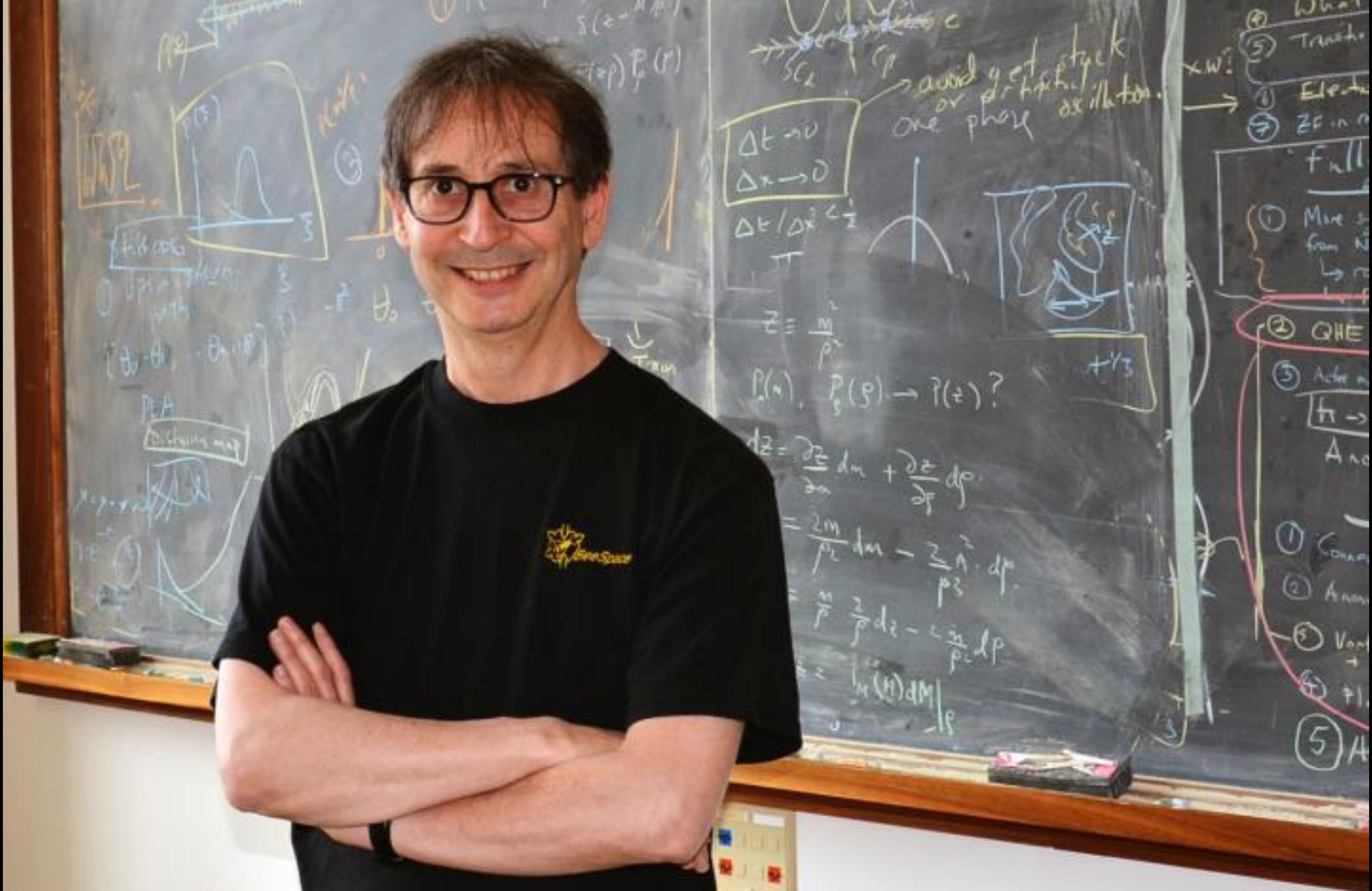
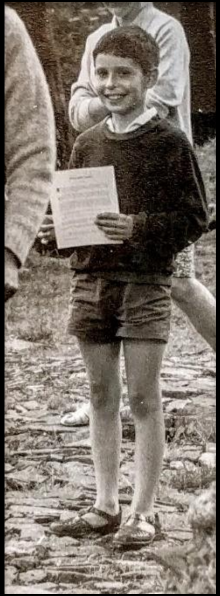
TEXAS
The University of Texas at Austin

Laudatio for Nigel Goldenfeld

121st Statistical Mechanics Conference
Rutgers University, New Brunswick, NJ
May 12–14, 2018

Paul Goldbart
The University of Texas at Austin





~ Impact ~

~ Mentoring ~

Graduate students

Minhui Zhu
Sang Hyun Choi
Purba Chatterjee
Chi Xue
Vikyath Rao
K. Michael Martini
Farshid Jafarpour
Tommaso Biancalani
Maksim Sipos
Zhenyu Wang
Patricio Jeraldo
Tuan Tran
Tom Butler
Nicholas Guttenberg
Patrick Chan
John Veysey
Badri Athreya
Hector Garcia Martin
Kalin Vetsigian
Tae Kim
Vivek Aji
Qing Hou
Lin-Yuan (Patrick) Chan
John Stewart
Maurizio Mondello
Fong Liu
An-Chang Shi

Postdocs

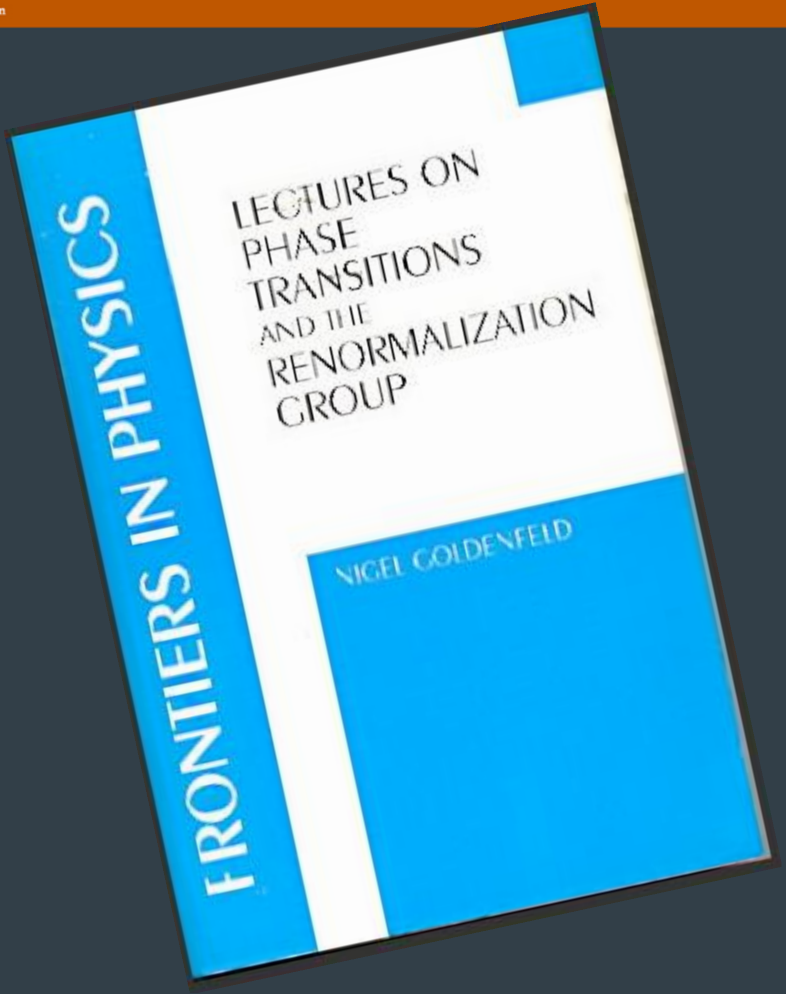
Hong-Yan Shih
Luiza Angheluta
Chi Xue
Michael Assaf
Nicholas Lee-Ping Chia
Andreas Menzel
Pinaki Chakraborty
Lanying Zeng
David Reynolds
Navot Israeli
Jun-Jo Jeong
George Bonheyo
Greg Bauer
Nik Provatas
Ken Elder
Shin-ichi Sasa
Hisao Hayakawa
Greg Eyink
Tim Newman
Sergei Esipov
Scott Renn
James Annett
Olivier Martin

Faculty

PMG
and *numerous* others…

~ Teaching ~

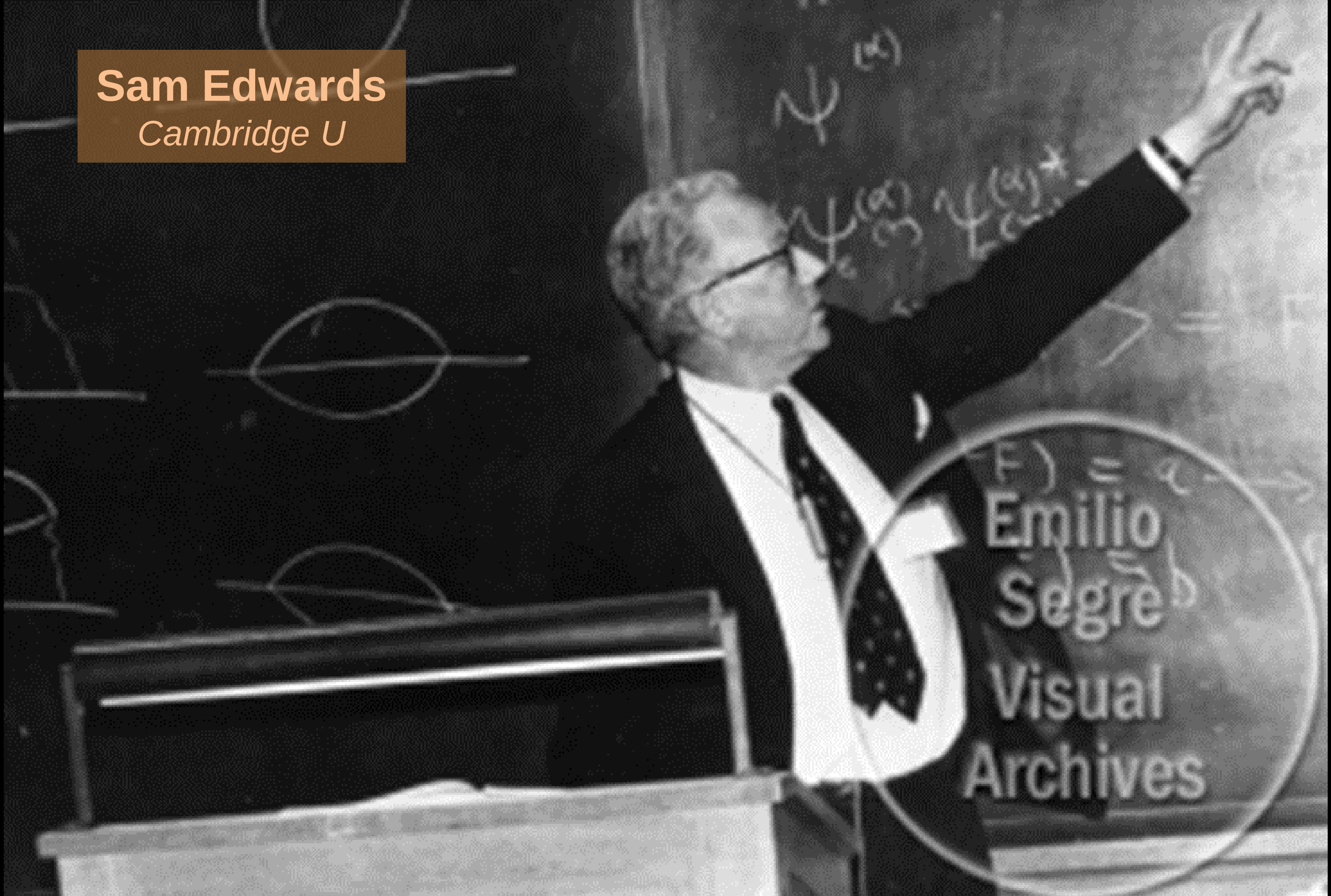
- 563 Phase Transitions and Renormalization Group
- 569 Emergent States of Matter
  [just one example… http://guava.physics.uiuc.edu/%7Enigel/courses/569/]
- 504 Statistical Mechanics
- 598BIO Biological Information and Complexity


FRONTIERS IN PHYSICS
LECTURES ON
PHASE
TRANSITIONS
AND THE
RENORMALIZATION
GROUP
NIGEL GOLDENFELD

~ Listening ~

Sam Edwards

Cambridge U

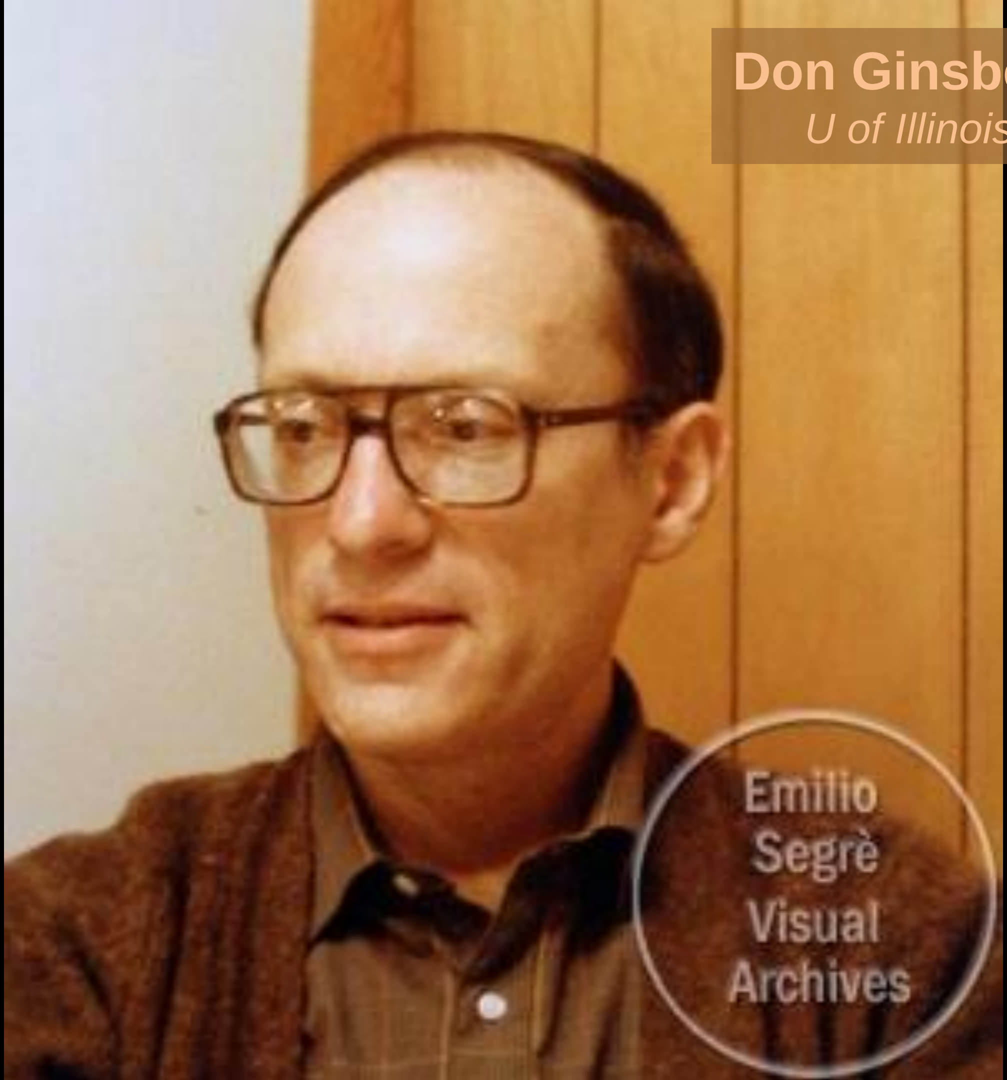


Jim Langer
ITP UCSB

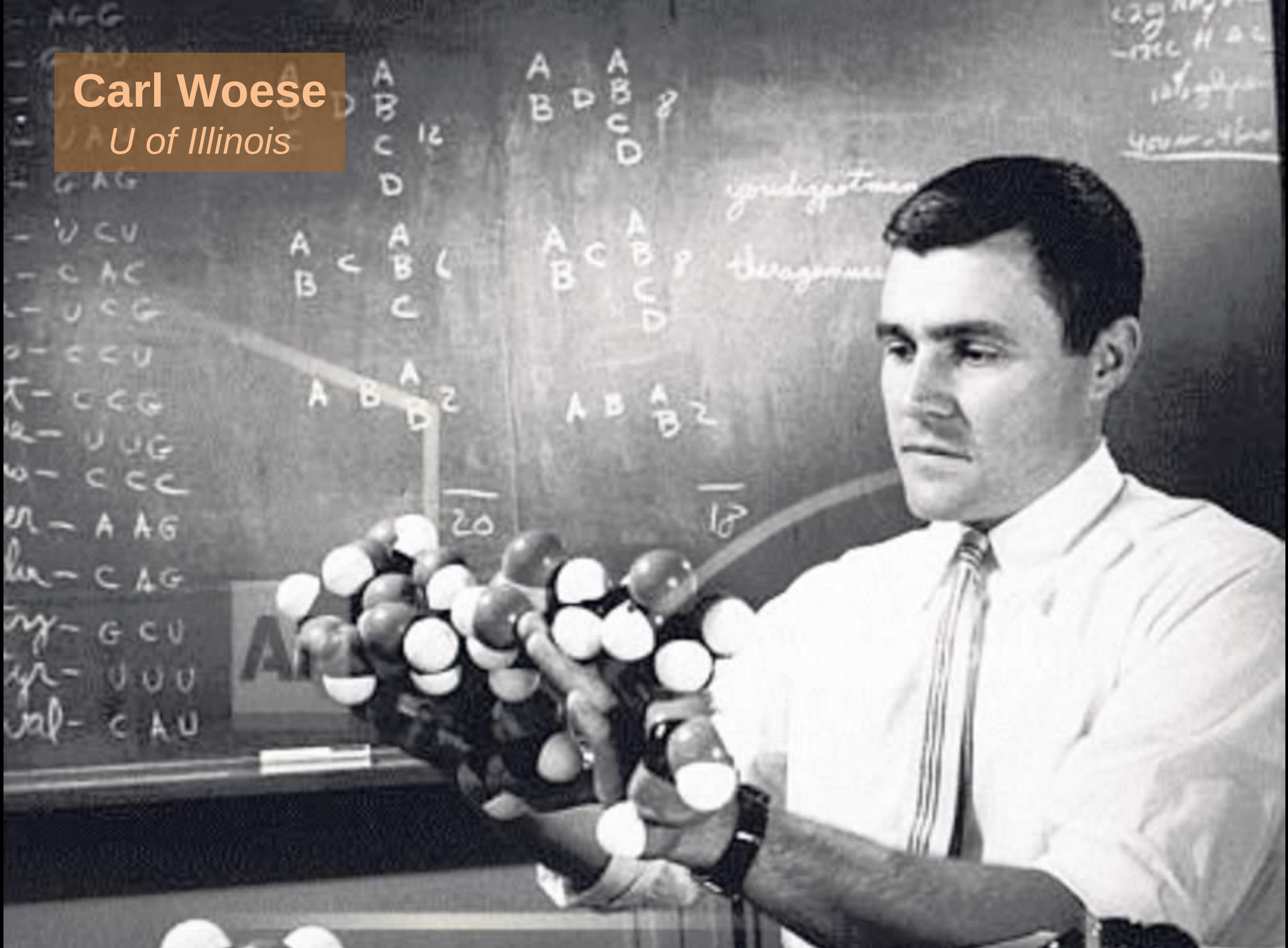
Leo Kadanoff

U of Chicago

Don Ginsberg
U of Illinois




Grisha Barenblatt
UC Berkeley



Carl Woese

U of Illinois

~ Pattern formation ~

~ Pattern formation ~

TUESDAY, JANUARY 6, 1987

Science Times

With Education, Style, Arts

The New York Times

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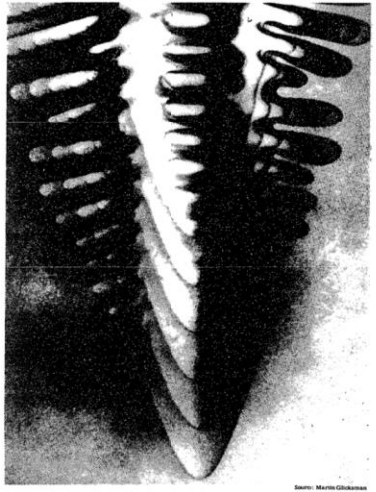
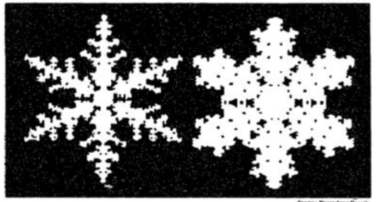


Source: Martin Glicksman



Source: Fereydoon Family

Crystal Growth: Real and Programmed

A crystal tip or dendrite, top, magnified about 40 times and photographed is multiple exposure, becomes unstable as it grows downward, and subbranches bud from the sides. "Snowflakes" generated by computer reflect the variations of the real world. The computer uses a set of equations to model the physical conditions the flakes encounter. Slight changes in temperature or surface tension lead to very different patterns.

Snowflake's Riddle Yields To Probing Of Science

By JAMES GLEICK

SCIENCE has conquered the snowflake problem. In resolving two of nature's most poetic and maddening riddles — why are snowflakes symmetrical, and why are they all different — theoretical physicists have created a new body of mathematics for the laws that control the delicate branching growth of an unstable solidifying crystal.

Where traditionally snowflakes were left to weather experts and atmospheric scientists, now they have become part of a growing science of pattern formation that is drawing together theorists, computer modelers and engineers with practical problems ranging from metallurgy to flame propagation to oil recovery. The principles that govern ice crystals apply as well to metallic crystals, whose microscopic structure helps determine the strength of cast alloys.

> Snowflakes obey math laws of surprising subtlety.

Generations of snowflake-watchers sketched and catalogued the variegated patterns formed by airborne ice crystals: plates and columns, crystals and polycrystals, needles and dendrites. But snowflakes obey mathematical laws of surprising subtlety, and it has been impossible to predict precisely how fast a tip will grow, how narrow it will be or how often it will branch.

"In the last two years, those problems have been solved," said Herbert Levine of the Schlumberger-Doll Research Center in Connecticut, one of the pioneers of pattern-formation research. The most recent breakthrough has provided a working mathematics for tying together the forces that stabilize the growing patterns and the forces that destabilize them.

By understanding the interplay of randomness and determinism, large-scale processes and microscopic processes, this new wing of physics has related a variety of subjects that were formerly treated separately.

"We've reached a very interesting point scientifically where we're starting to look at a whole bunch of older problems of pattern formation in nature, how complex formations emerge out of a generally featureless soup," said James S. Langer of the Institute for Theoretical Physics in Santa Barbara, Calif. "We finally seem to have a good idea of what controls these things."

A key to the new approach has been the availability of computers with which scientists could propose models, test them, make pictures of the results and then improve their models. Only recently, though, after more than five years of research by several groups, have computer simulations succeeded in realistically capturing the physics of crystal growth.

One problem is that such growth entails, as Dr. Langer says, "a highly nonlinear unstable free boundary problem," meaning that models need to track a complex, wiggly boundary that changes dynamically. "That's tough, trying to understand where this boundary is moving," he said. "If you guess wrong, the computer program just blows up on you."

Another problem has been deciding which of the many physical forces involved are important and which can safely be ignored. Most important, as scientists have long realized, is the diffusion of the heat released when

Continued on Page C3

VOLUME 53, NUMBER 22 PHYSICAL REVIEW LETTERS 26 NOVEMBER 1984

Pattern Selection in Dendritic Solidification

E. Ben-Jacob,[a] Nigel Goldenfeld, B. G. Kotliar, and J. S. Langer
Institute for Theoretical Physics, University of California, Santa Barbara, California 93106

(Received 13 August 1984)

We show that the dynamically selected velocity and tip radius of dendrites in the boundary-layer model of solidification have the special values which permit the existence of steady-state needle-crystal solutions. This result, in conjunction with considerations of stability, provides new insight concerning the validity of the marginal stability hypothesis.

VOLUME 55, NUMBER 12 PHYSICAL REVIEW LETTERS 16 SEPTEMBER 1985

Experimental Demonstration of the Role of Anisotropy in Interfacial Pattern Formation

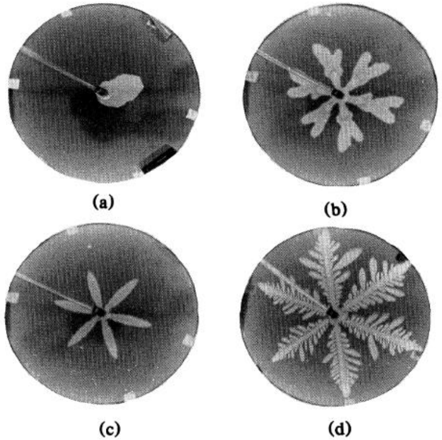


FIG. 2. The various patterns observed in the Hele-Shaw experiments with anisotropy. (a)–(d) correspond to points (A)–(D) in Fig. 1, respectively, and show (a) faceted growth; (b) tip splitting; (c) needle crystals; (d) dendrites. The plate is 25 cm across.

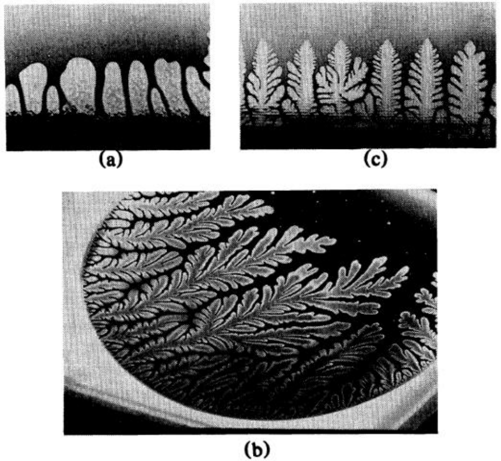


FIG. 3. The lifting Hele-Shaw experiment. (a) "Fingers" at low velocity. (b) Branched "fingers" at higher velocity. (c) Array of dendrites with imposed anisotropy.

~ Pattern formation ~

Watching rocks grow

JOHN VEYSEY II AND NIGEL GOLDENFELD*
Department of Physics, University of Illinois at Urbana-Champaign, 1110 W. Green St., Urbana, Illinois 61801, USA
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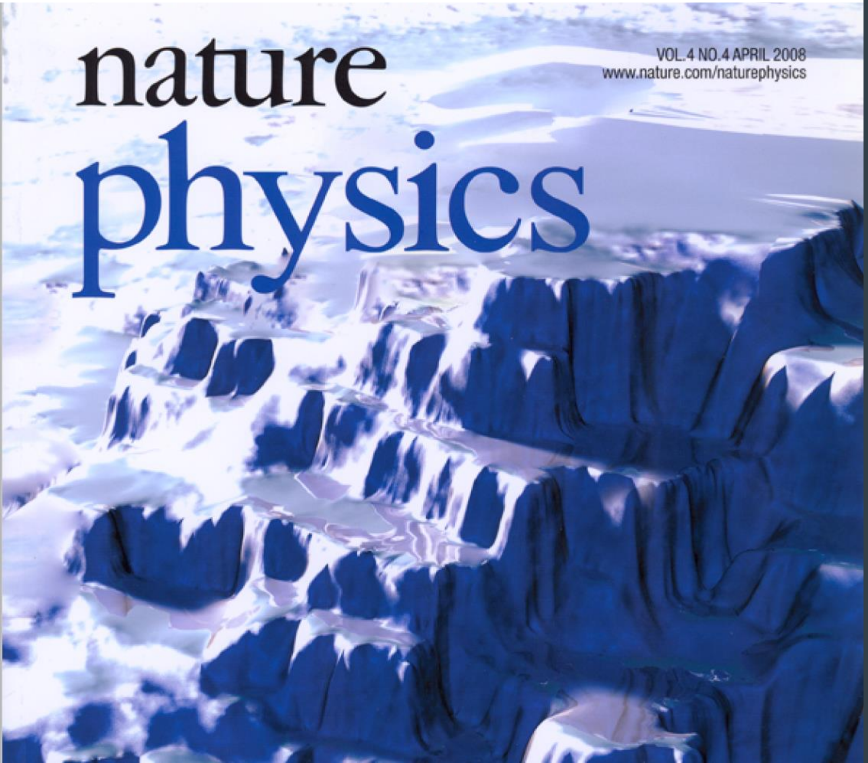


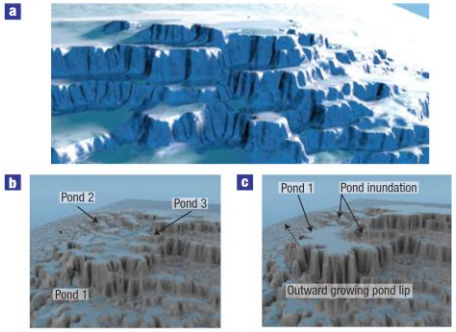


Figure 1 Dynamics of synthetic hot-spring landscapes. These still frames are rendered from CDS simulations. **a**, Overview of results after long simulation times. The model ultimately results in a well-developed landscape that is qualitatively very

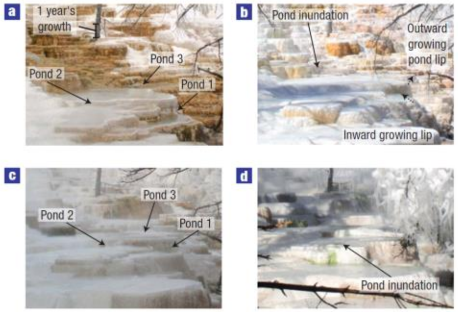
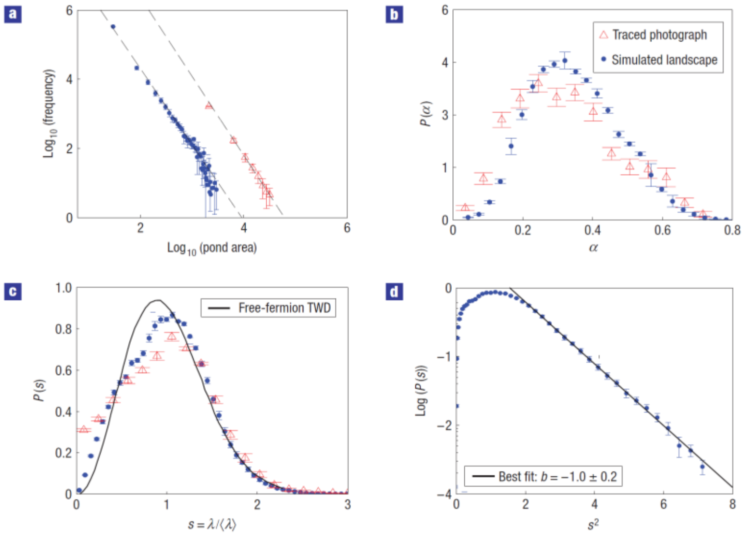


Figure 2 Watching rocks grow. Four still frames from our time-lapse movie, showing one year at Canary Springs. The frames are taken roughly three months apart, show the growth and interaction of several ponds and illustrate three specific processes. **a**, The initial state, together with the extent of subsequent precipitation.



~ Intermediate asymptotics ~

~ Intermediate asymptotics ~

VOLUME 64, NUMBER 12 PHYSICAL REVIEW LETTERS 19 MARCH 1990

Anomalous Dimensions and the Renormalization Group in a Nonlinear Diffusion Process

Nigel Goldenfeld, Olivier Martin,[a] Y. Oono, and Fong Liu
Department of Physics, Materials Research Laboratory, and Beckman Institute, University of Illinois at Urbana-Champaign, 1110 West Green Street, Urbana, Illinois 61801
(Received 22 January 1990)

We present a renormalization-group (RG) approach to the nonlinear diffusion process $\partial_t u = D\,\partial_x^2 u$, with $D=\frac{1}{2}$ for $\partial_x^2 u > 0$ and $D=(1+\epsilon)/2$ for $\partial_x^2 u < 0$, which describes the pressure during the filtration of an elastic fluid in an elastoplastic porous medium. Our approach recovers Barenblatt's long-time result that, for a localized initial pressure distribution, $u(x,t) \sim t^{-(\alpha+1/2)} f(x/\sqrt{t},\epsilon)$, where f is a scaling function and $\alpha = \epsilon/(2\pi e)^{1/2} + O(\epsilon^2)$ is an anomalous dimension, which we compute perturbatively using the RG. This is the first application of the RG to a nonlinear partial differential equation in the absence of noise.

PACS numbers: 47.55.Mh, 47.25.Cg, 64.60.Ak, 64.60.Ht

Buckingham's Π theorem[1] states that the dependence of a physical quantity on a set of dimensionful parameters may be expressed as the dependence of a dimensionless quantity Π on dimensionless combinations $\Pi_0, \Pi_1, \ldots, \Pi_n$ of the governing parameters:

$$\Pi = f(\Pi_0, \Pi_1, \ldots, \Pi_n)\,. \tag{1}$$

This elementary result is the root of dimensional

is well defined:

$$\lim_{\Pi_0 \to 0} \frac{\Pi}{\Pi_0^{\alpha}} = \lim_{\Pi_0 \to 0} \Pi_0^{-\alpha} f\left(\Pi_0, \frac{\Pi_1}{\Pi_0^{\alpha_1}}, \ldots, \frac{\Pi_n}{\Pi_0^{\alpha_n}}\right), \tag{2}$$

with the exponents $\alpha, \alpha_1, \ldots, \alpha_n$ being real parameters, not determined by dimensional analysis, but determined,

~ Intermediate asymptotics ~

PHYSICAL REVIEW E VOLUME 54, NUMBER 1 JULY 1996

Renormalization group and singular perturbations: Multiple scales, boundary layers, and reductive perturbation theory

Lin-Yuan Chen,[1,2] Nigel Goldenfeld,[1] and Y. Oono[1]
[1]*Department of Physics, Materials Research Laboratory, and Beckman Institute, 1110 West Green Street, University of Illinois at Urbana–Champaign, Urbana, Illinois 61801-3080*
[2]*Institute for Theoretical Physics, University of California, Santa Barbara, California 93106-4030*
(Received 20 June 1995)

Perturbative renormalization group theory is developed as a unified tool for global asymptotic analysis. With numerous examples, we illustrate its application to ordinary differential equation problems involving multiple scales, boundary layers with technically difficult asymptotic matching, and WKB analysis. In contrast to conventional methods, the renormalization group approach requires neither *ad hoc* assumptions about the structure of perturbation series nor the use of asymptotic matching. Our renormalization group approach provides approximate solutions which are practically superior to those obtained conventionally, although the latter can be reproduced, if desired, by appropriate expansion of the renormalization group approximant. We show that the renormalization group equation may be interpreted as an amplitude equation, and from this point of view develop reductive perturbation theory for partial differential equations describing spatially extended systems near bifurcation points, deriving both amplitude equations and the center manifold. [S1063-651X(96)00506-5]

~ High-temperature superconductivity ~

"Woodstock"
APS, NYC 1987

http://www.w2agz.com/Library/HTSC%20History/Woodstock%20Items/Front%20Row.jpg

~ High-temperature superconductivity ~

PHYSICAL REVIEW B VOLUME 43, NUMBER 4 1 FEBRUARY 1991

Interpretation of the temperature dependence of the electromagnetic penetration depth in $YBa_2Cu_3O_{7-\delta}$

James Annett
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Nigel Goldenfeld and S. R. Renn
Department of Physics and Science and Technology Center for Superconductivity, University of Illinois at Urbana-Champaign, 1110 West Green Street, Urbana, Illinois 61801

(Received 10 July 1990)

PHYSICAL REVIEW B VOLUME 48, NUMBER 6 1 AUGUST 1993-II

Effect of strong scattering on the low-temperature penetration depth of a *d*-wave superconductor

Peter J. Hirschfeld
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Nigel Goldenfeld
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(Received 7 May 1993)

VOLUME 73, NUMBER 13 PHYSICAL REVIEW LETTERS 26 SEPTEMBER 1994

Penetration Depth Measurements of 3D *XY* Critical Behavior in $YBa_2Cu_3O_{6.95}$ Crystals

S. Kamal,[1] D. A. Bonn,[1] Nigel Goldenfeld,[2] P. J. Hirschfeld,[3] Ruixing Liang,[1] and W. N. Hardy[1]
[1]*Department of Physics, University of British Columbia, Vancouver, British Columbia, Canada V6T 1Z1*
[2]*Department of Physics, University of Illinois at Urbana-Champaign, 1110 West Green Street, Urbana, Illinois 61801-3080*
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(Received 21 March 1994)

~ Turbulence ~

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~ Turbulence ~

WHAT STARTS HERE CHANGES THE WORLD

PRL **96,** 044503 (2006) PHYSICAL REVIEW LETTERS week ending 3 FEBRUARY 2006

Roughness-Induced Critical Phenomena in a Turbulent Flow

Nigel Goldenfeld
Department of Physics, University of Illinois at Urbana-Champaign, 1110 West Green Street, Urbana, Illinois, 61801-3080, USA
(Received 16 September 2005; published 30 January 2006)

I present empirical evidence that turbulent flows are closely analogous to critical phenomena, from a reanalysis of friction factor measurements in rough pipes. The data collapse found here corresponds to Widom scaling near critical points, and implies that a full understanding of turbulence requires explicit accounting for boundary roughness.

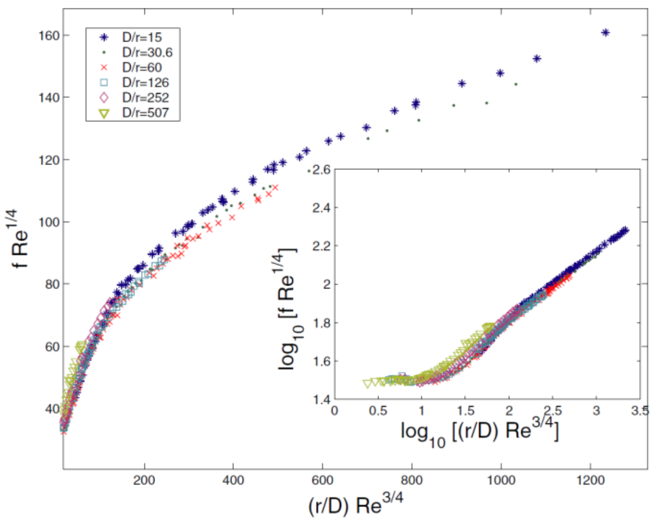

FIG. 2 (color online). Friction factor for turbulent flow in a rough pipe, as reported by Nikuradze [11], scaled according to the text. Inset: the same plot on a logarithmic scale.

PHYSICAL REVIEW E **84**, 035304(R) (2011)

Directed percolation describes lifetime and growth of turbulent puffs and slugs

Maksim Sipos and Nigel Goldenfeld
Department of Physics, Loomis Laboratory of Physics, University of Illinois at Urbana-Champaign, 1110 West Green Street, Urbana, Illinois 61801-3080, USA
(Received 30 January 2011; revised manuscript received 11 August 2011; published 29 September 2011)

We show that directed percolation (DP) simulations in a pipe geometry in 3 + 1 dimensions capture the observed complex phenomenology of the transition to turbulence. At low Reynolds numbers (Re), turbulent puffs form and spontaneously relaminarize. At high Re, turbulent slugs expand uniformly into the laminar regions. In a spatiotemporally intermittent state between these two regimes of Re, puffs split and turbulent regions exhibit laminar patches. DP also captures some of the quantitative features of the transition, with a superexponentially diverging characteristic lifetime below the transition. Above the percolation threshold, active (turbulent) clusters expand into the inactive (laminar) phase with a well-defined velocity whose scaling with control parameter (Reynolds number or percolation probability) is consistent with experimental results. Our results provide strong evidence in favor of a conjecture of Pomeau.

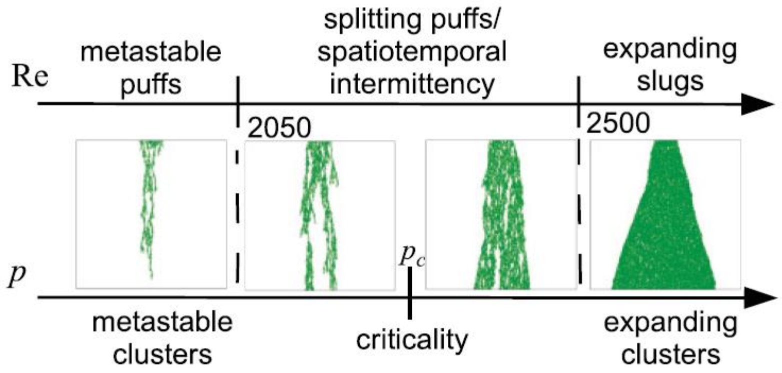

FIG. 1. (Color online) Comparison of the phenomenology of transitional turbulence as a function of Re with that of DP in 3 + 1 dimensions as a function of p, both in a pipe geometry.

~ Biology ~

~ Biology ~

PNAS PNAS

Collective evolution and the genetic code

Kalin Vetsigian*, Carl Woese†‡§, and Nigel Goldenfeld*‡¶

Departments of *Physics and †Microbiology and ‡Institute for Genomic Biology, University of Illinois at Urbana–Champaign, Urbana, IL 61801

A dynamical theory for the evolution of the genetic code is presented, which accounts for its universality and optimality. The central concept is that a variety of collective, but non-Darwinian, mechanisms likely to be present in early communal life generically lead to refinement and selection of innovation-sharing protocols, such as the genetic code. Our proposal is illustrated by using a simplified computer model and placed within the context of a sequence of transitions that early life may have made, before the emergence of vertical descent.

Life is Physics: Evolution as a Collective Phenomenon Far From Equilibrium

Nigel Goldenfeld[1] and Carl Woese[1,2]

[1]Department of Physics, Center for the Physics of Living Cells, and Institute for Genomic Biology, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801; email: nigel@illinois.edu

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Annu. Rev. Condens. Matter Phys. 2011. 2:375–99

First published online as a Review in Advance on January 3, 2011

Abstract

Evolution is the fundamental physical process that gives rise to biological phenomena. Yet it is widely treated as a subset of population genetics, and thus its scope is artificially limited. As a result, the key issues of how rapidly evolution occurs and its coupling to ecology have not been satisfactorily addressed and formulated. The lack of widespread appreciation for, and understanding of, the evolutionary process has arguably retarded the development of biology as a science, with disastrous consequences for its applications to medicine, ecology, and the global environment. This review focuses on evolution as a problem in nonequilibrium statistical mechanics, where the key dynamical modes are collective, as evidenced by the plethora of mobile genetic elements whose role in shaping evolution has been revealed by modern genomic surveys. We discuss how condensed matter physics concepts might provide a useful perspective in evolutionary biology, the conceptual failings of the modern evolutionary synthesis, the open-ended growth of complexity, and the quintessentially self-referential nature of evolutionary dynamics.

~ Newtonizing ~


Thank you for
inspiring us all to…
think more carefully,
reach more boldly,
and care more deeply