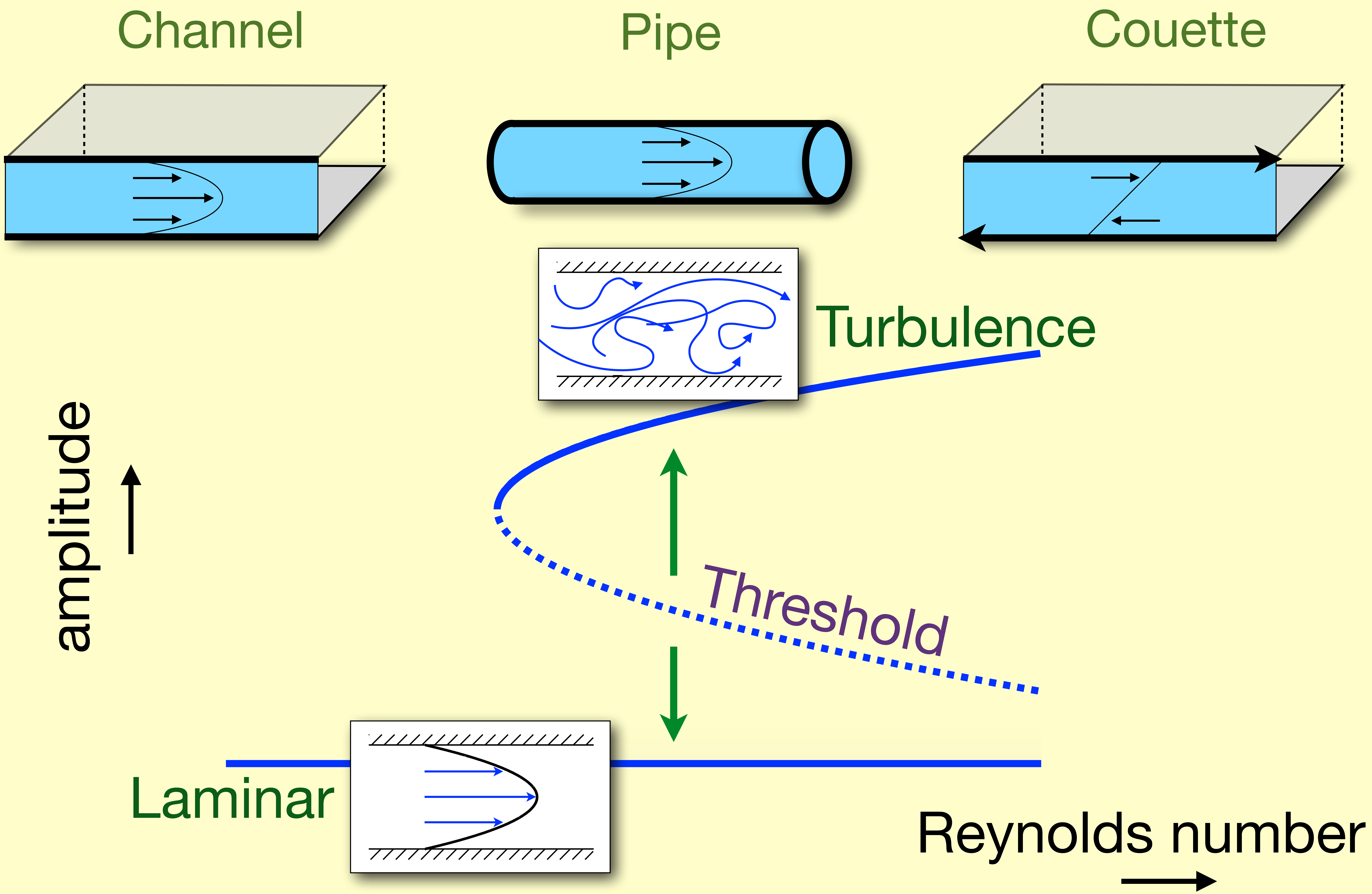
Directed Percolation and the Route to Turbulence

The Route to Turbulence





Subcritical Transition



Subcritical Transition

(also known as First-order or Hard Transition)

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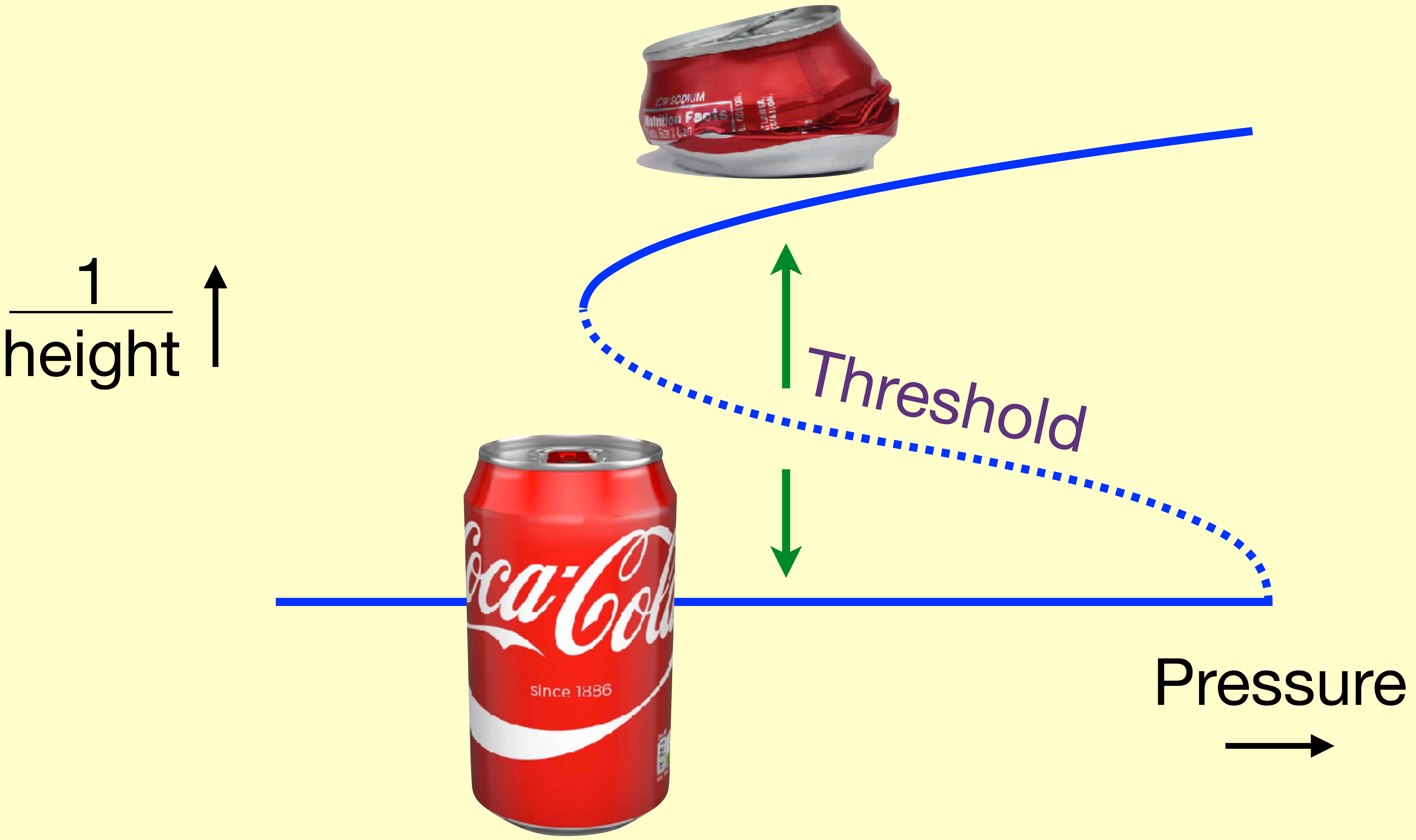
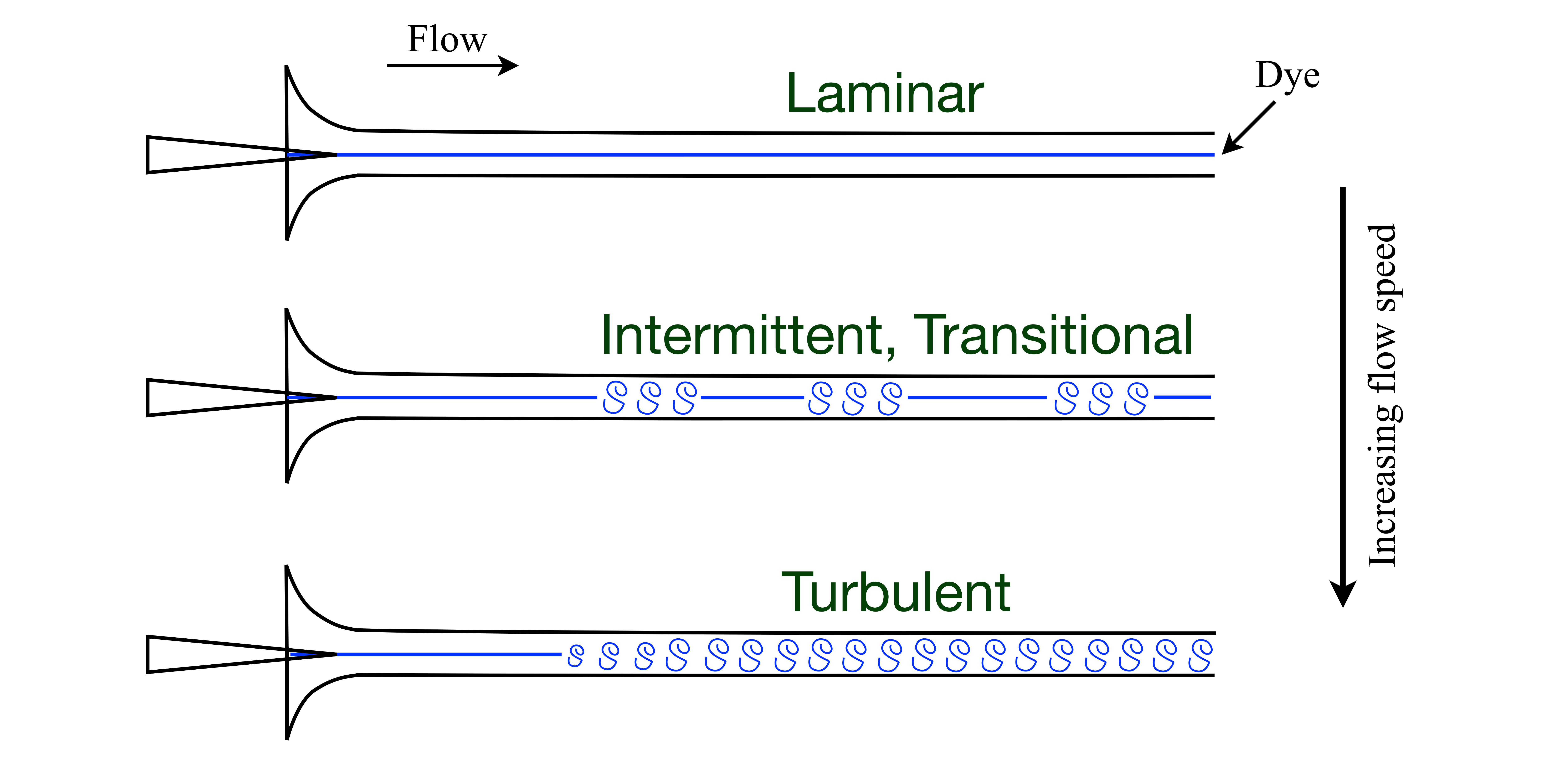
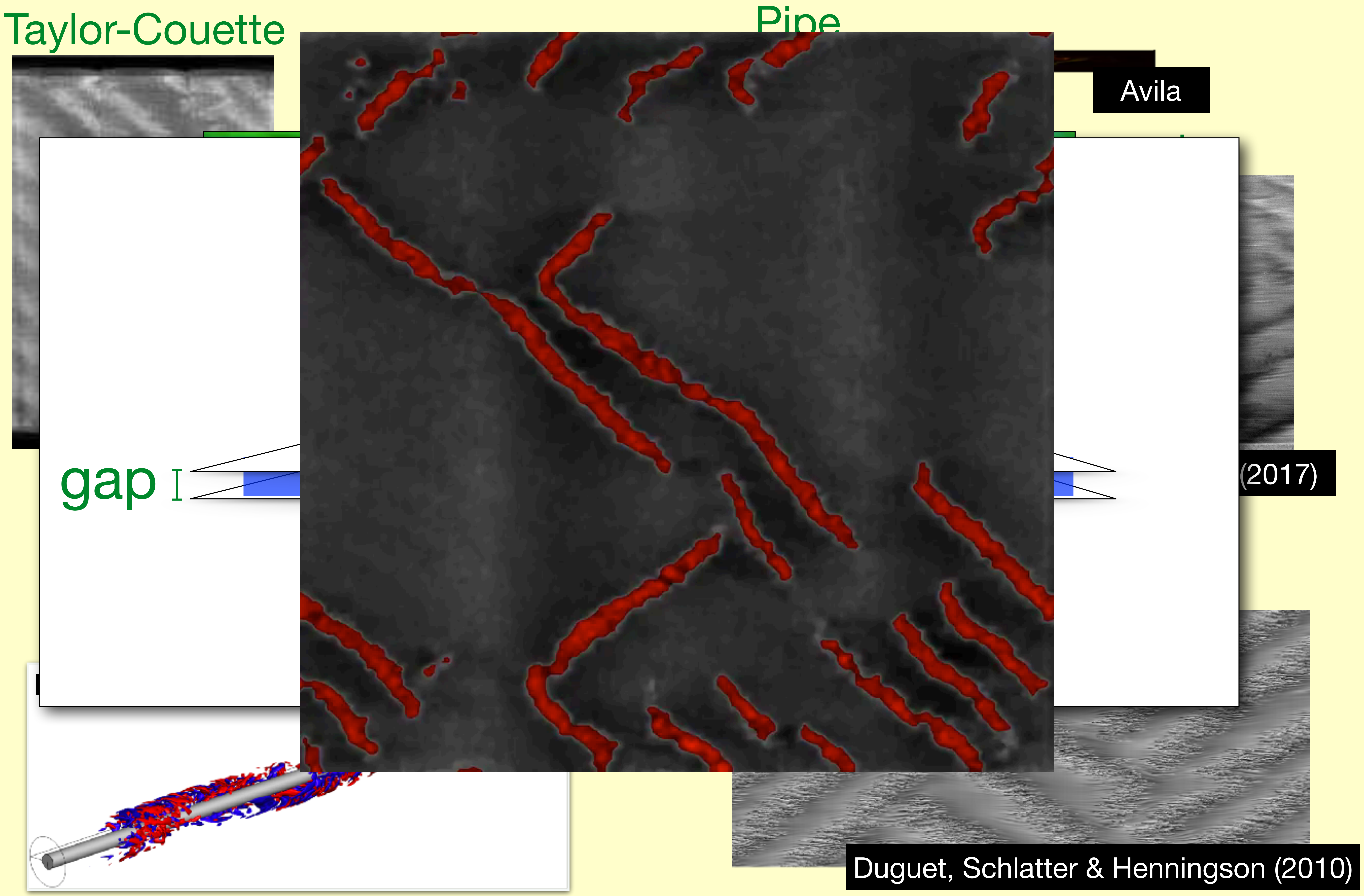
(also known as First-order or Hard Transition)



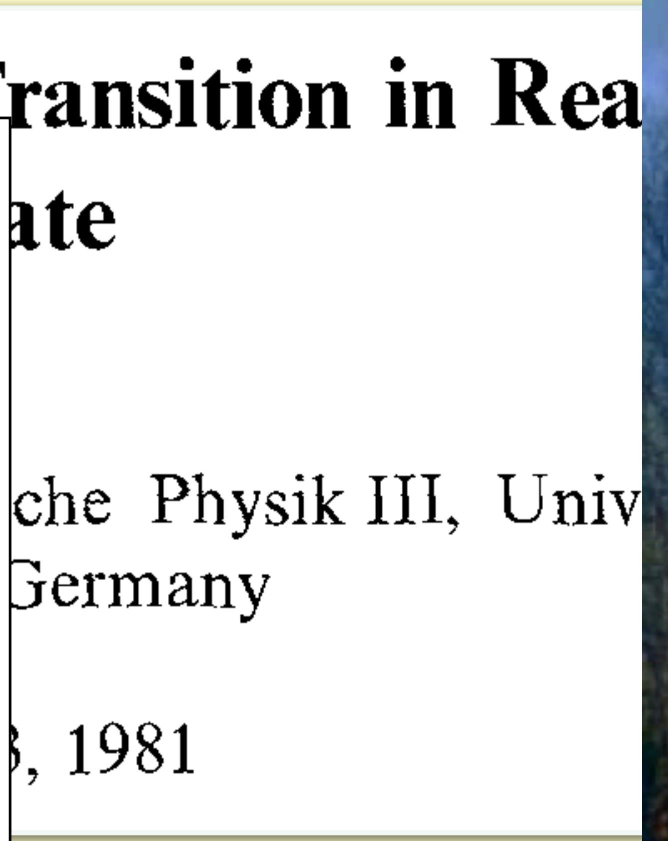
Observations by Reynolds (1883)



Intermittent Turbulence



Absorbing State Transitions



On the Nonequilibrium Phase Transition in Rea

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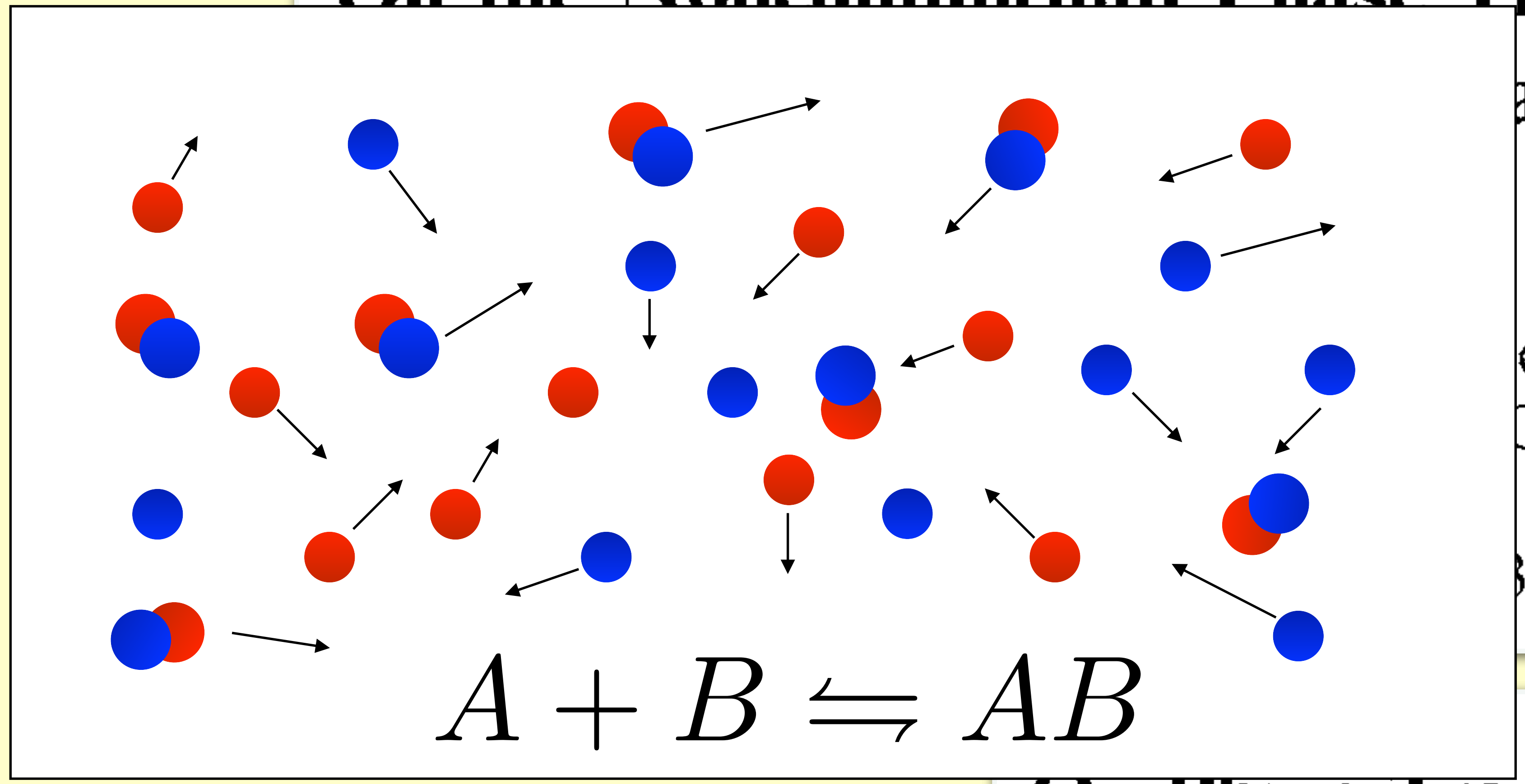
che Physik III, Univ

Germany

, 1981

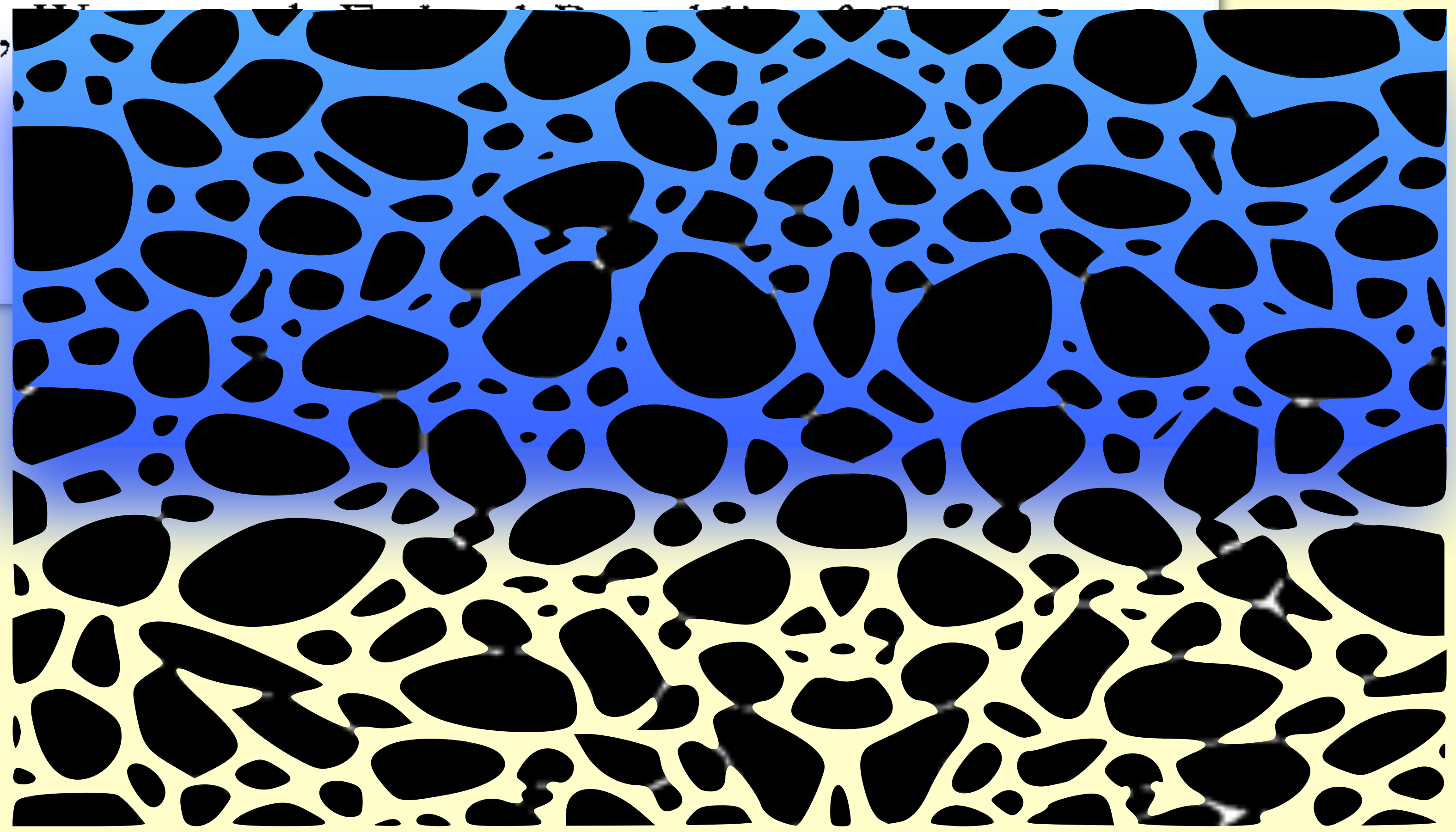


On Phase Transitions in Schlögl's Second Model

rassberger*

sik Department der Universität,

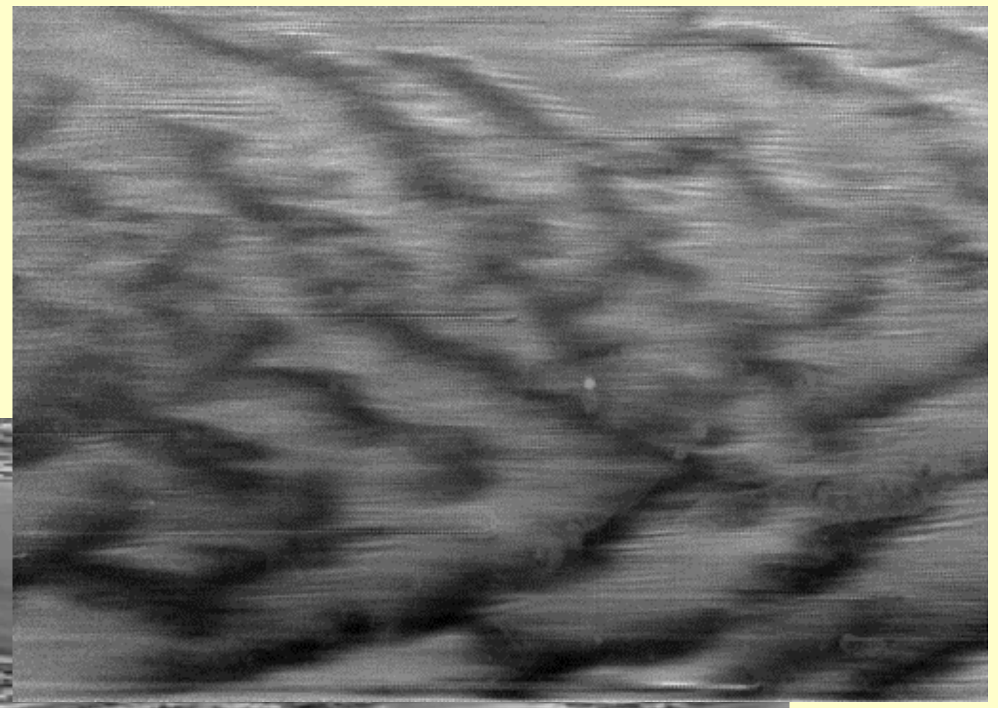
eived March 25, 1982

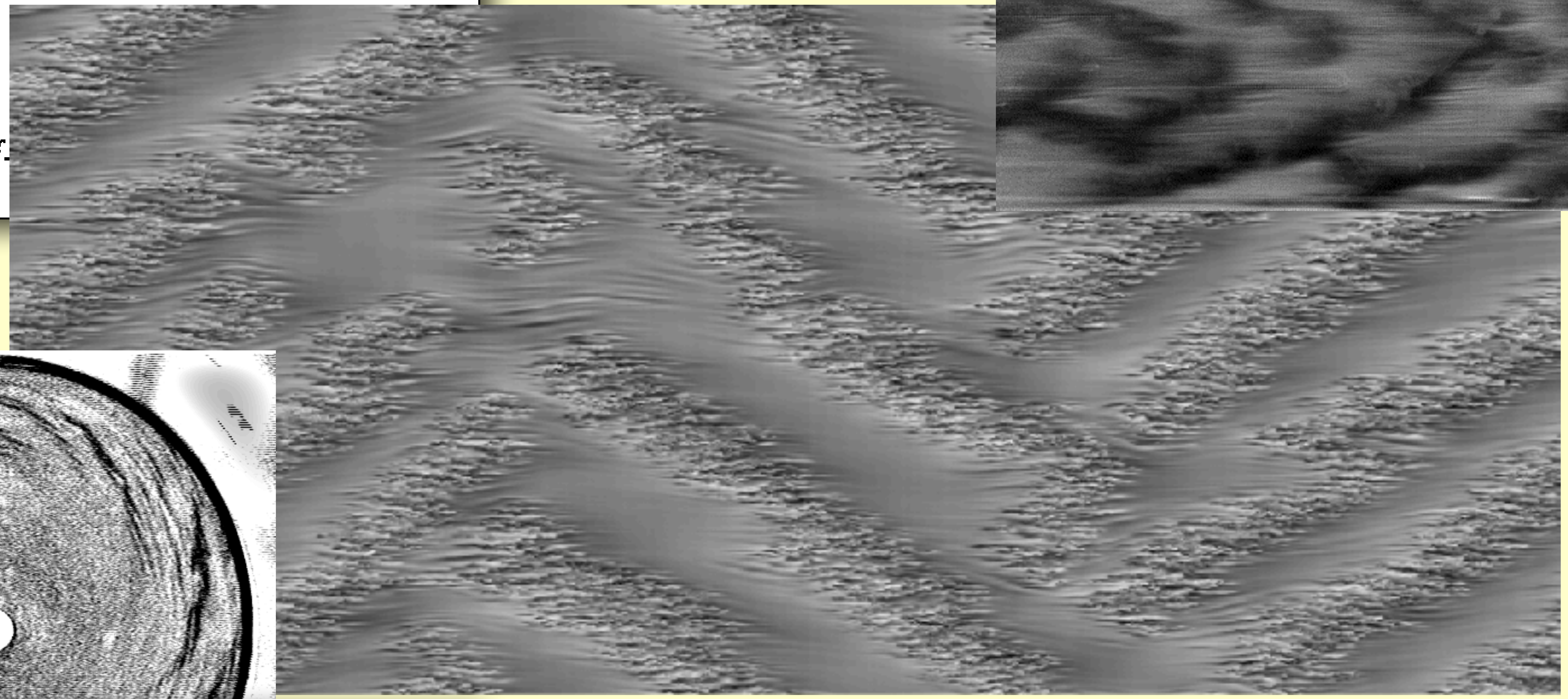


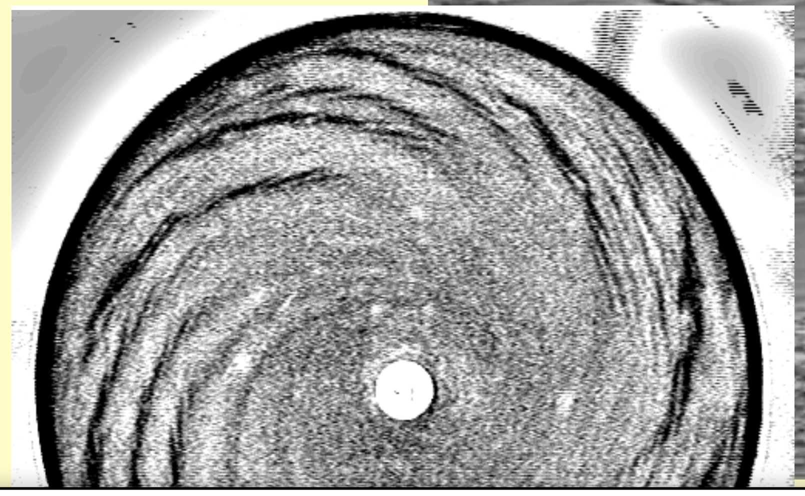
Physica 23D (1986) 3–11
North-Holland, Amsterdam

FRONT MOTION, METASTABILITY AND SUBCRITICAL BIFURCATIONS IN HYDRODYNAMICS

Y. POMEAU
Service de Physique Théorique, Centre d'Etudes Nucléaires de Saclay, 91191 Gif-







EUROPHYSICS LETTERS 15 July 1998
Europhys. Lett., **43** (2), pp. 171-176 (1998)

Discontinuous transition to spatiotemporal intermittency in plane Couette flow

S. Bottin[1], F. Daviaud[1], P. Manneville[2,1] and O. Dauchot[1]
[1] *Groupe Instabilités et Turbulence, CEA*
[2] *Laboratoire d'Hydrodynamique, École*

Eur. Phys. J. B **6**, 143–155 (1998)
The European Physical Journal B

Statistical analysis of the transition to turbulence in plane Couette flow

S. Bottin and H. Chaté

RAPID COMMUNICATIONS
PHYSICAL REVIEW E **79**, 025301(R) (2009)

Spatiotemporal perspective on the decay of turbulence in wall-bounded flows

Paul Manneville*
Laboratoire d'Hydrodynamique, Ecole Polytechnique, 91128 Palaiseau, France
(Received 7 October 2008; published 20 February 2009)

Absorbing State

(Laminar Flow)

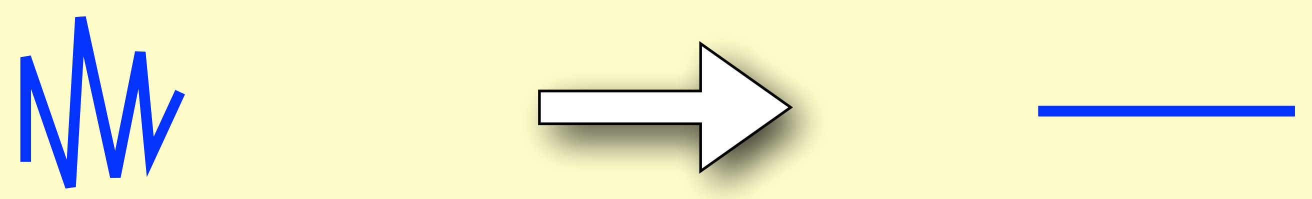
cannot spontaneously become active

Active State

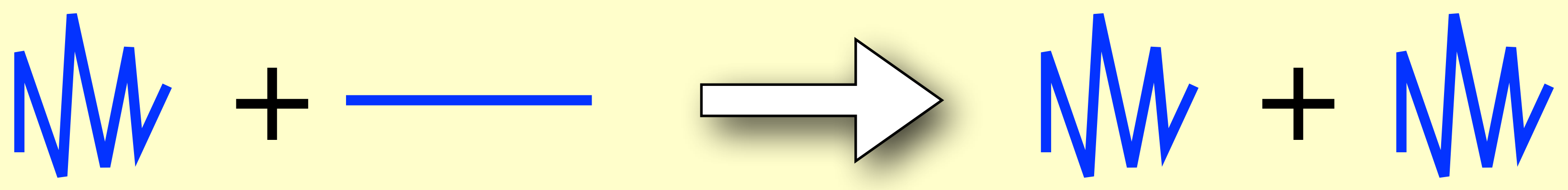
(Turbulence)

With some degree of randomness either:

reverts to absorbing state



excites absorbing state

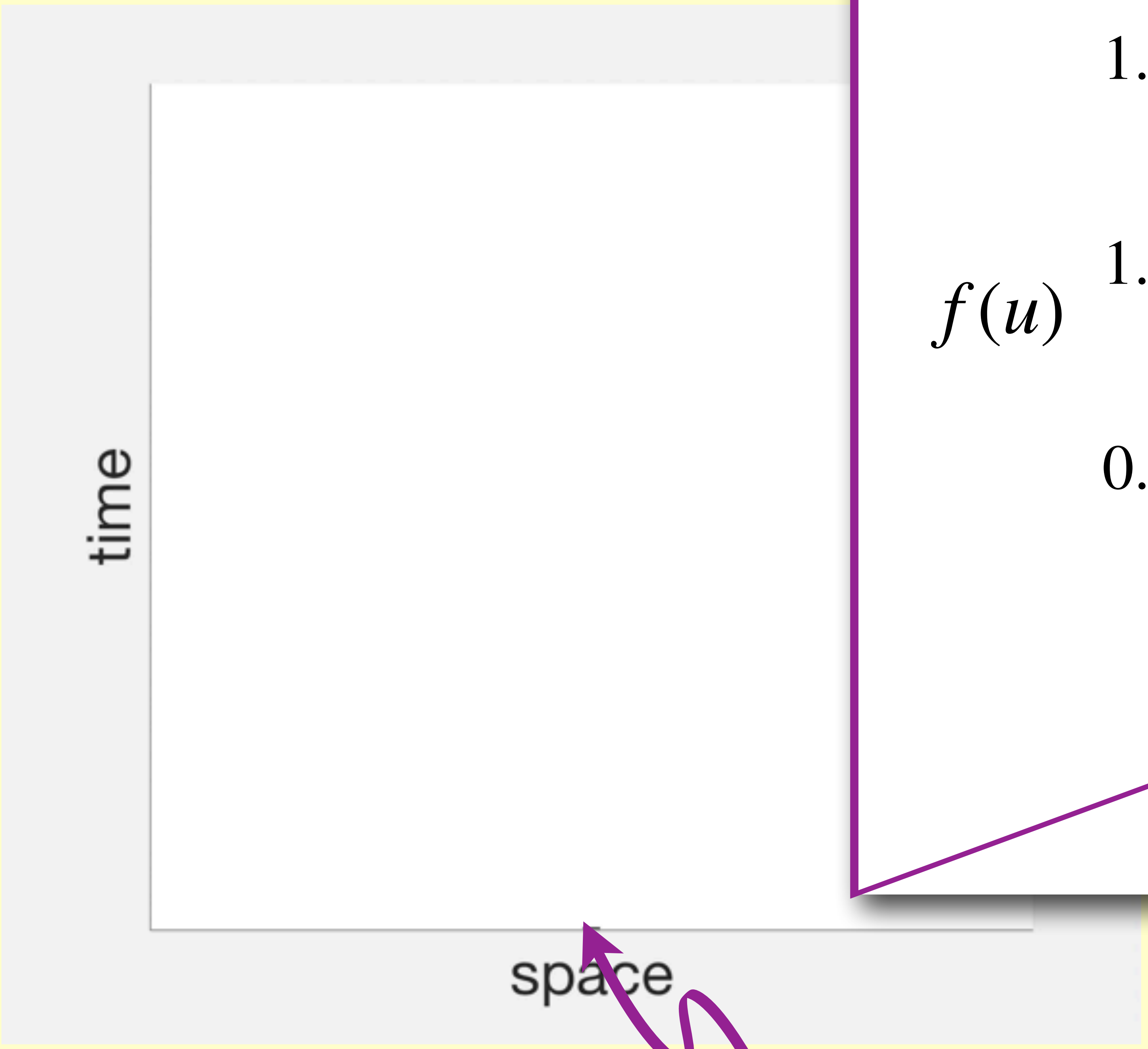


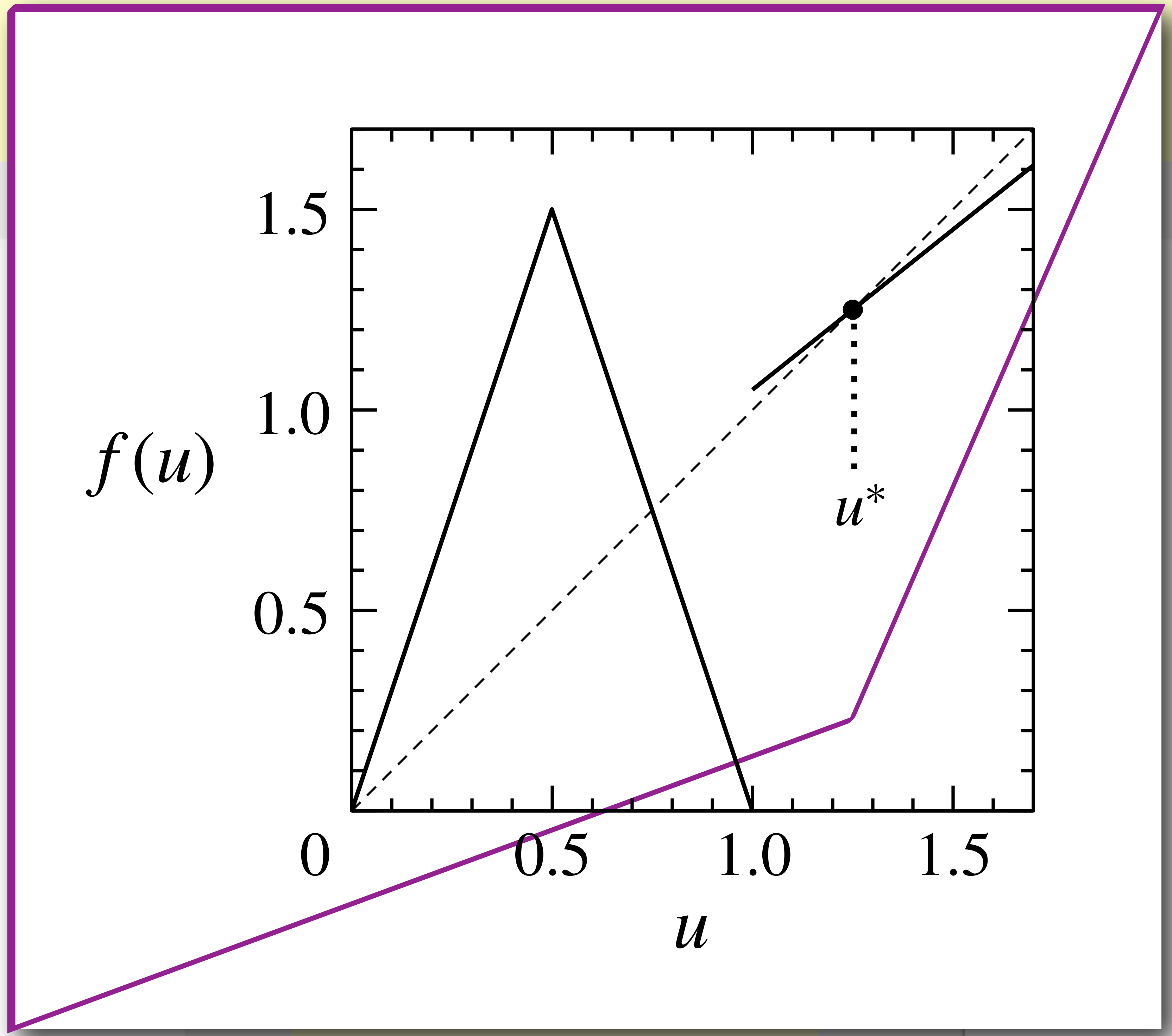
Generic behavior

active state (turbulent, black)
absorbing state (laminar, white)

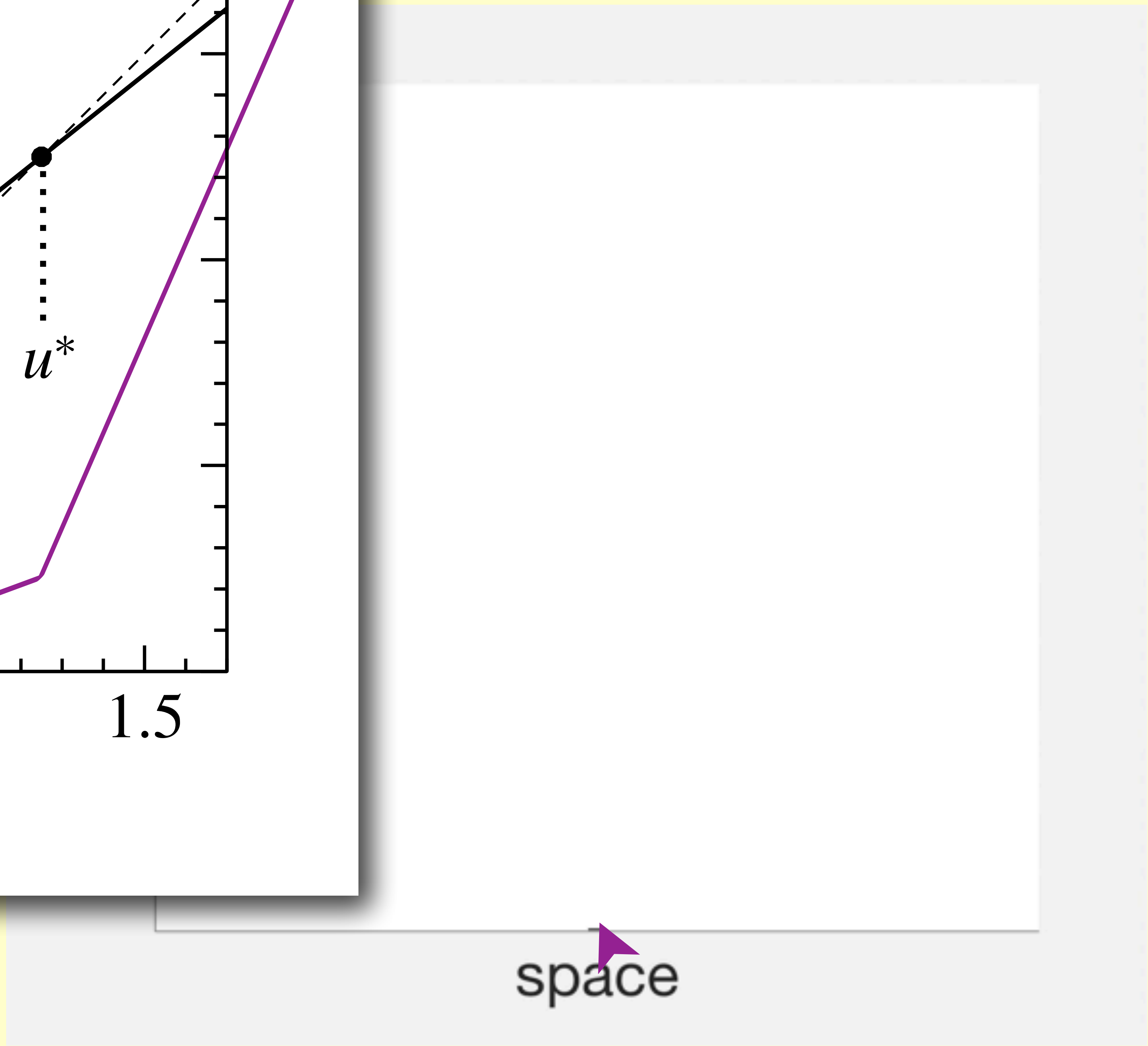
$$R = \frac{\text{Spreading rate}}{\text{Decay rate}}$$

small R





large R



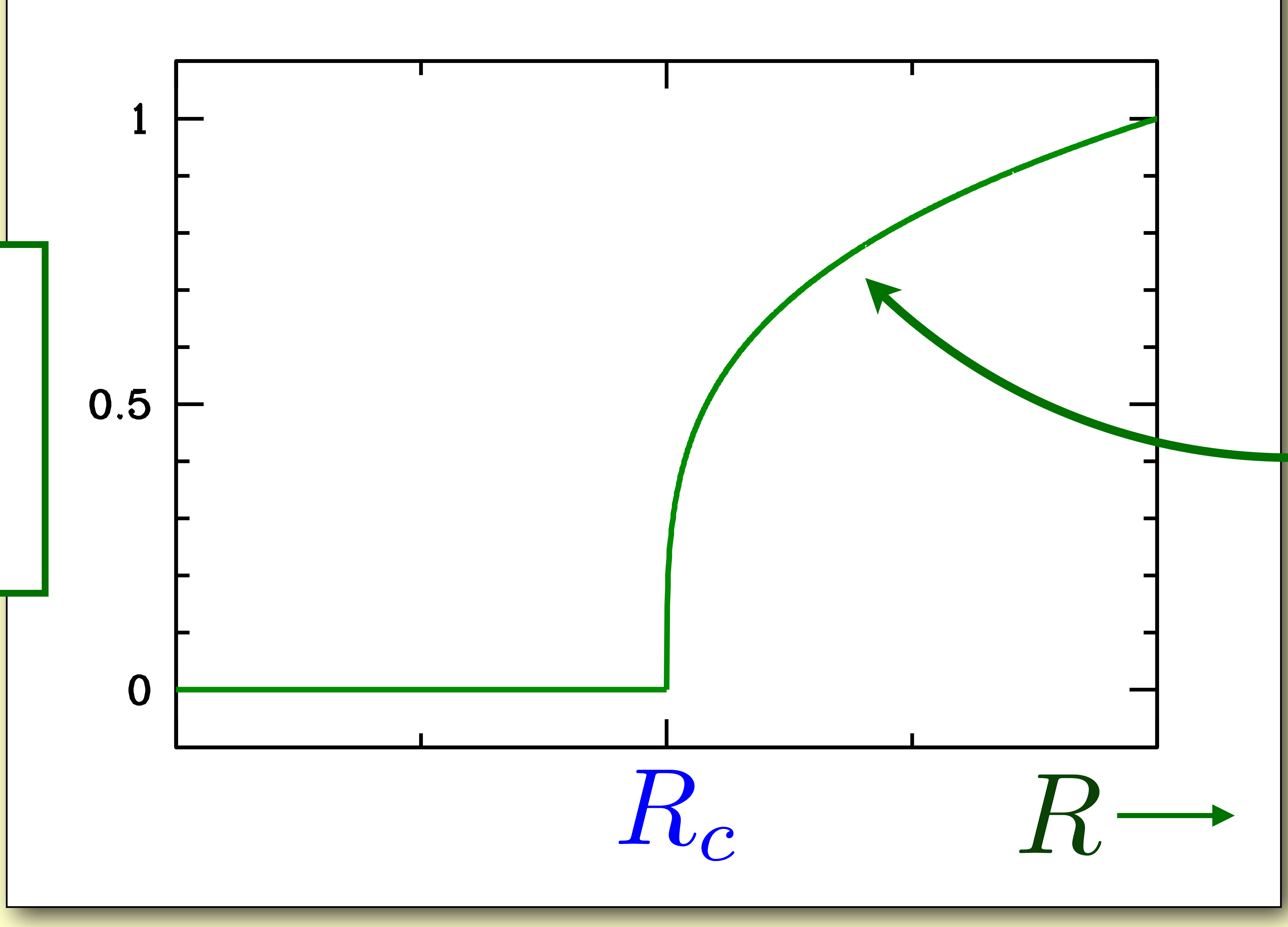
Initial seed

Initial seed

Order parameter

Turbulence fraction

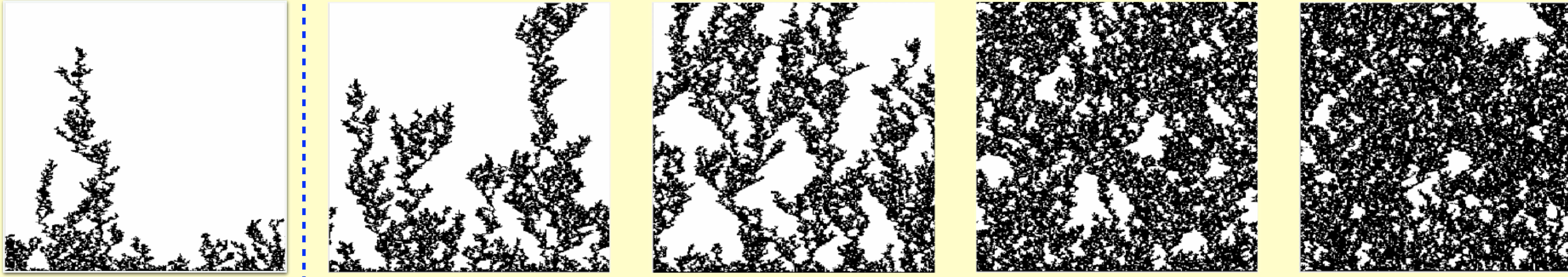
F_t



$F_t \sim (R - R_c)^\beta$

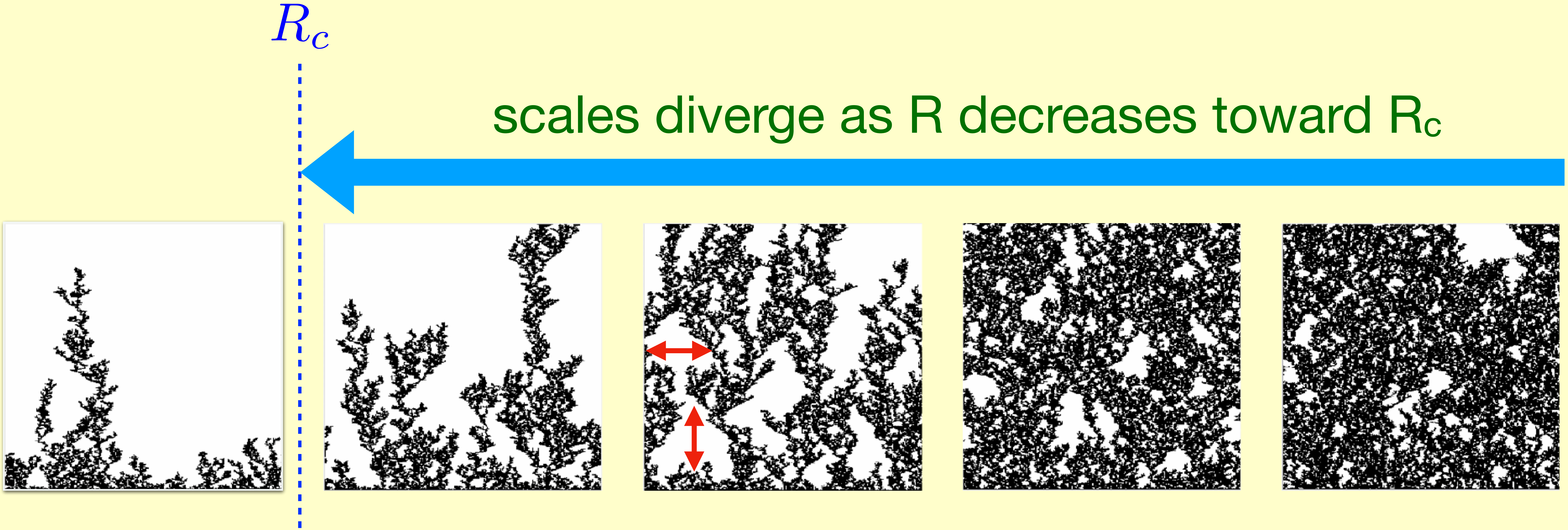
R_c

Turbulence fraction increases as R increases from R_c



Characteristic temporal scale: $\xi_{\parallel} \sim (R - R_c)^{-\nu_{\parallel}}$

Characteristic spatial scale: $\xi_{\perp} \sim (R - R_c)^{-\nu_{\perp}}$



First Experimental Realization

PRL **99,** 234503 (2007) PHYSICAL REVIEW LETTERS week ending 7 DECEMBER 2007

Directed Percolation Criticality in Turbulent Liquid Crystals

Kazumasa A. Takeuchi,[1,*] Masafumi Kuroda,[1] Hugues Chaté,[2] and Masaki Sano[1,†]

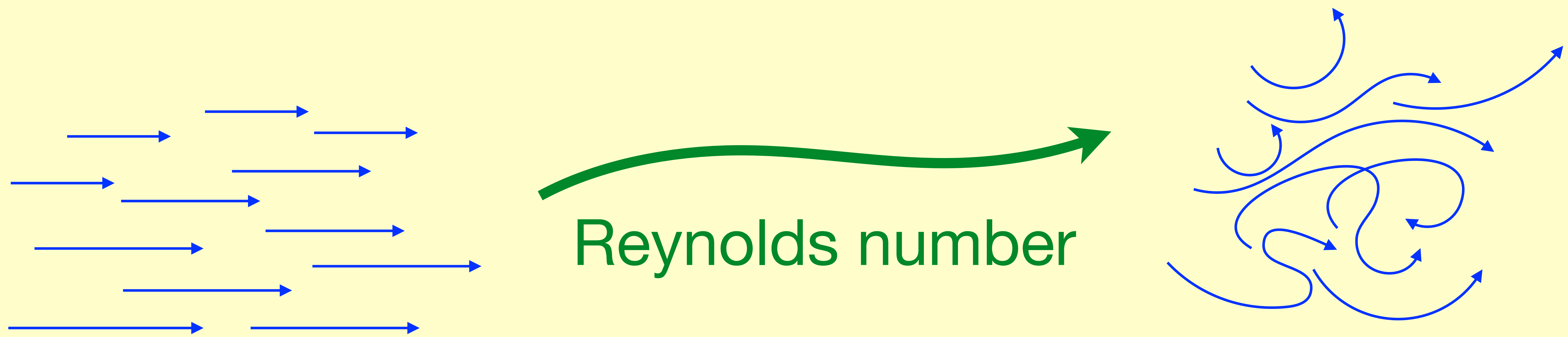
Selected for a Viewpoint in *Physics*

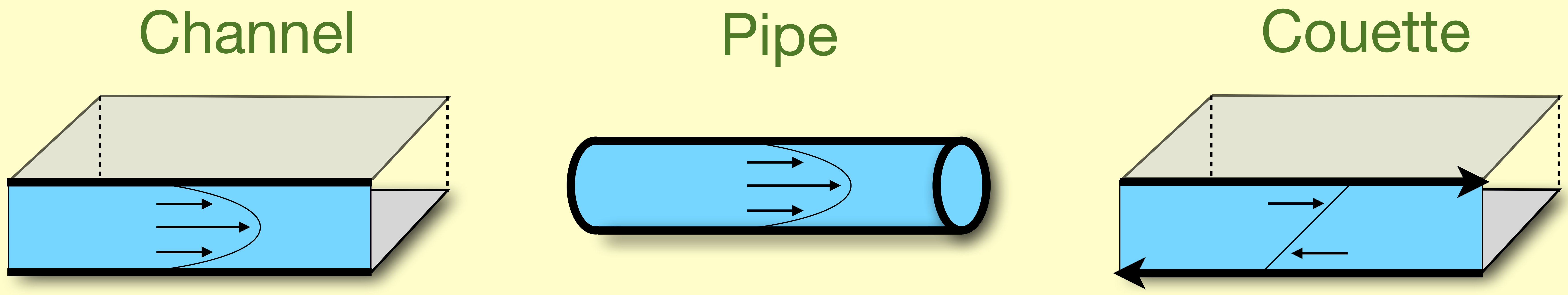
PHYSICAL REVIEW E **80**, 051116 (2009)

Experimental realization of directed percolation criticality in turbulent liquid crystals

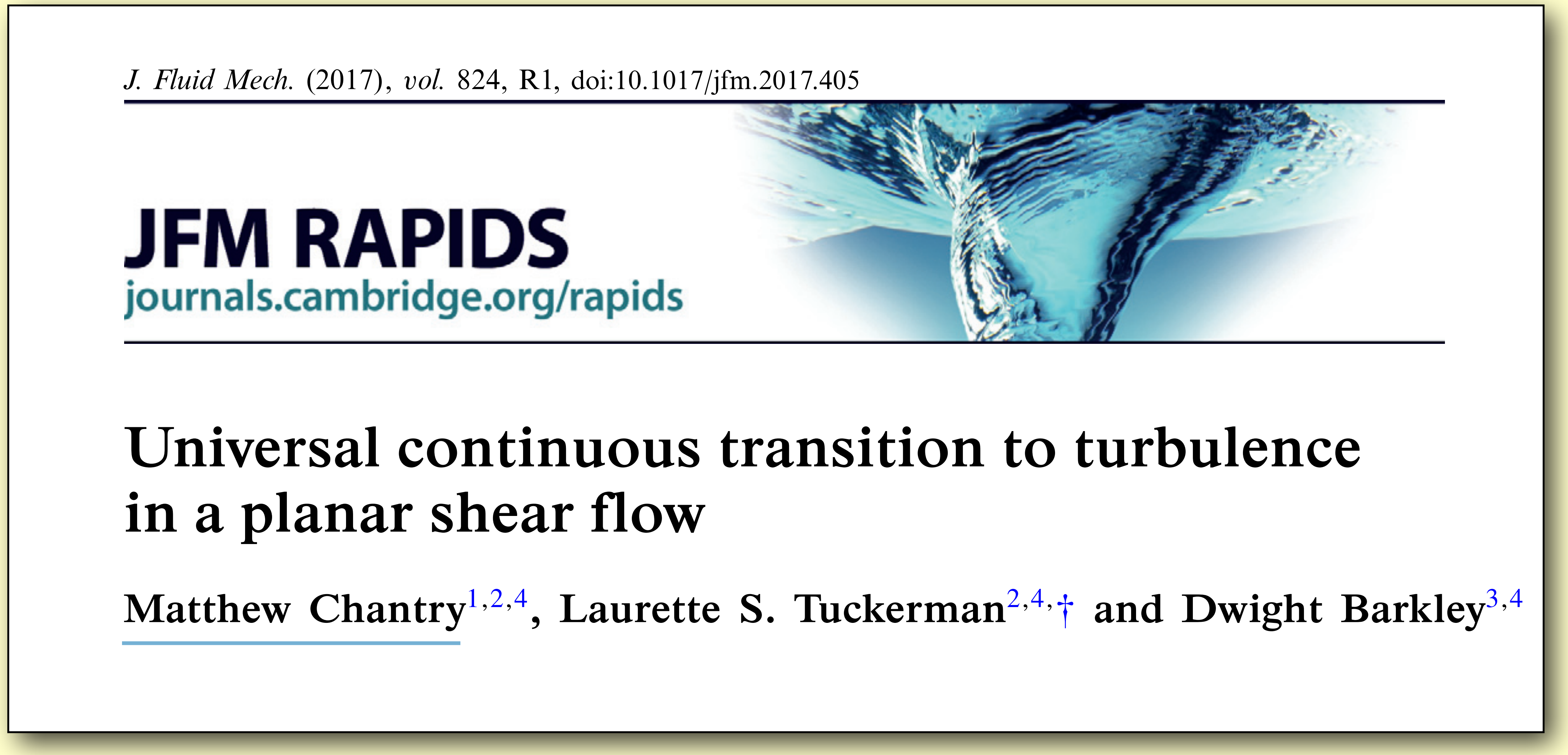
Kazumasa A. Takeuchi,[1,2,*] Masafumi Kuroda,[1] Hugues Chaté,[2] and Masaki Sano[1,†]
[1]*Department of Physics, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan*
[2]*Service de Physique de l'État Condensé, CEA-Saclay, 91191 Gif-sur-Yvette, France*
(Received 24 July 2009; published 16 November 2009)

The Route to Turbulence





Matthew Chantry
University of Oxford



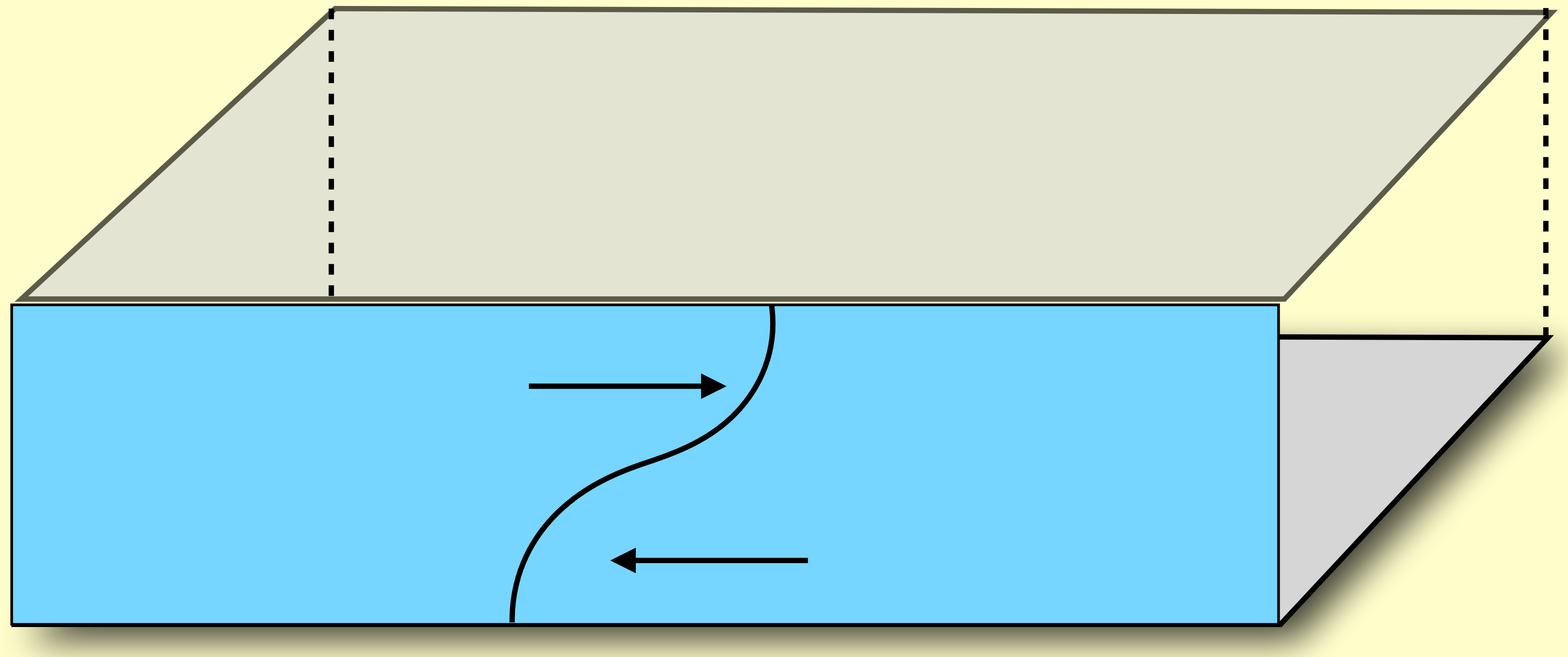
J. Fluid Mech. (2017), vol. 824, R1, doi:10.1017/jfm.2017.405

JFM RAPIDS
journals.cambridge.org/rapids

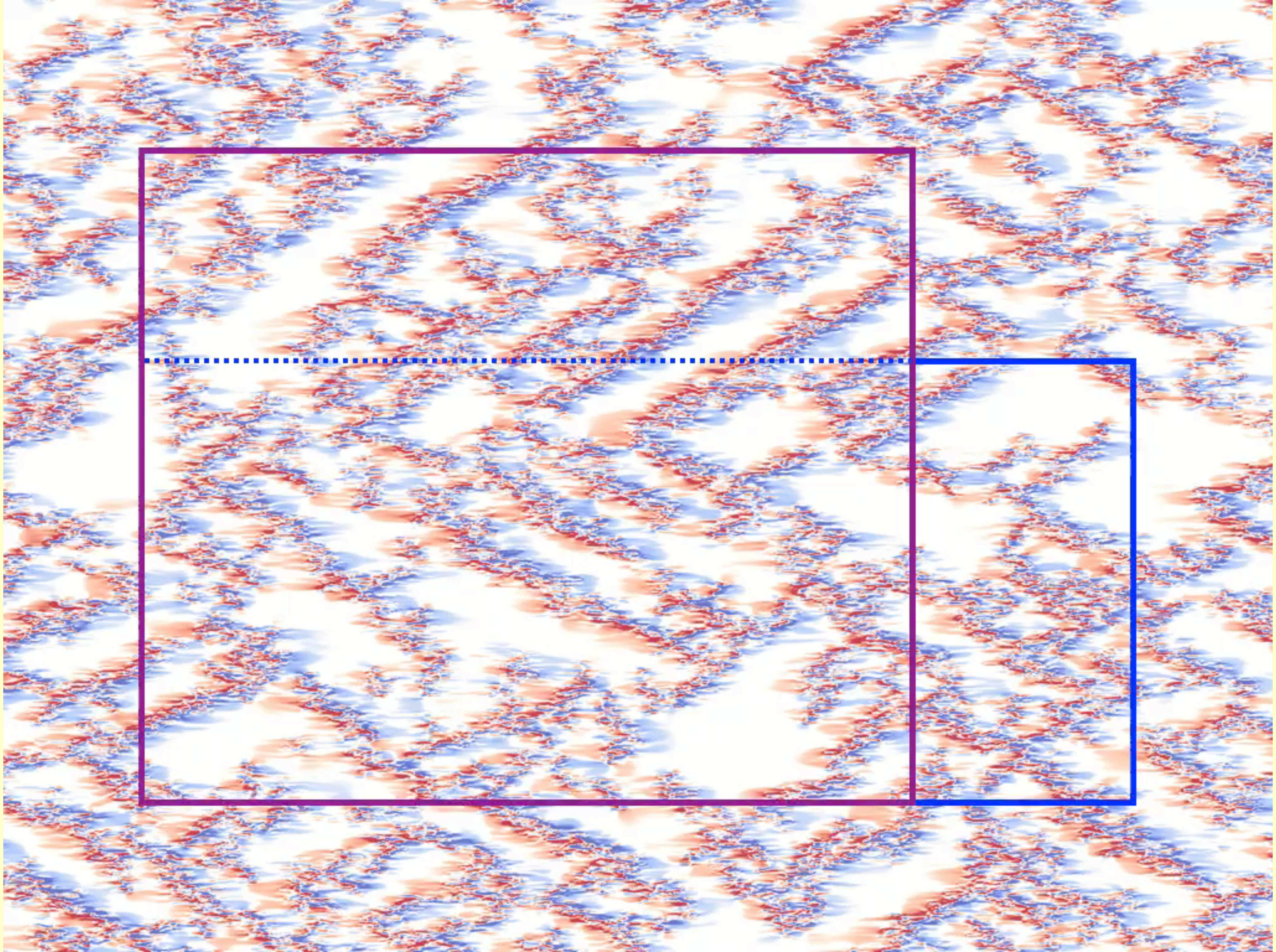
Universal continuous transition to turbulence in a planar shear flow

Matthew Chantry[1,2,4], Laurette S. Tuckerman[2,4,†] and Dwight Barkley[3,4]

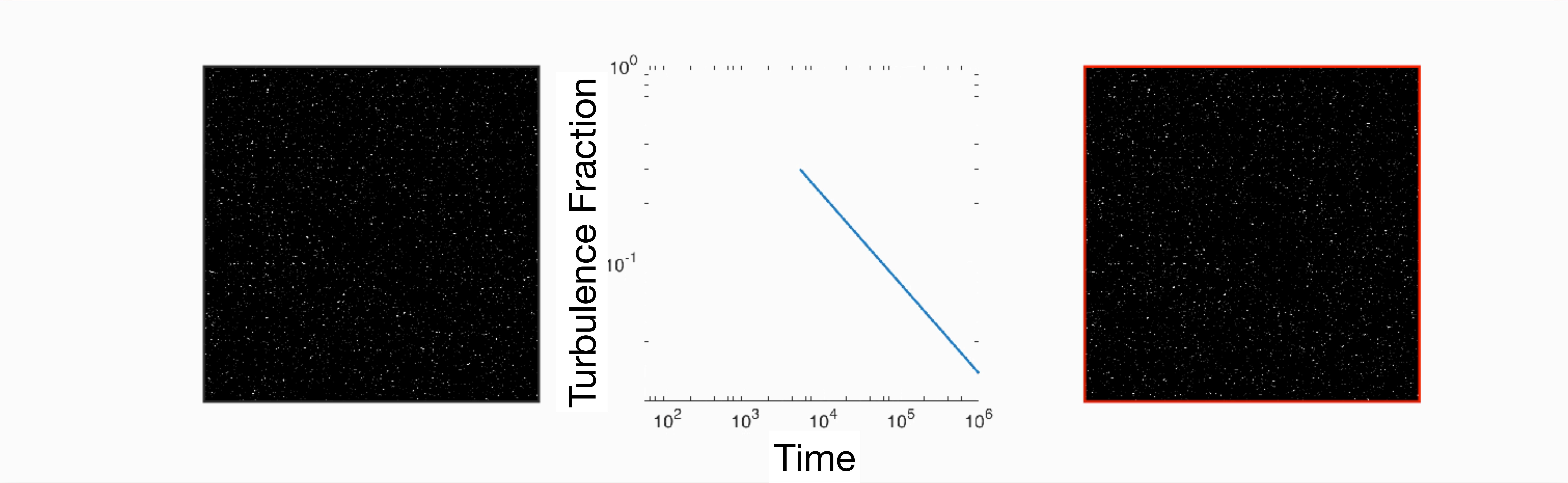
"Waleffe flow"



stress-free walls
driven by body force



$Re \simeq Re_c$ $Re > Re_c$



J. Fluid Mech. (2017), vol. 824, R1, doi:10.1017/jfm.2017.405

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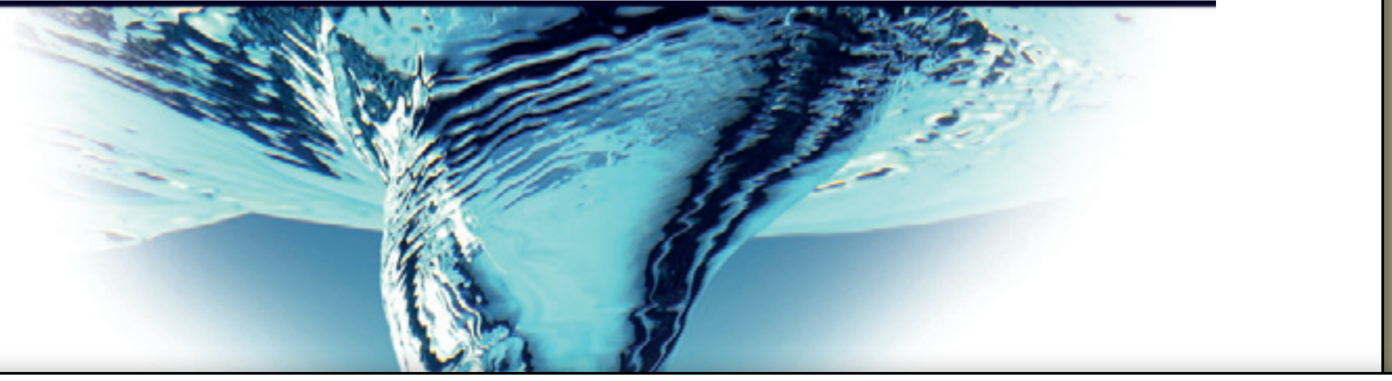

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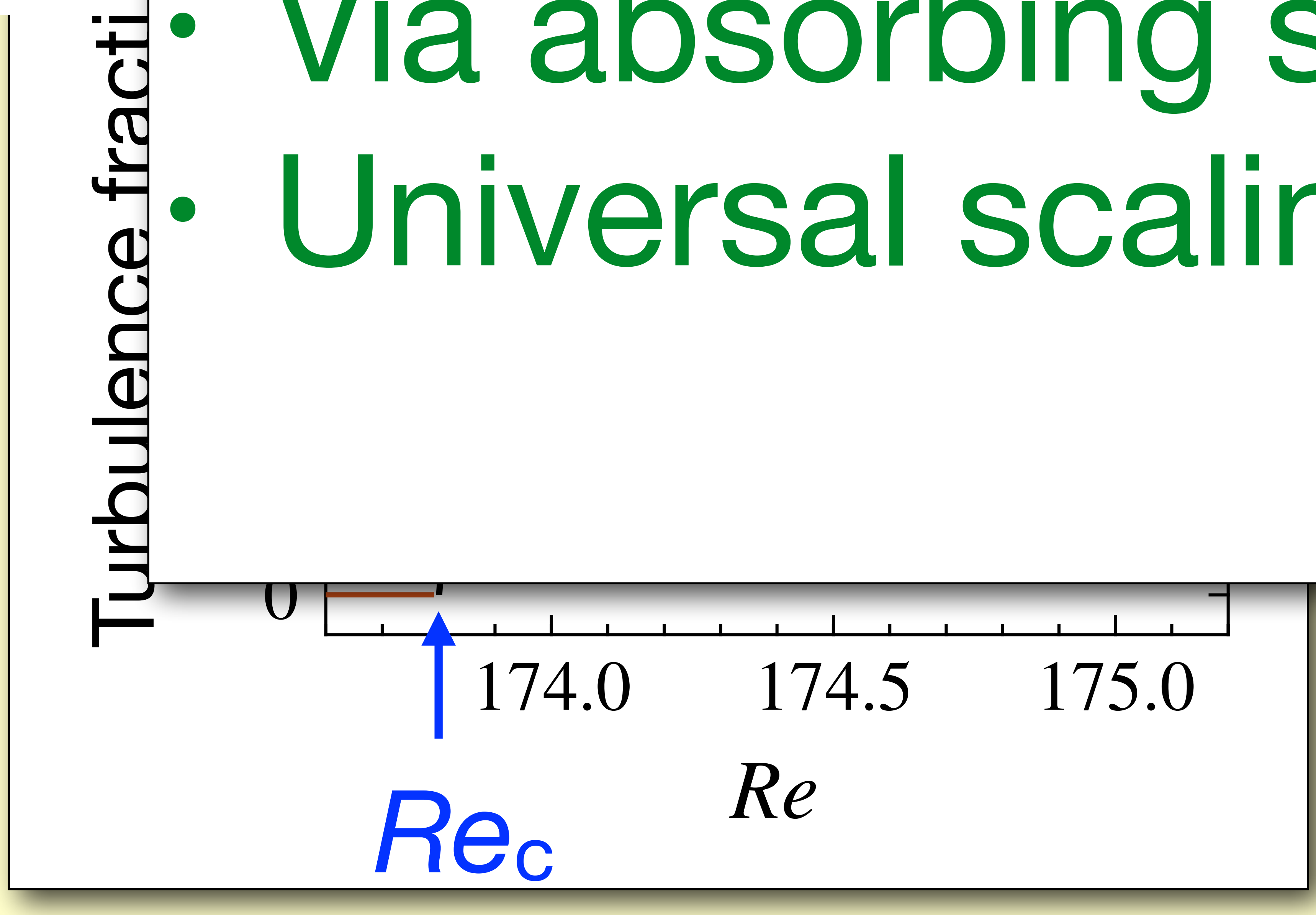
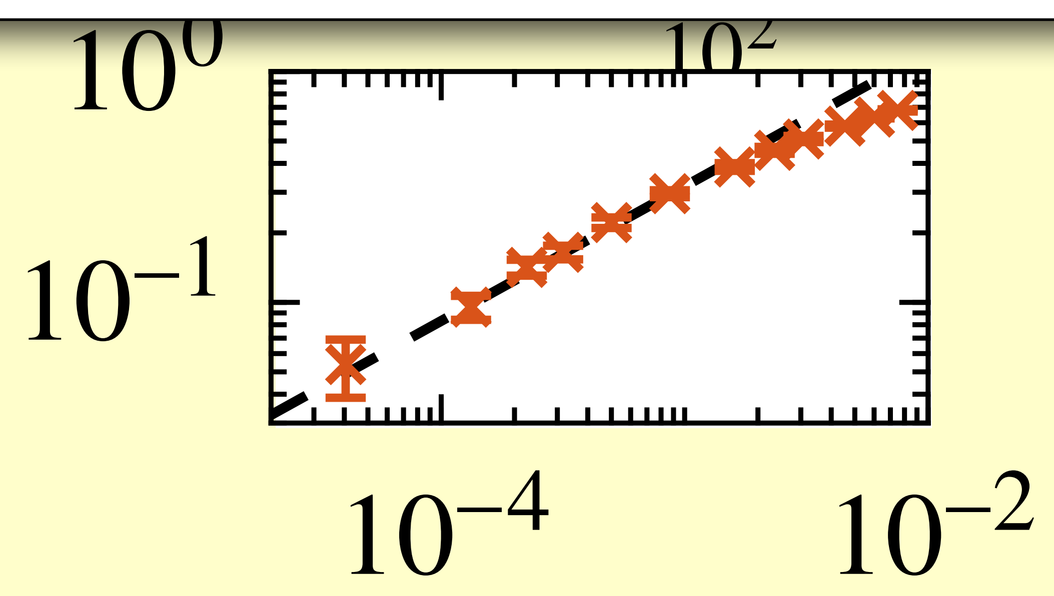
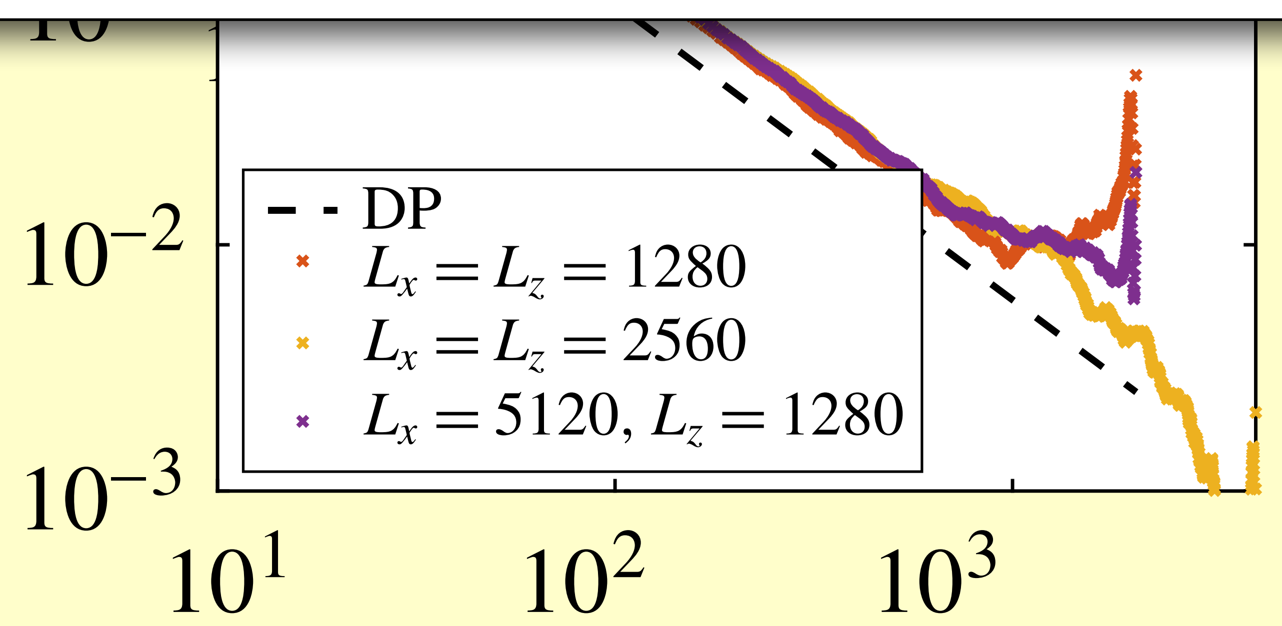


First evidence for a planar shear flow:

- Subcritical route to turbulence is continuous
- Via absorbing state phase transition
- Universal scaling exponents





Acknowledgements

Collaborators

K. Avila
M. Avila
M. Chantry
B. Hof
G. Lemoult
A. de Lozar
D. Moxey
V. Mukund
B. Song
L. Tuckerman

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G. Kawahara
P. Manneville
Y. Pomeau
M. Schatz
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A. Willis