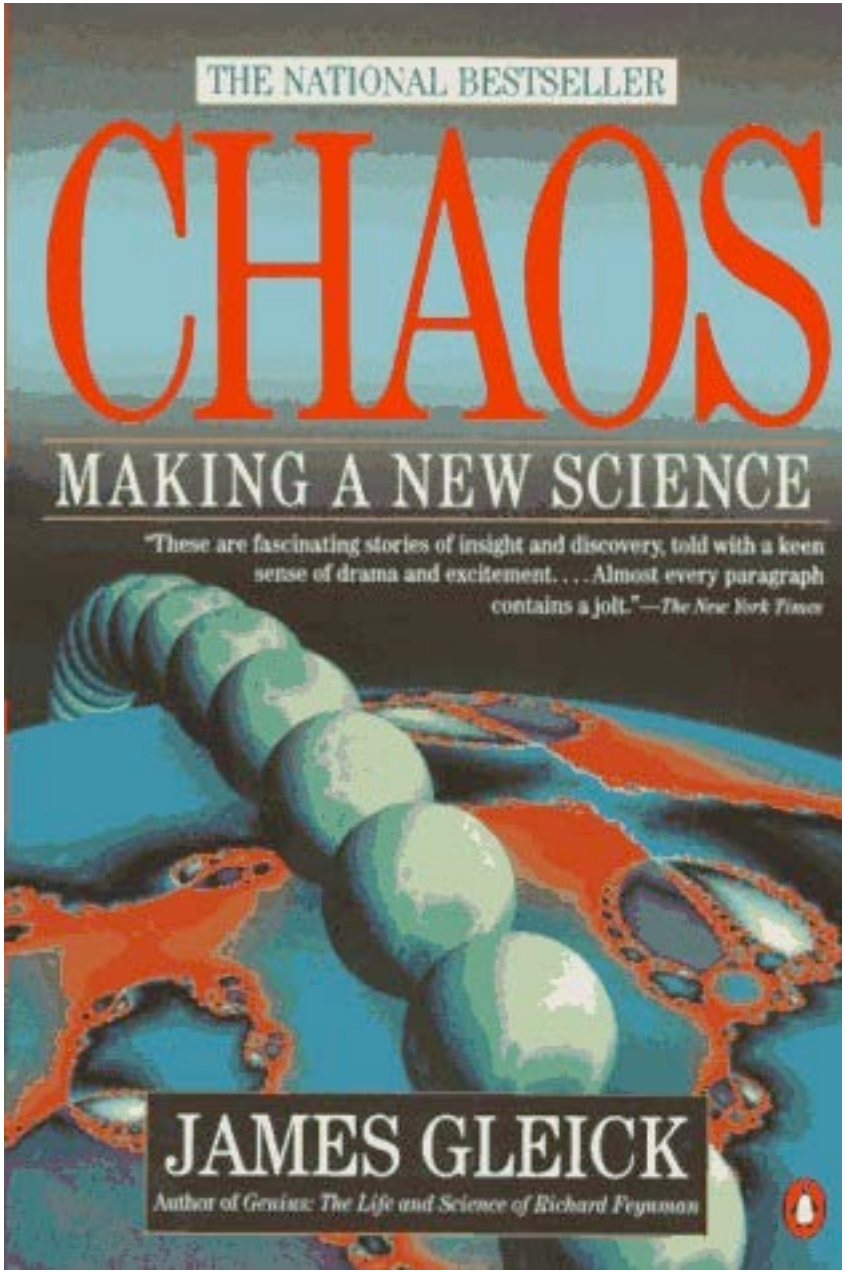
# Теорије хаоса и катастрофа

Ненад Швракић

1. У почетку створи Бог небо и земљу.
2. А земља беше без обличја и пуста, и беше тама над безданом; и дух Божји дизаше се над водом.




I was hoping that maybe one of the scholars could explain chaos theory to me and I could apply it to what I'm trying to do." (Bill Clinton - 23. juni, 1996)

Томас Малтус (1766-1834)

$$N(t) = N(0)e^{rt}$$

“Maltusova katastrofa”

Eugenika

AN

# ESSAY

ON THE

## *PRINCIPLE OF POPULATION,*

AS IT AFFECTS

## THE FUTURE IMPROVEMENT OF SOCIETY.

WITH REMARKS

ON THE SPECULATIONS OF MR. GODWIN,

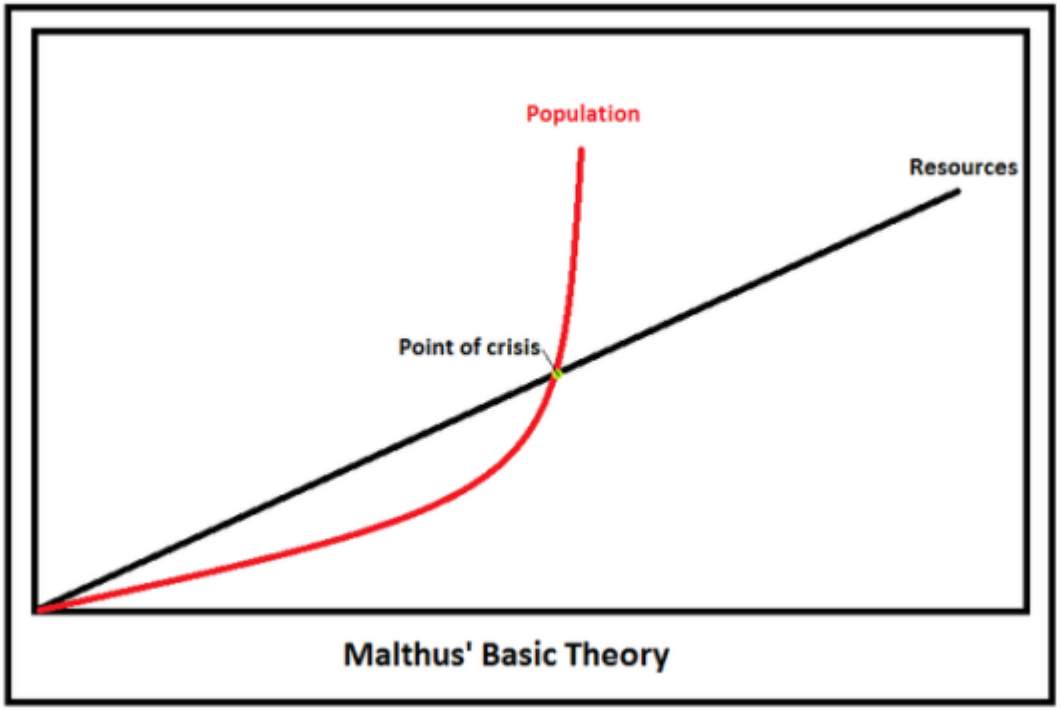
M. CONDORCET,

AND OTHER WRITERS.

LONDON:

PRINTED FOR J. JOHNSON, IN ST. PAUL'S CHURCH-YARD.

1798.




Malthus' Basic Theory

Suppose at the initial time t = 0, $N_0 = 1$ and $\lambda = 2$, then

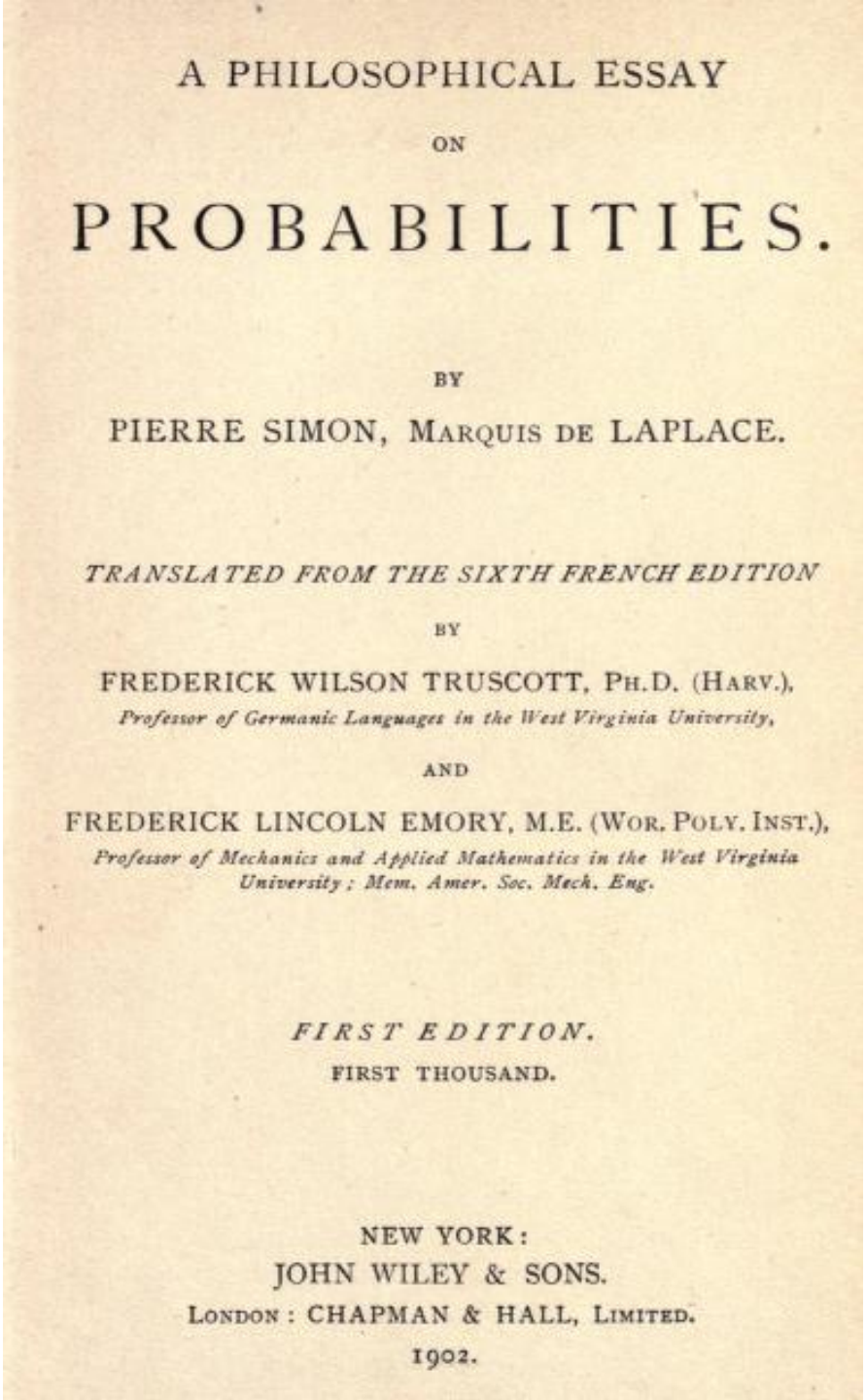
$$N_1 = \lambda N_0 = 2 * 1 = 2$$
$$N_2 = \lambda N_1 = 2 * 2 = 4 \quad \ldots = \lambda^2 N_0$$
$$N_3 = \lambda N_2 = 2 * 4 = 8 \quad \ldots = \lambda^3 N_0$$
$$N_4 = \lambda N_3 = 2 * 8 = 16 \quad \ldots = \lambda^4 N_0$$
$$N_5 = \lambda N_4 = 2 * 16 = 32 \quad \ldots = \lambda^5 N_0$$

We can solve the difference equation to give the population level at time t, $N_t$ in terms of the initial population level, $N_0$

$$N_t = \lambda^t N_0$$

Malthus "population, when unchecked, increases in a geometric ratio"

| Malthusian Growth Model (discrete-time model) | Exponential Growth Model (continuous-time model) |
| --- | --- |
| $N(t+1) = \lambda N(t)$ | $\frac{dN}{dt} = rN$ $\quad N_t = N_{t_0} e^{r(t - t_0)}$ |
| One parameter: $\lambda = 1 + b - d$ | One parameter: $r = b - d$ |
| $\lambda > 1$ → population grows<br>$\lambda = 1$ → population level<br>$0 < \lambda < 1$ → population declines | $r > 0$ → population grows<br>$r = 0$ → population level<br>$r < 0$ → population declines |



A PHILOSOPHICAL ESSAY

ON

# PROBABILITIES.

BY

PIERRE SIMON, MARQUIS DE LAPLACE.

*TRANSLATED FROM THE SIXTH FRENCH EDITION*

BY

FREDERICK WILSON TRUSCOTT, PH.D. (HARV.),
*Professor of Germanic Languages in the West Virginia University,*

AND

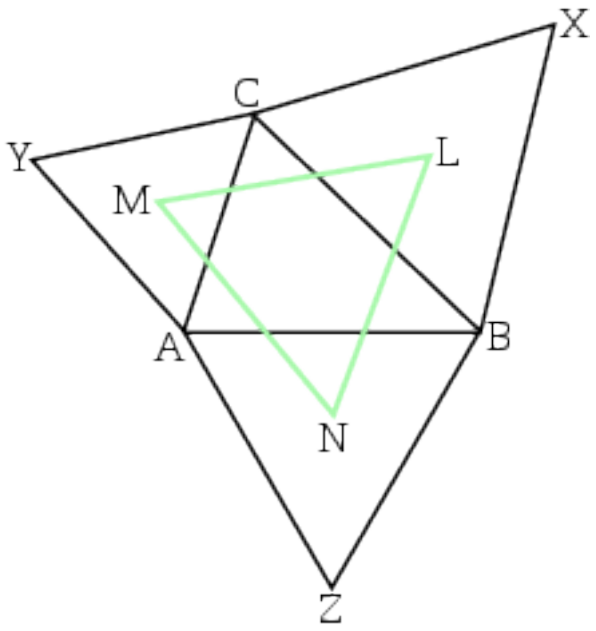
FREDERICK LINCOLN EMORY, M.E. (WOR. POLY. INST.),
*Professor of Mechanics and Applied Mathematics in the West Virginia University; Mem. Amer. Soc. Mech. Eng.*

*FIRST EDITION.*
FIRST THOUSAND.

NEW YORK:
JOHN WILEY & SONS.
LONDON: CHAPMAN & HALL, LIMITED.
1902.

We may regard the present state of the universe as the effect of its past and the cause of its future.
An intellect which at a certain moment would know all forces that set nature in motion, and all positions of all items of which nature is composed, if this intellect were also vast enough to submit these data to analysis, it would embrace in a single formula the movements of the greatest bodies of the universe and those of the tiniest atom; for such an intellect nothing would be uncertain and the future just like the past would be present before its eyes.
— Pierre Simon Laplace,
A Philosophical Essay on Probabilities[3]

# Napoleonova teorema



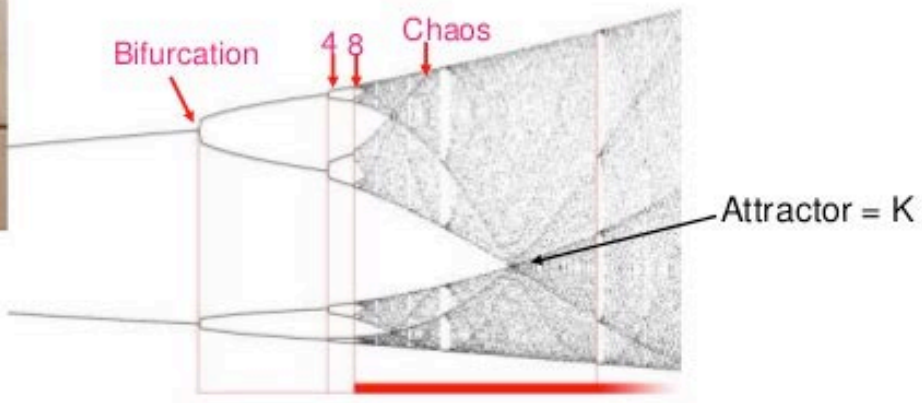
$$x_{n+1} = rx_n(1 - x_n)$$

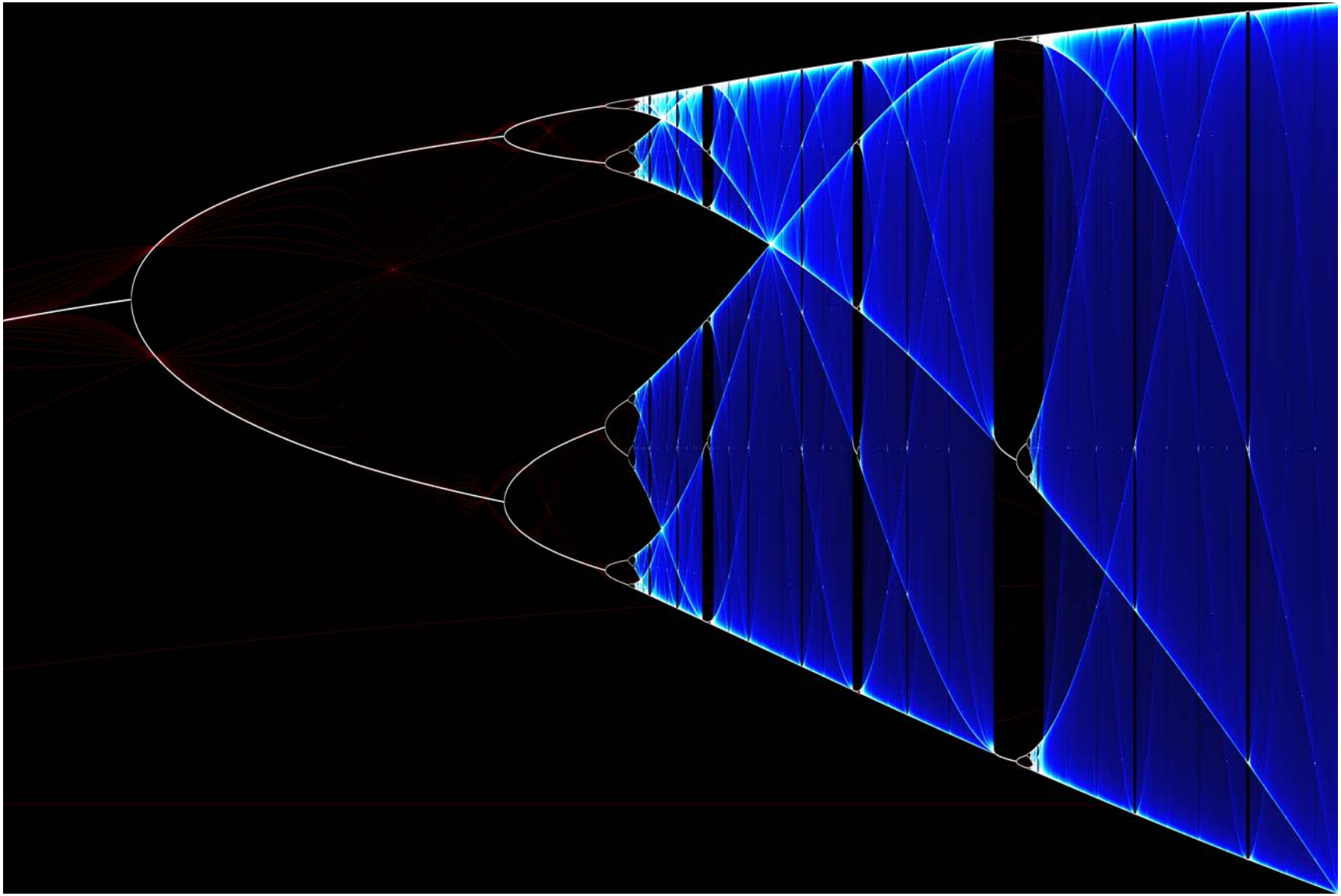
Deterministička jednačina - Laplace

# Large r and Chaos

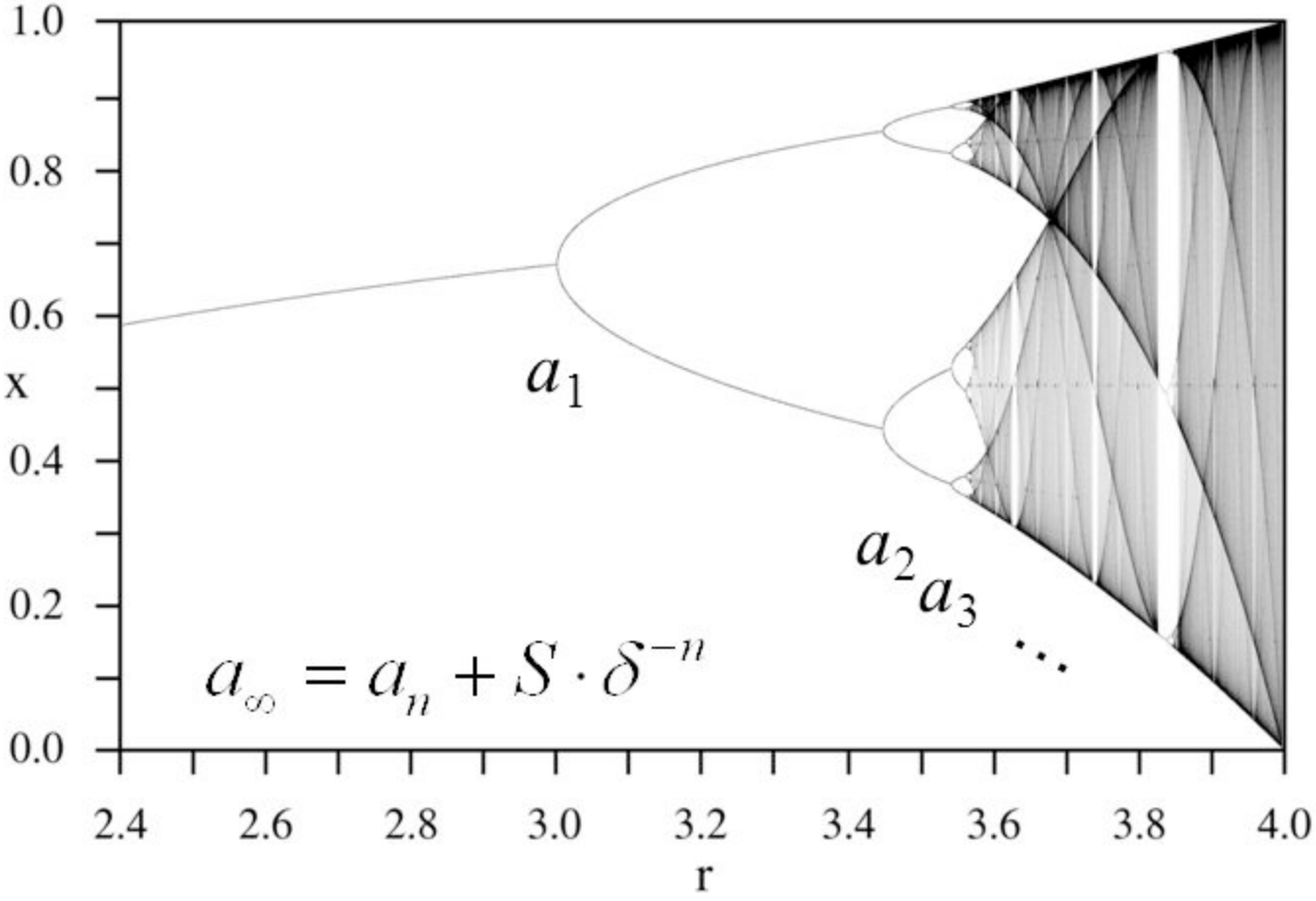
- Chaos = a non-repeating, drastic fluctuation in population size with a simple deterministic model…shocking.

Lord Robert May
1936 – present
Oxford University





# Logistic equation and onset of chaos

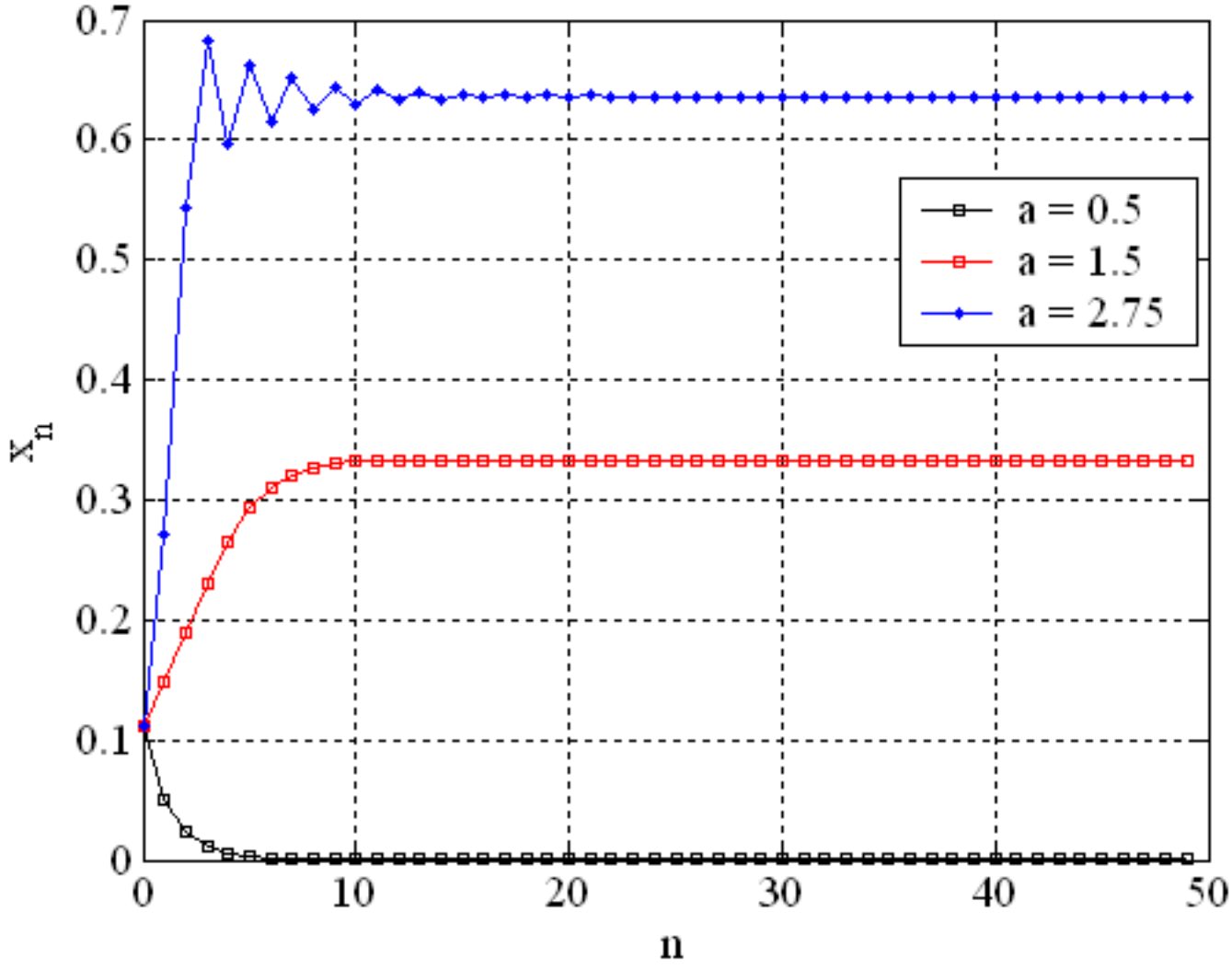


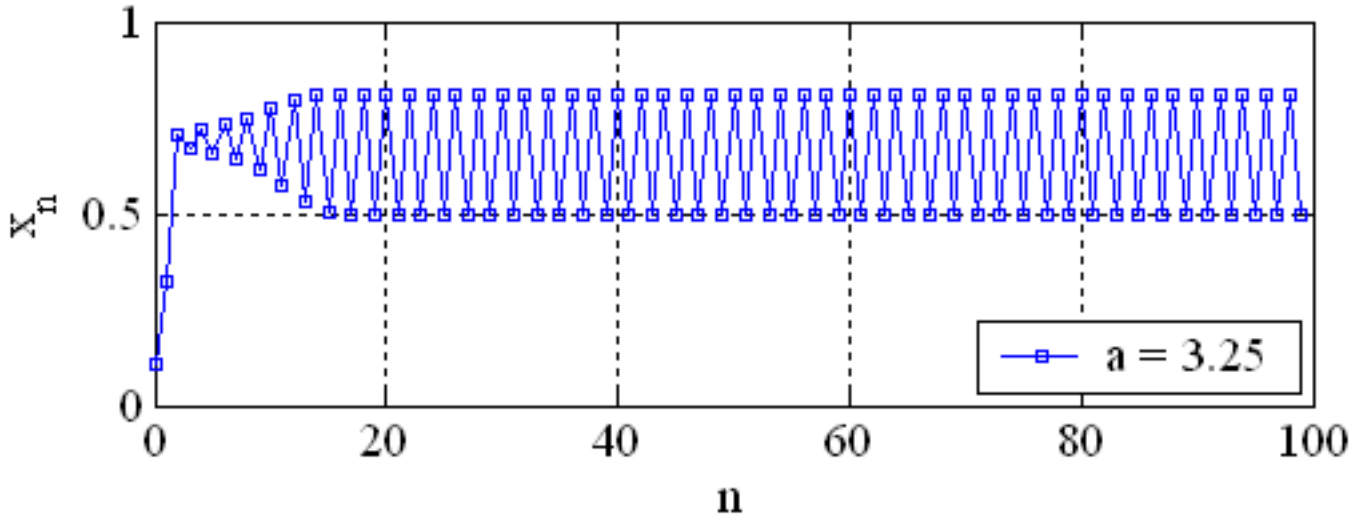

Feigenbaum number: $\delta = 4.6692\ldots$

Mitchell Feigenbaum (July 1978) "Quantitative universality for a class of nonlinear transformations," *Journal of Statistical Physics*, vol. 19, no. 1, pages 25–52.

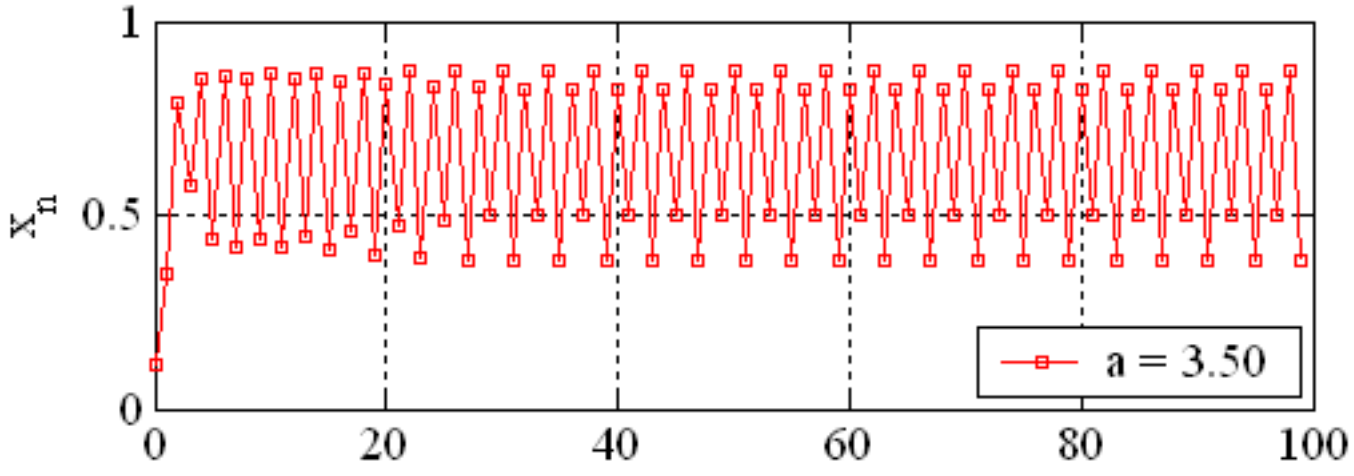
Atraktor – jedna tačka

$$x_{n+1} = r x_n (1 - x_n)$$



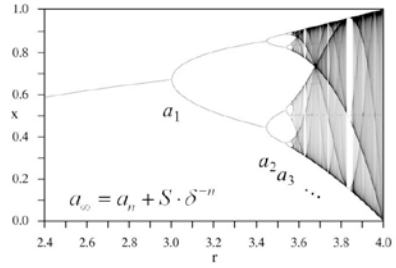



2pt




4pt

Logistic equation and onset of chaos

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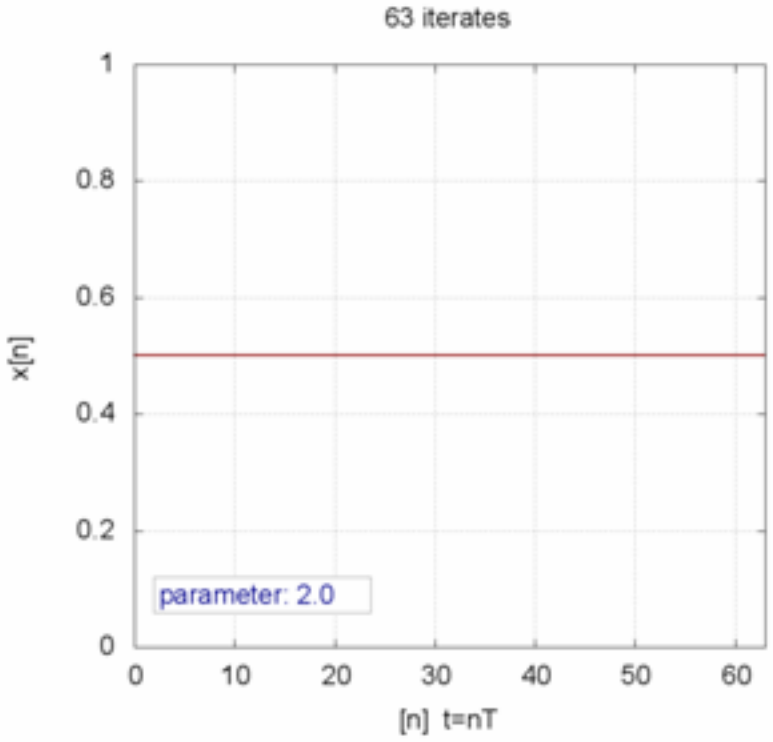
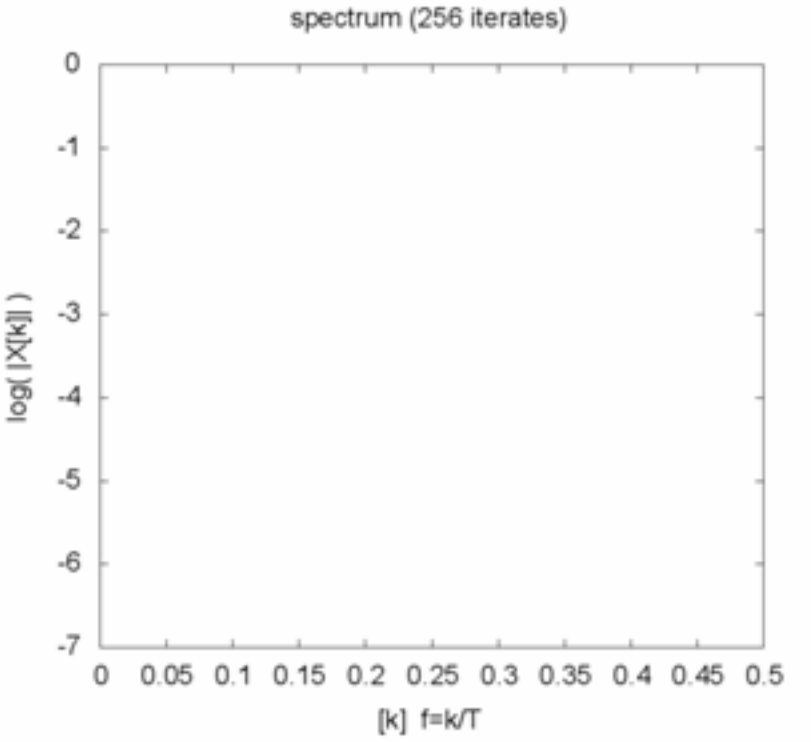
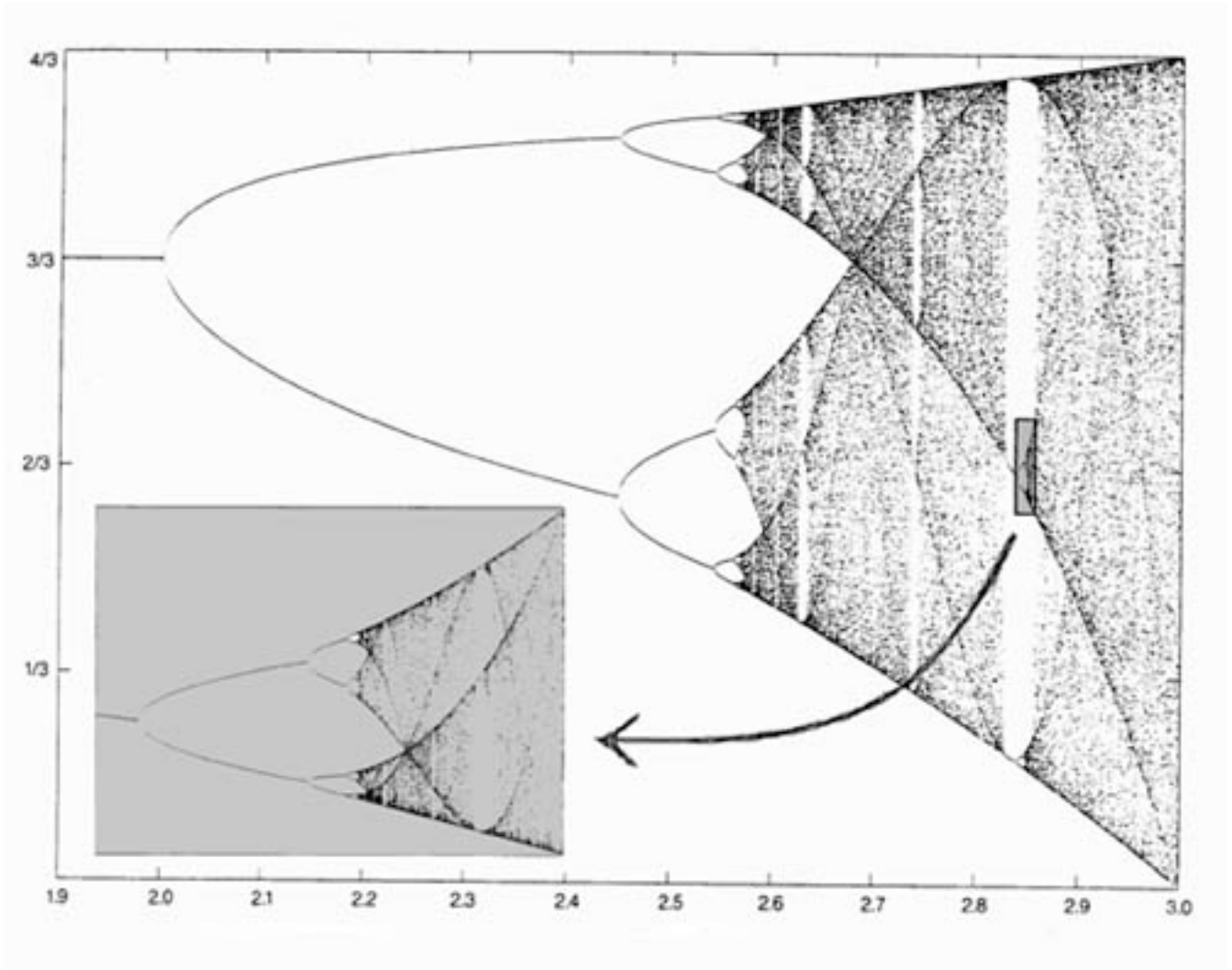
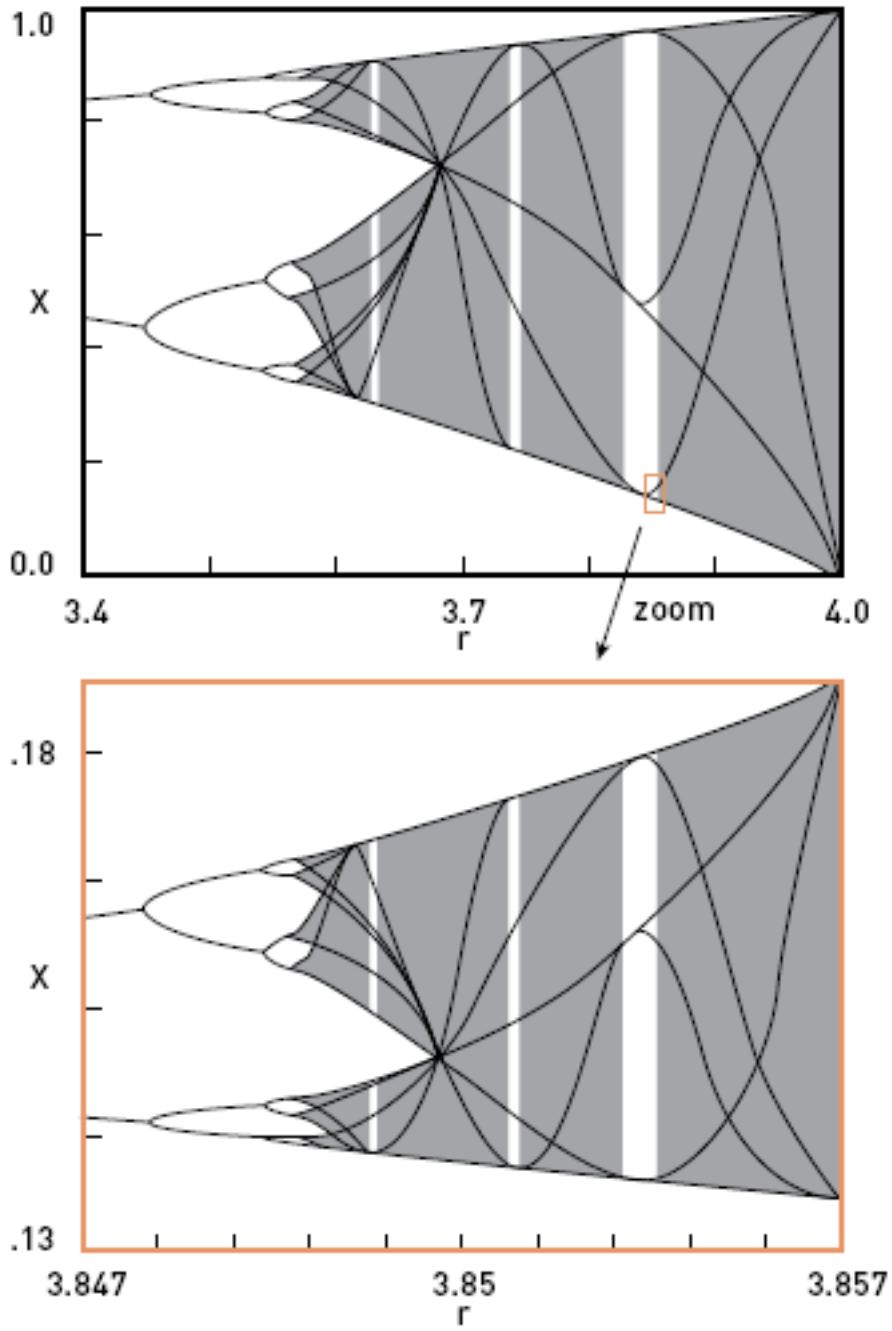

63 iterates
x[n]
1
0.8
0.6
0.4
0.2
0
parameter: 2.0
0
10
20
30
40
50
60
[n] t=nT

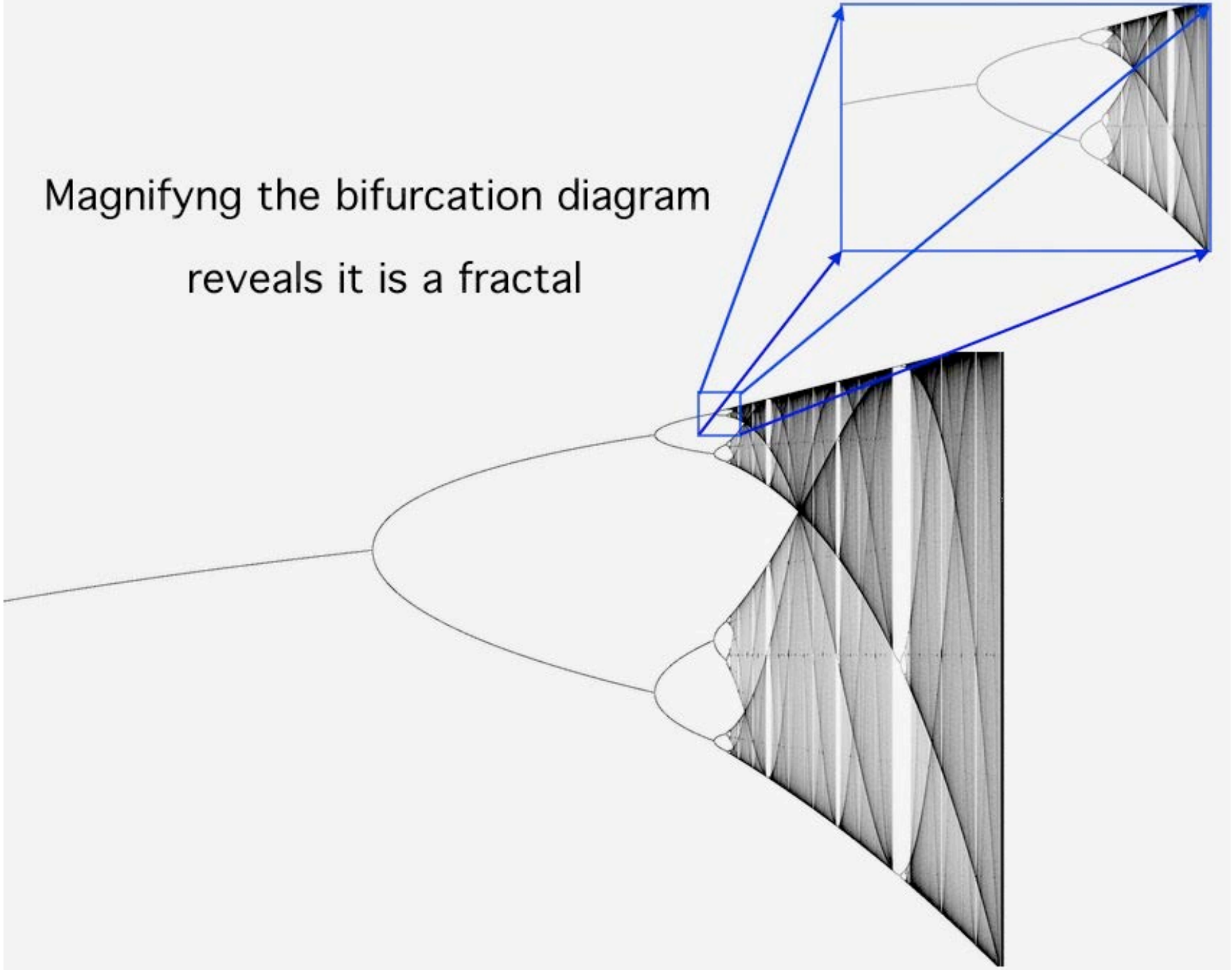

spectrum (256 iterates)
log( |X[k]| )
0
-1
-2
-3
-4
-5
-6
-7
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
[k] f=k/T


4/3
3/3
2/3
1/3
1.9
2.0
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
2.9
3.0

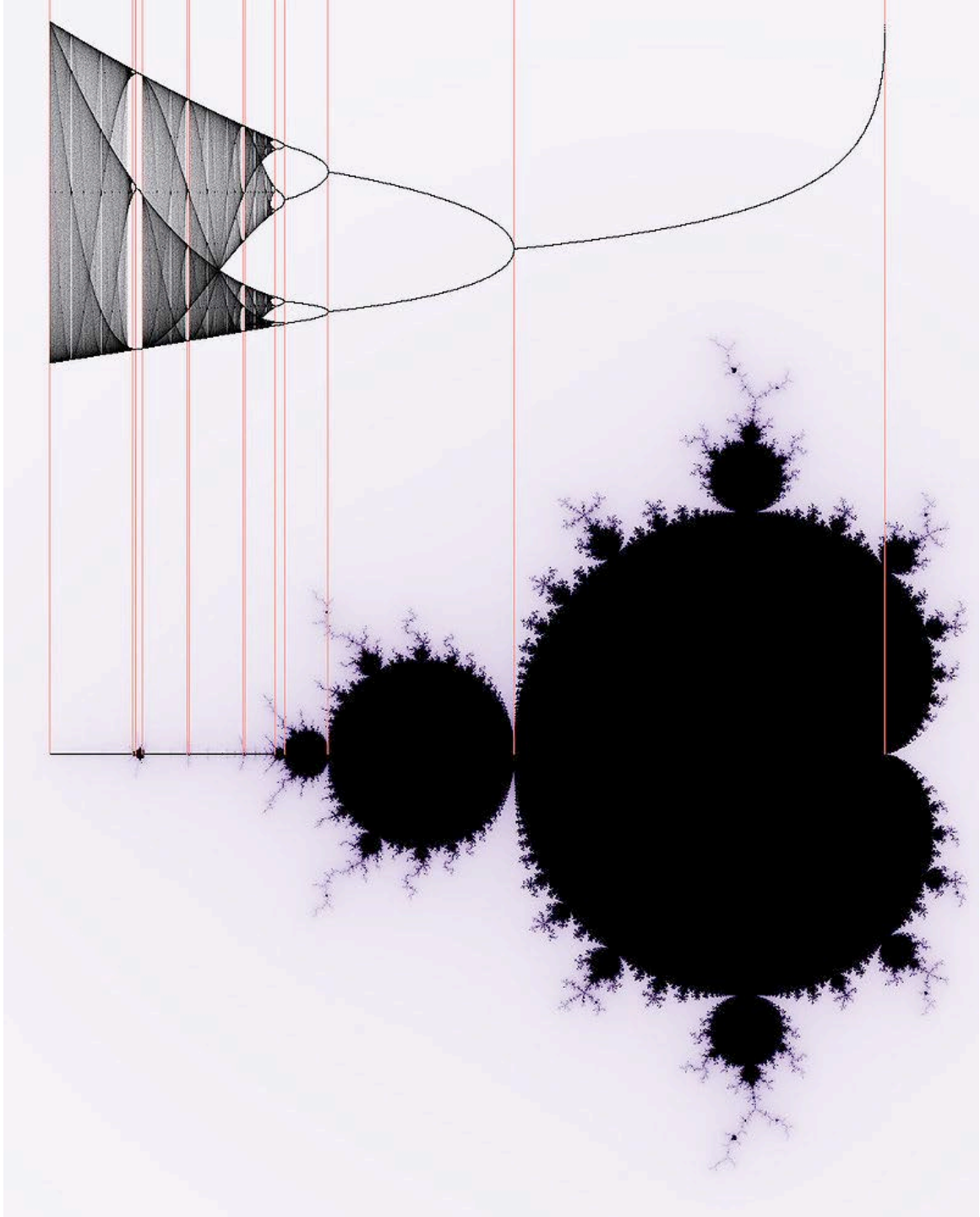

1.0
X
0.0
3.4
3.7
r
zoom
4.0
.18
X
.13
3.847
3.85
r
3.857

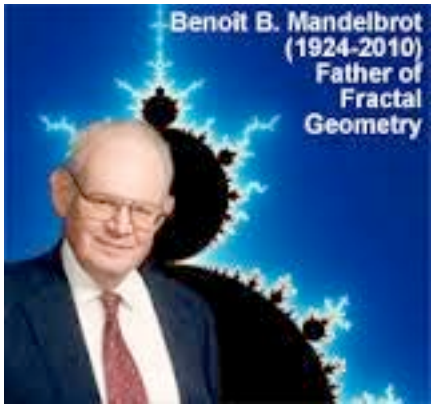
Magnifyng the bifurcation diagram

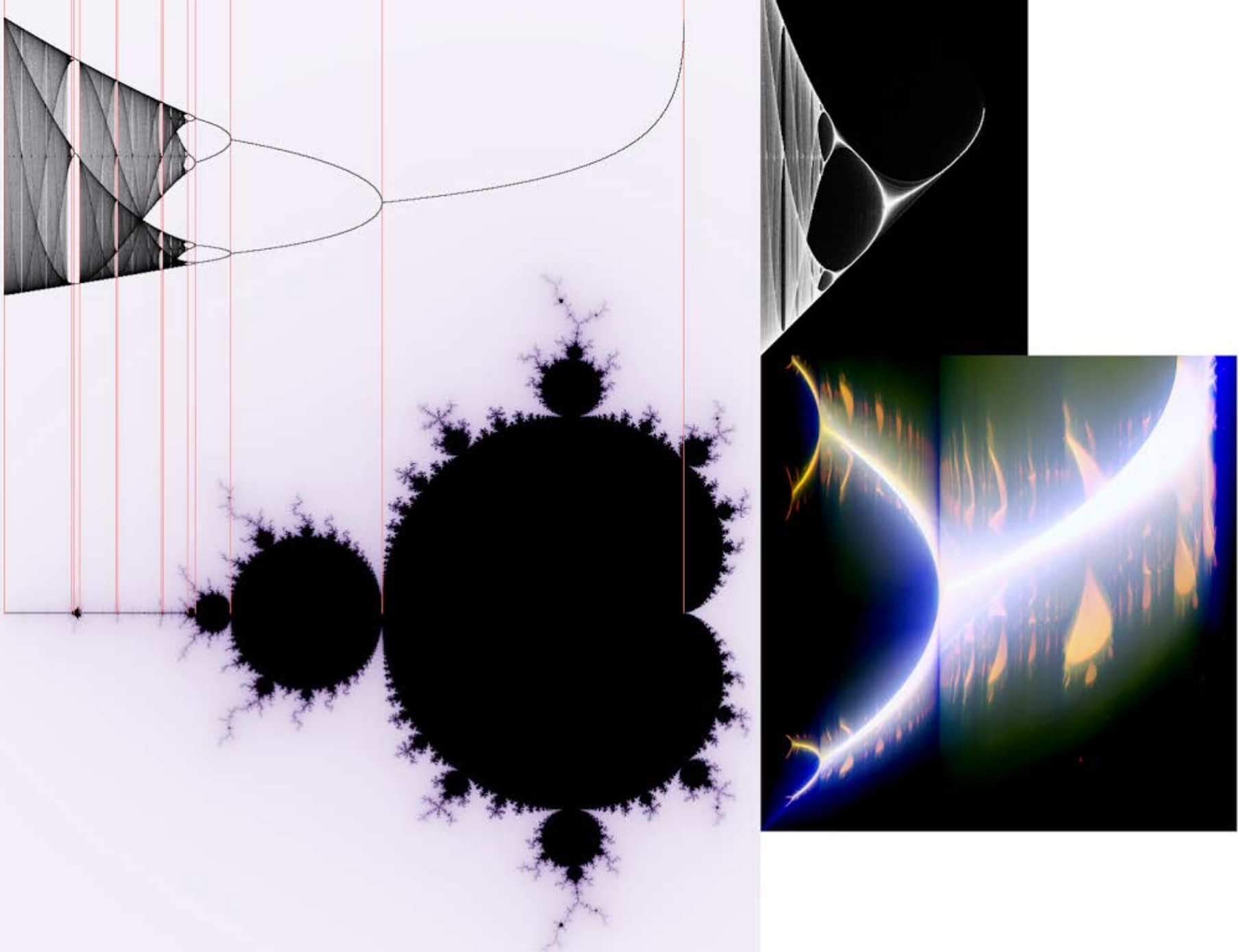
reveals it is a fractal



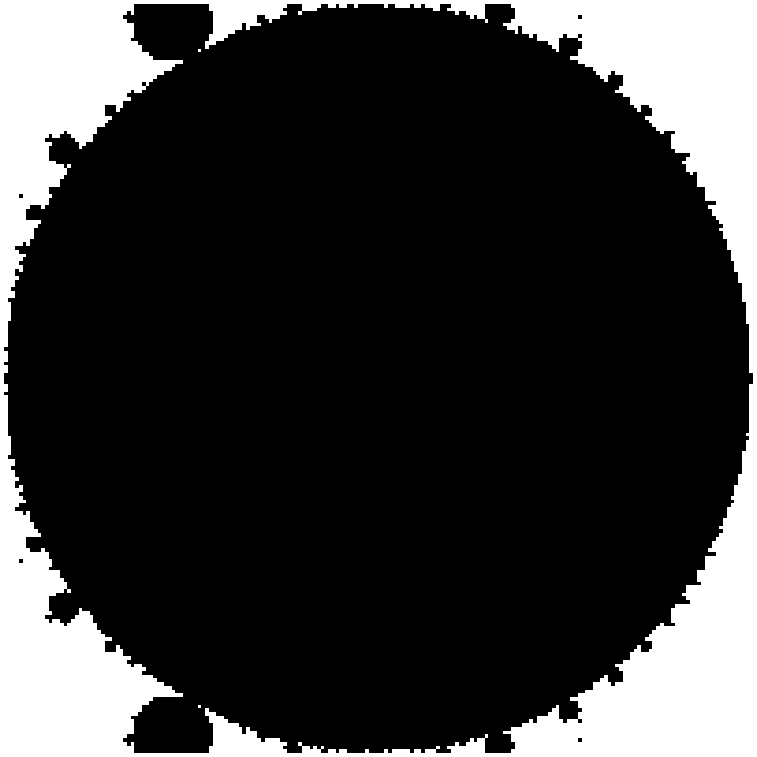
$z' = z^2 + c$



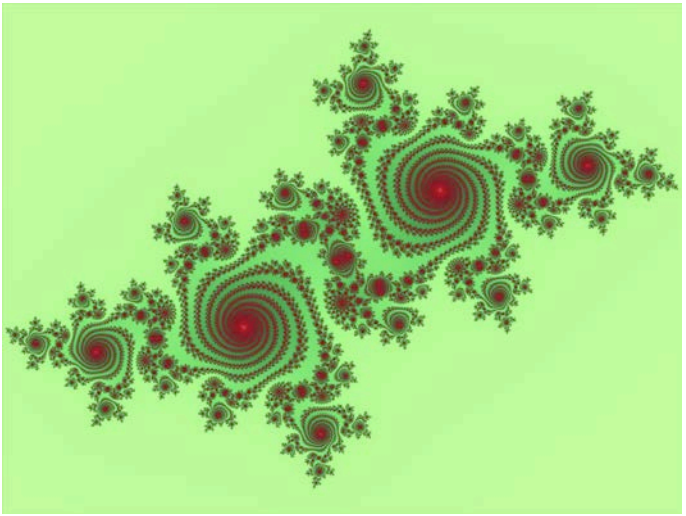


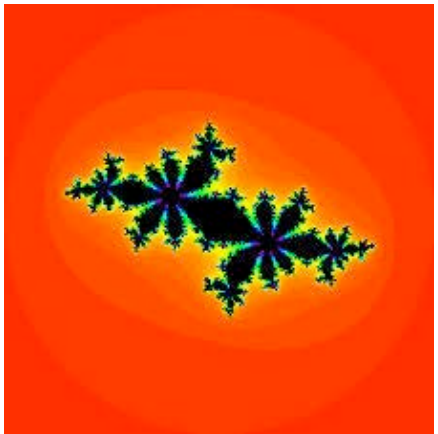


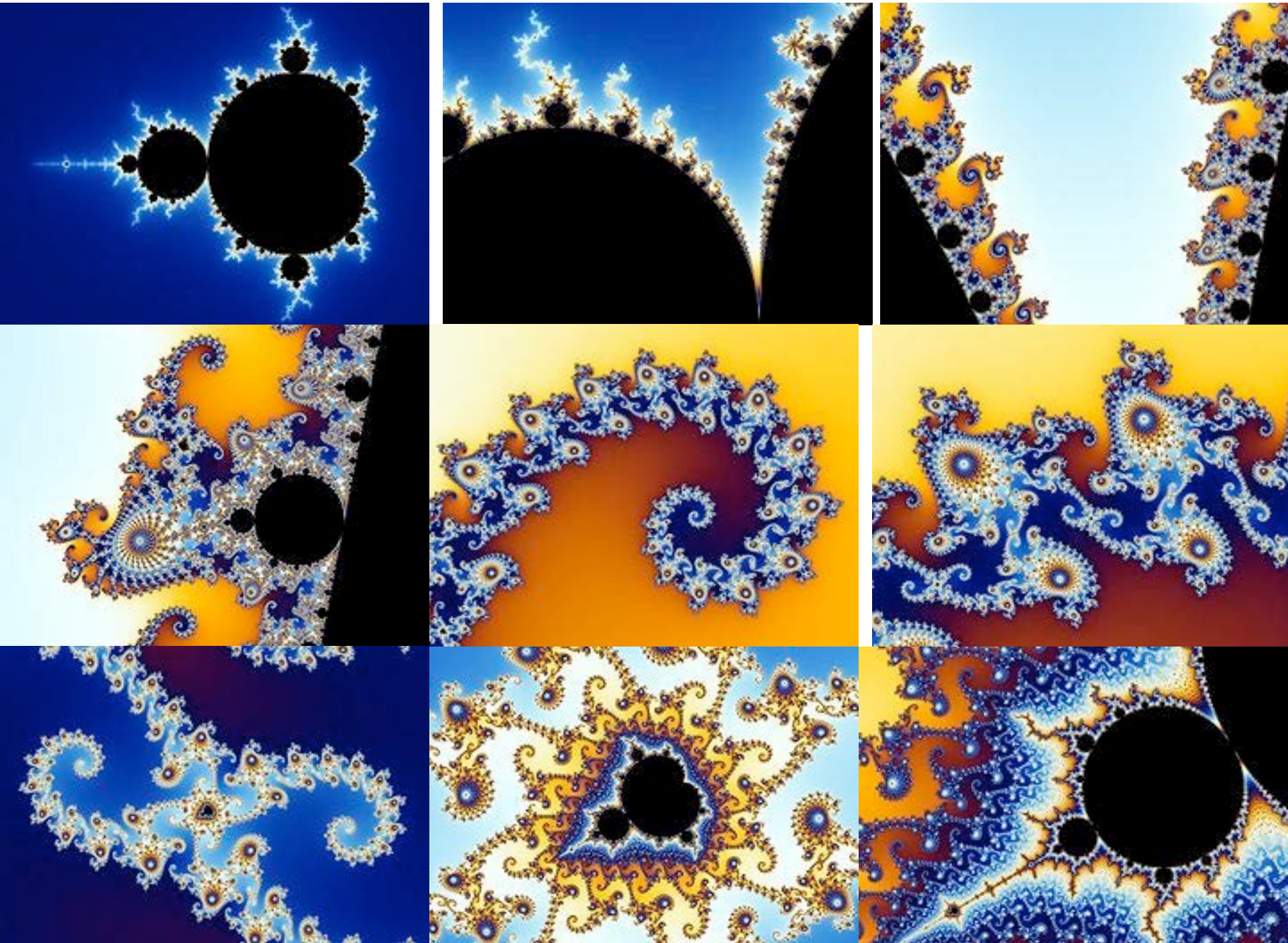
Mandelbrotov skup je ekvivalentan bifurkacionom dijagramu



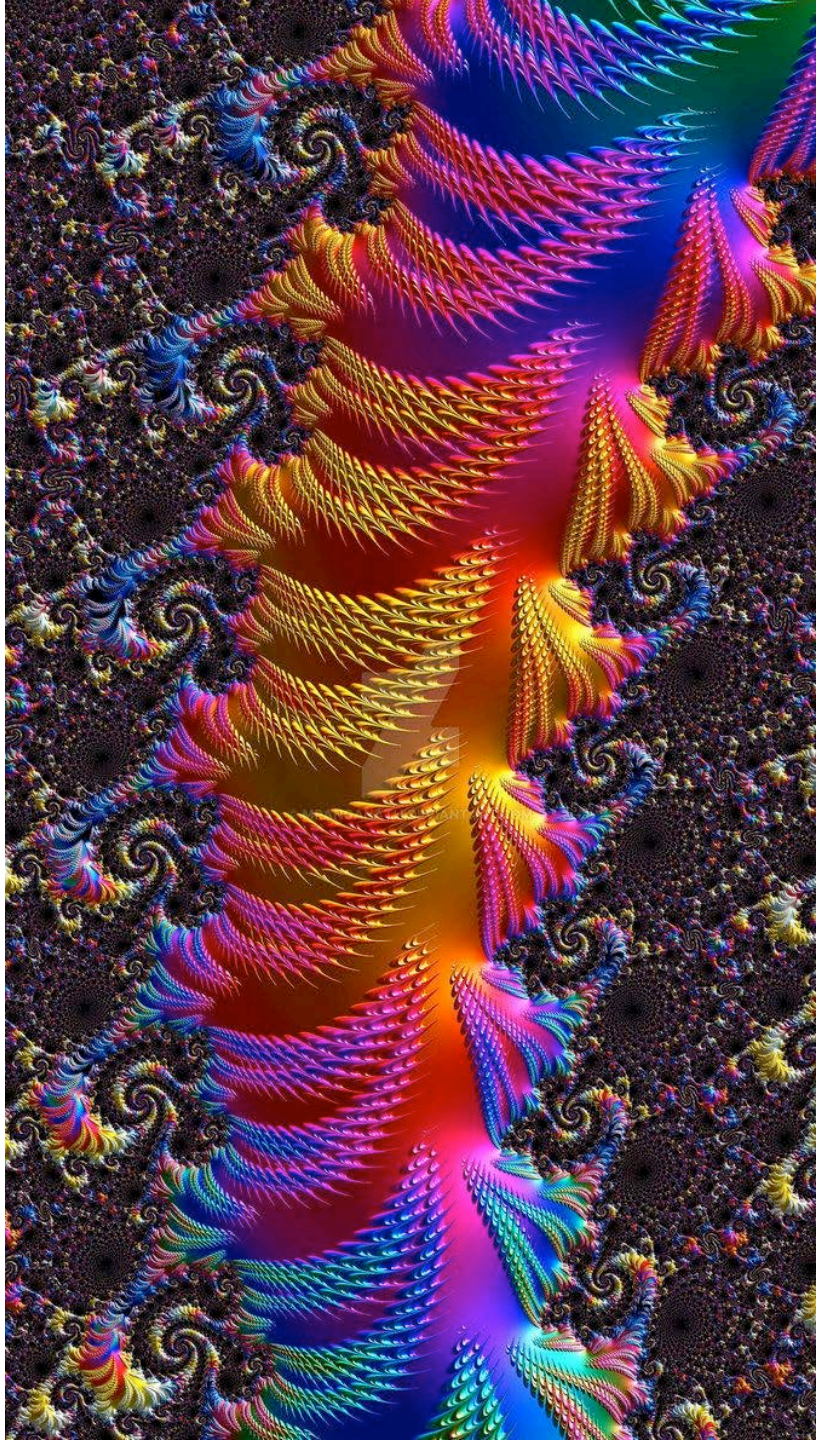
Gaston Julia 1893-1978

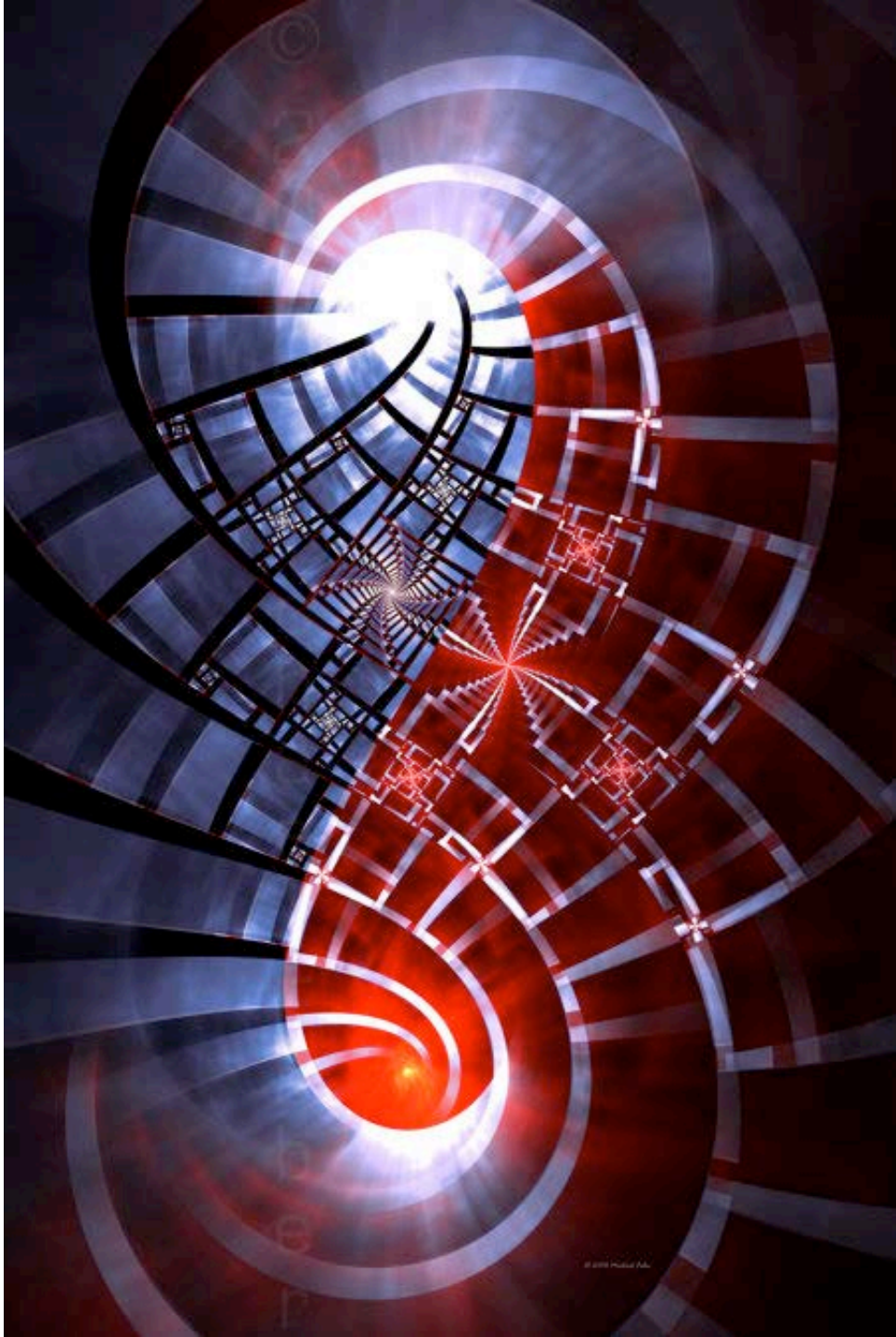


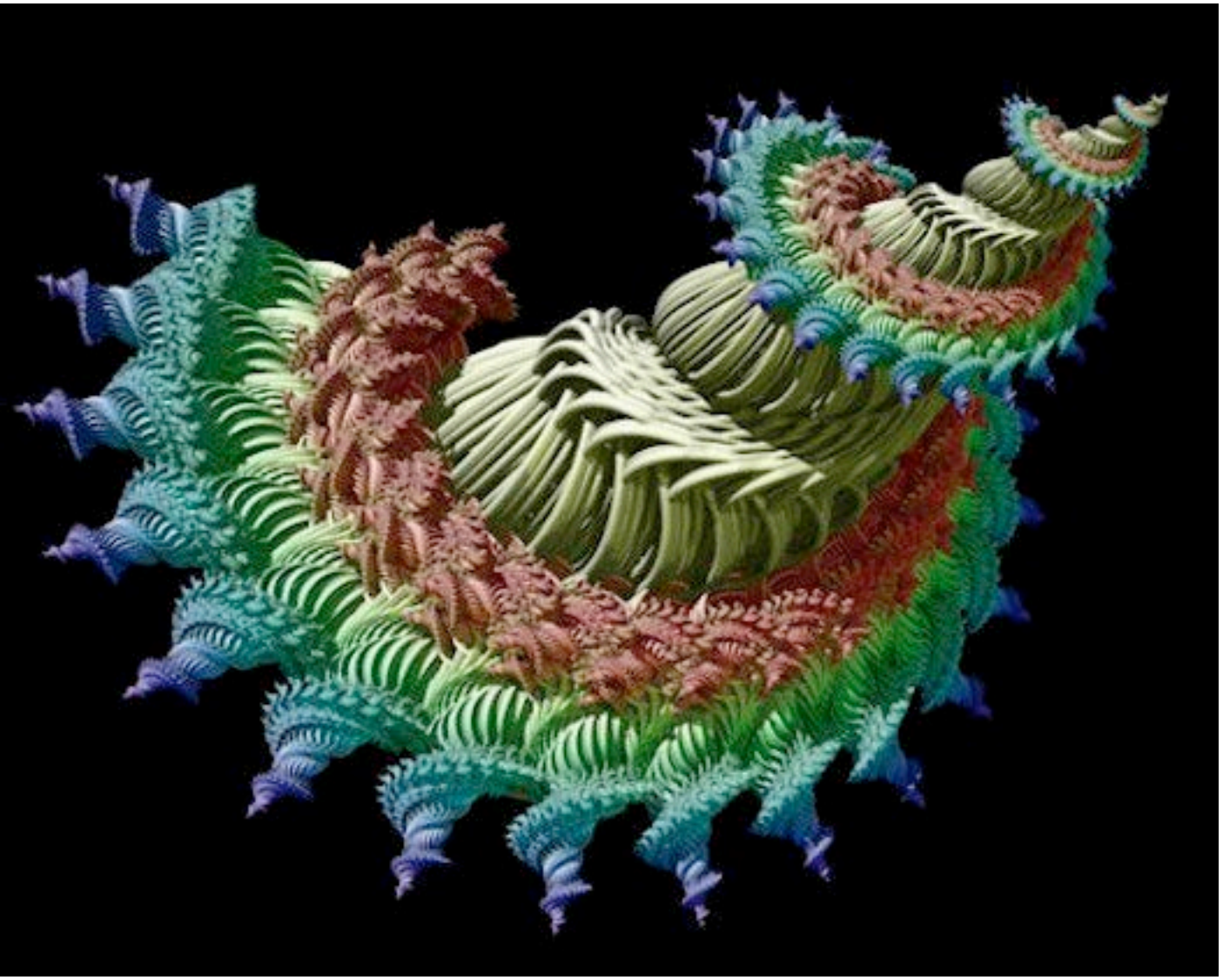




Fraktalna umetnost





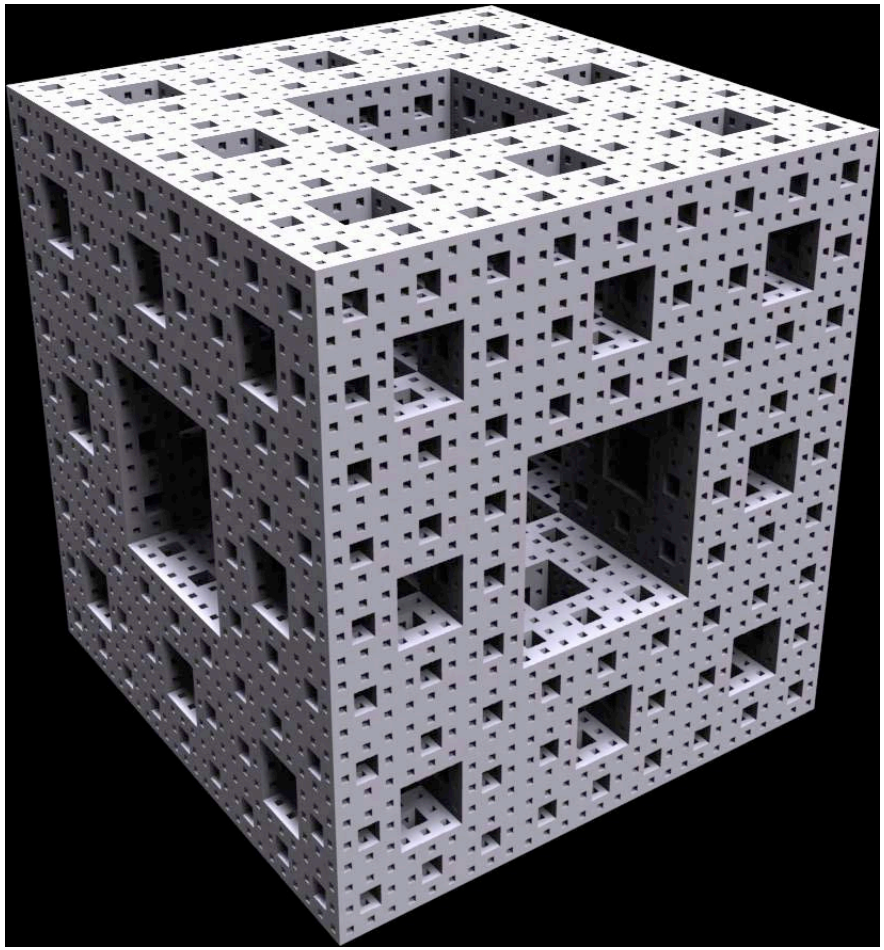


Romanesco karfiol


gettyimages
Markus Keller
130850973

Paul Sorey


Sierpinski sunđer



Lideta Mercato, Etiopija

Ekstremna osetljivost na početne uslove


Lorenz jednačine -1963 Meteorologija

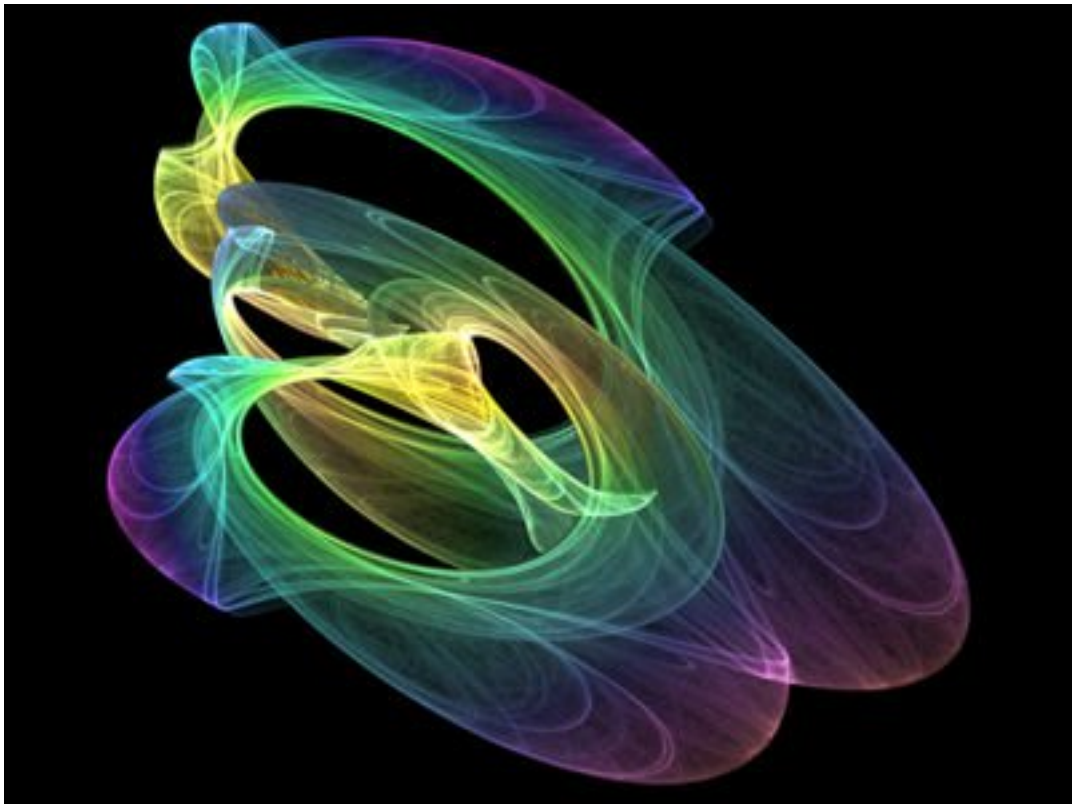
$$\frac{dx}{dt} = a\,(y - x)$$

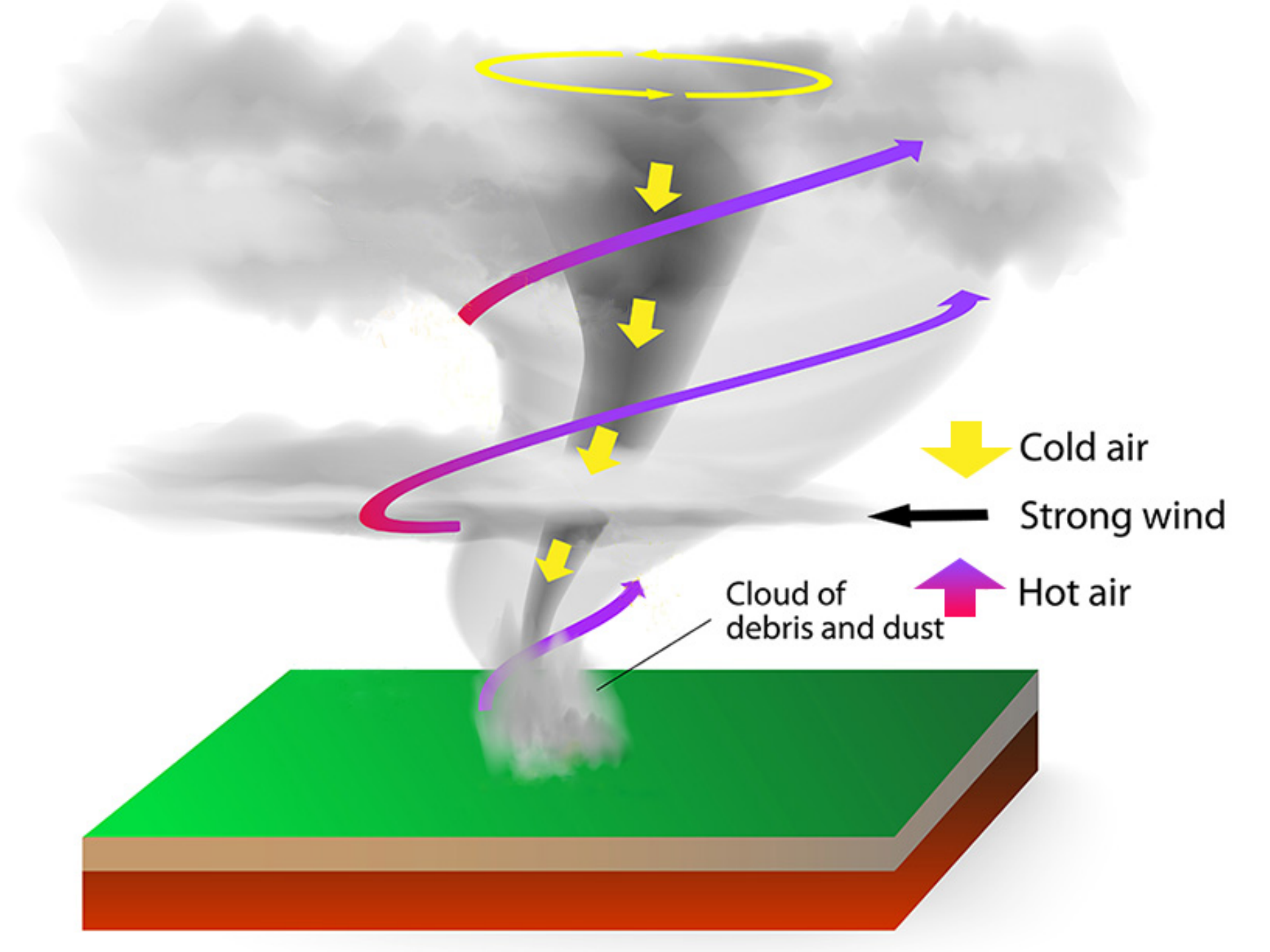
$$\frac{dy}{dt} = x(b - z) - y$$

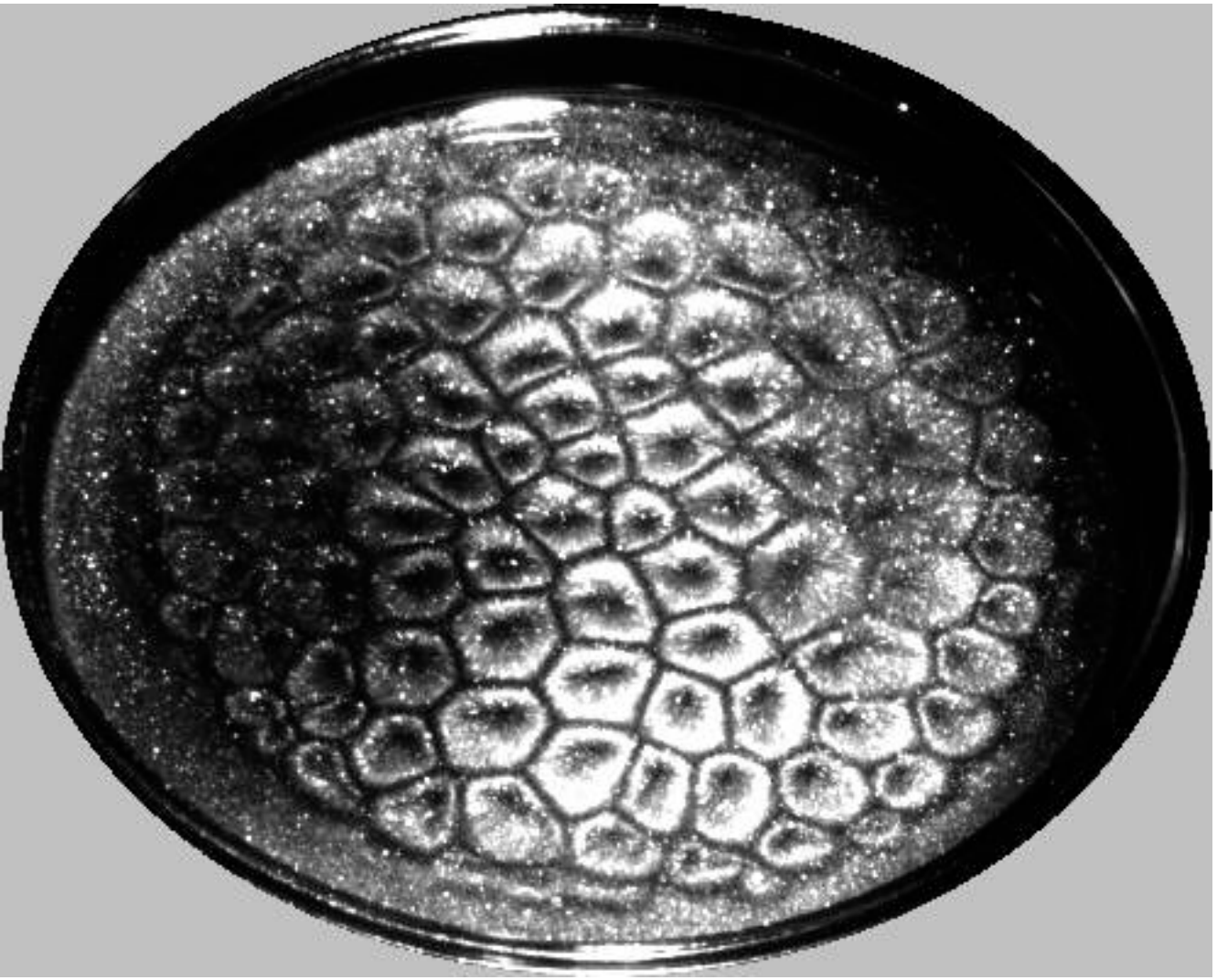
$$\frac{dz}{dt} = xy - cz$$

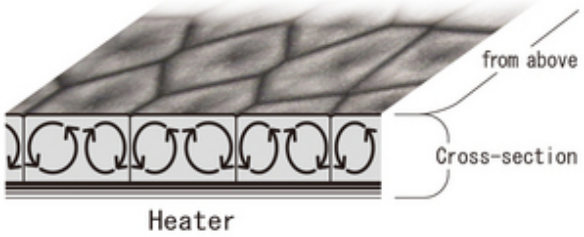
Efekat leptira

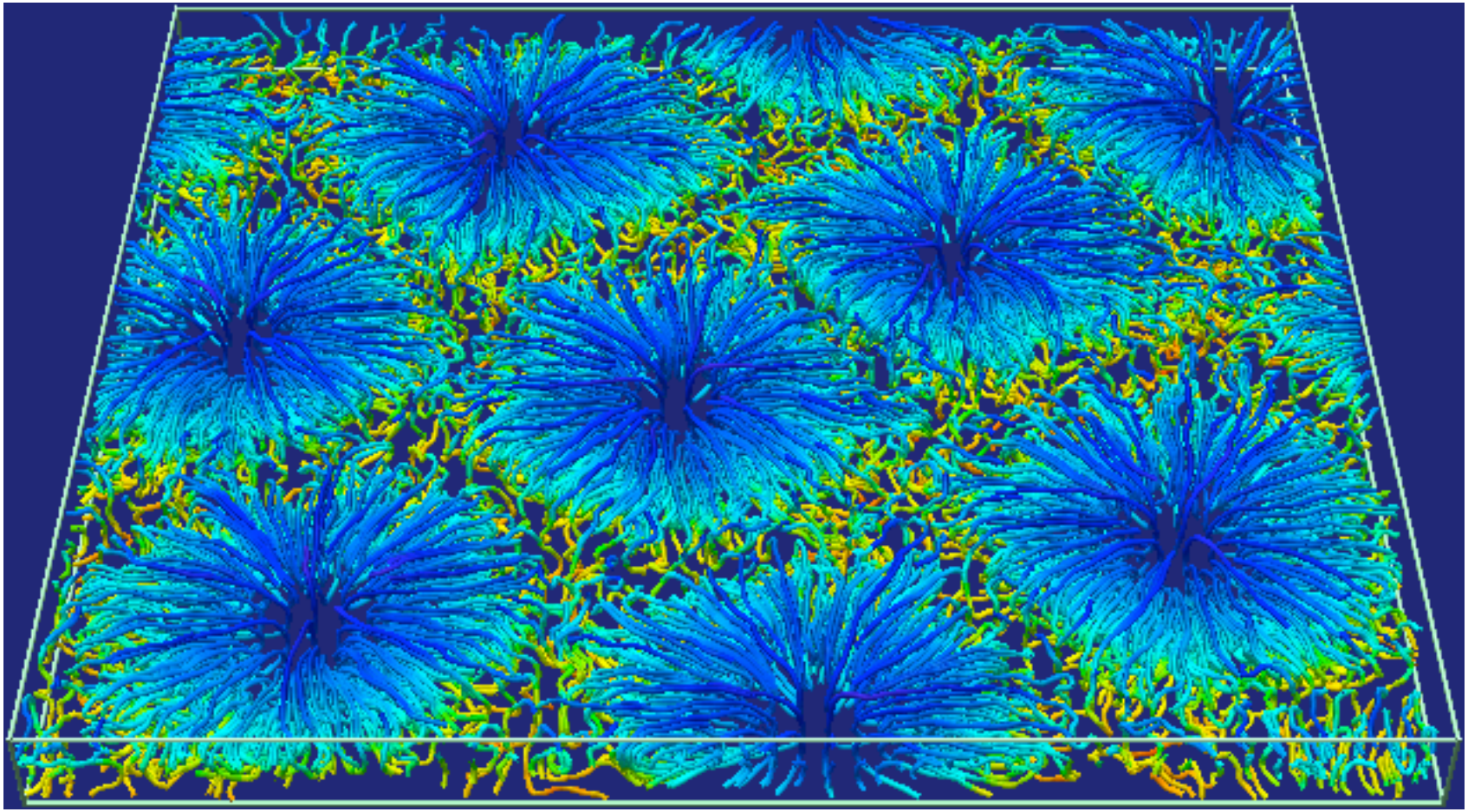
Strange attractor

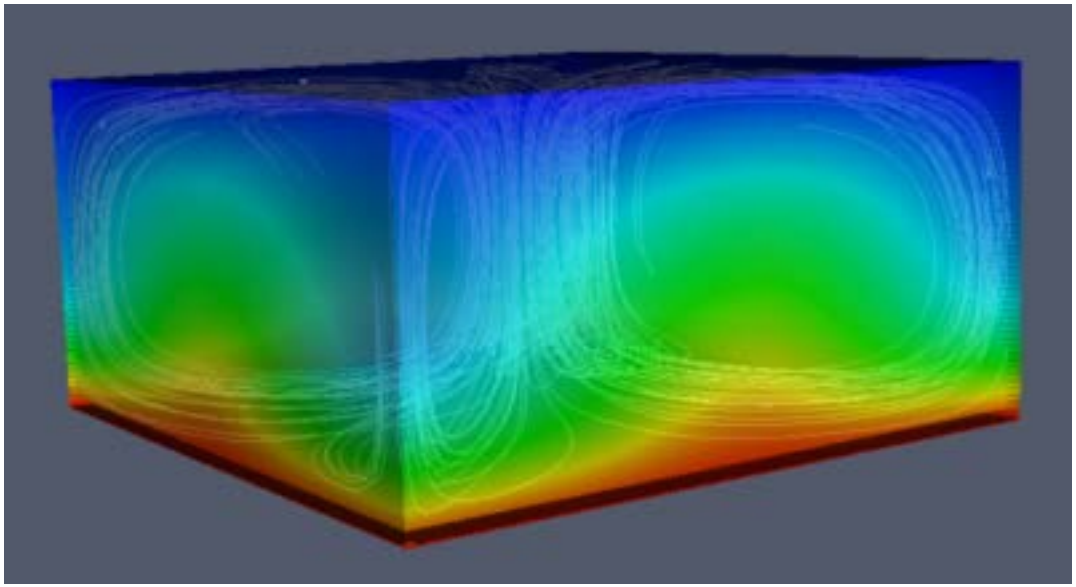


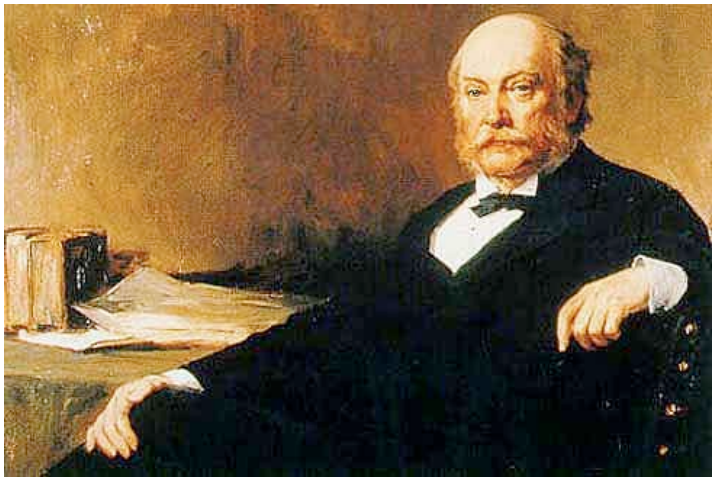

Cold air
Strong wind
Hot air
Cloud of
debris and dust



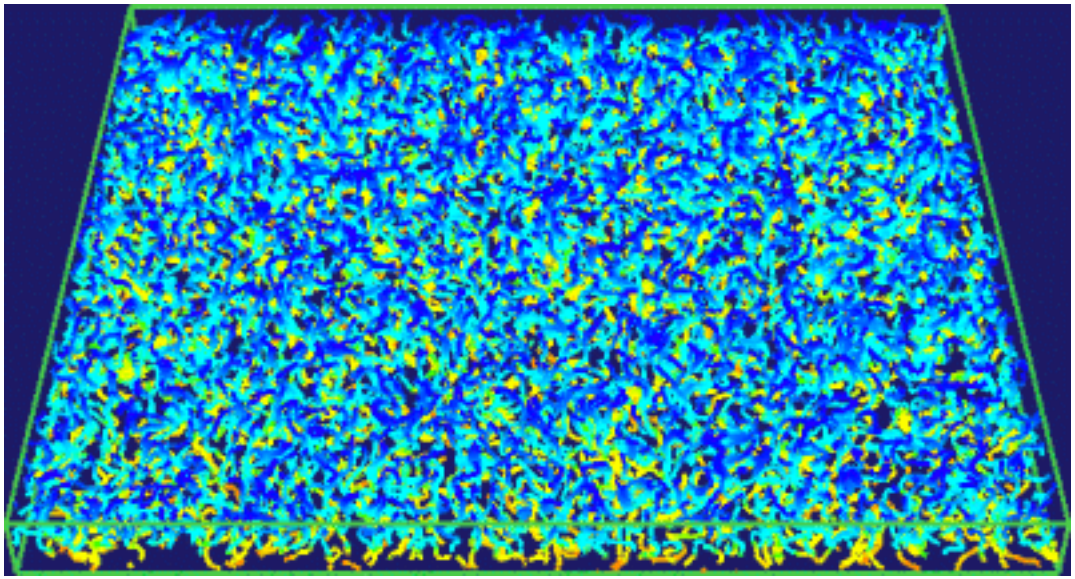

from above
Cross-section
Heater



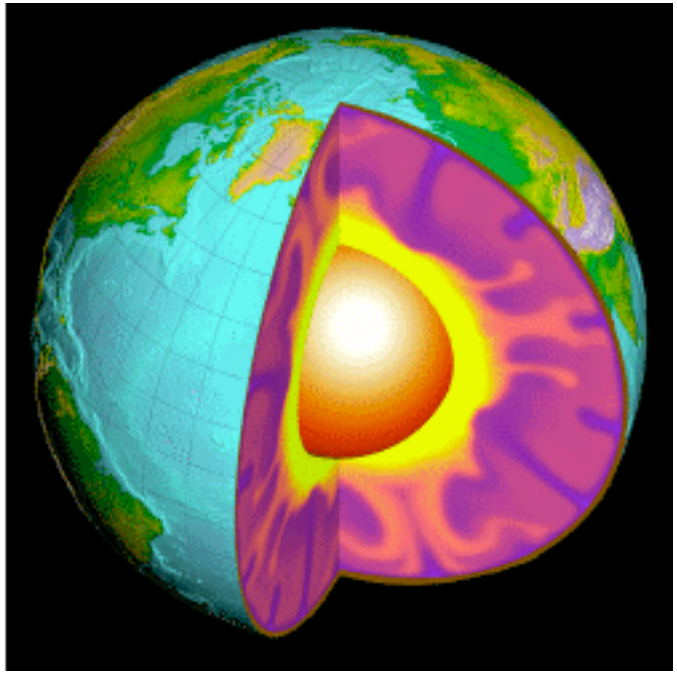


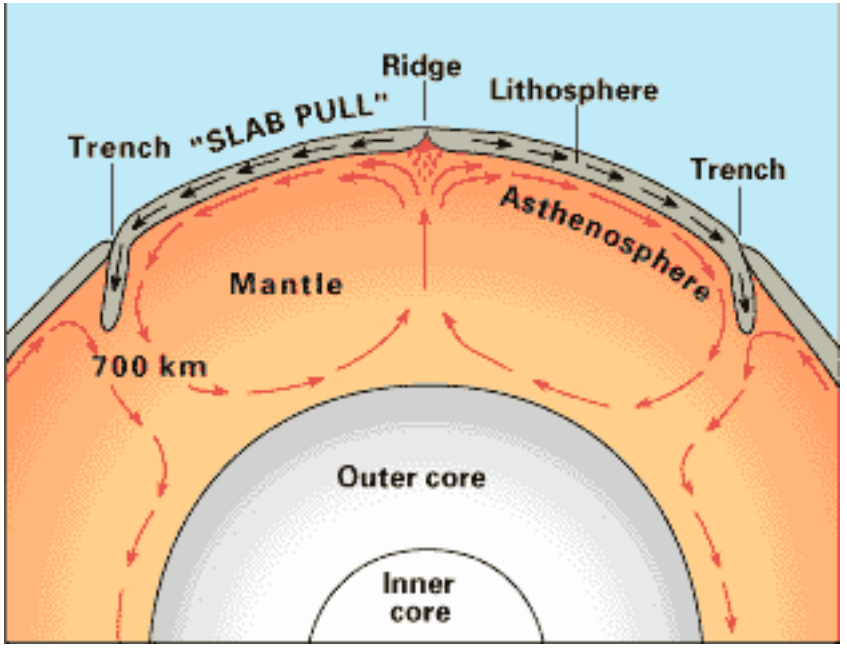


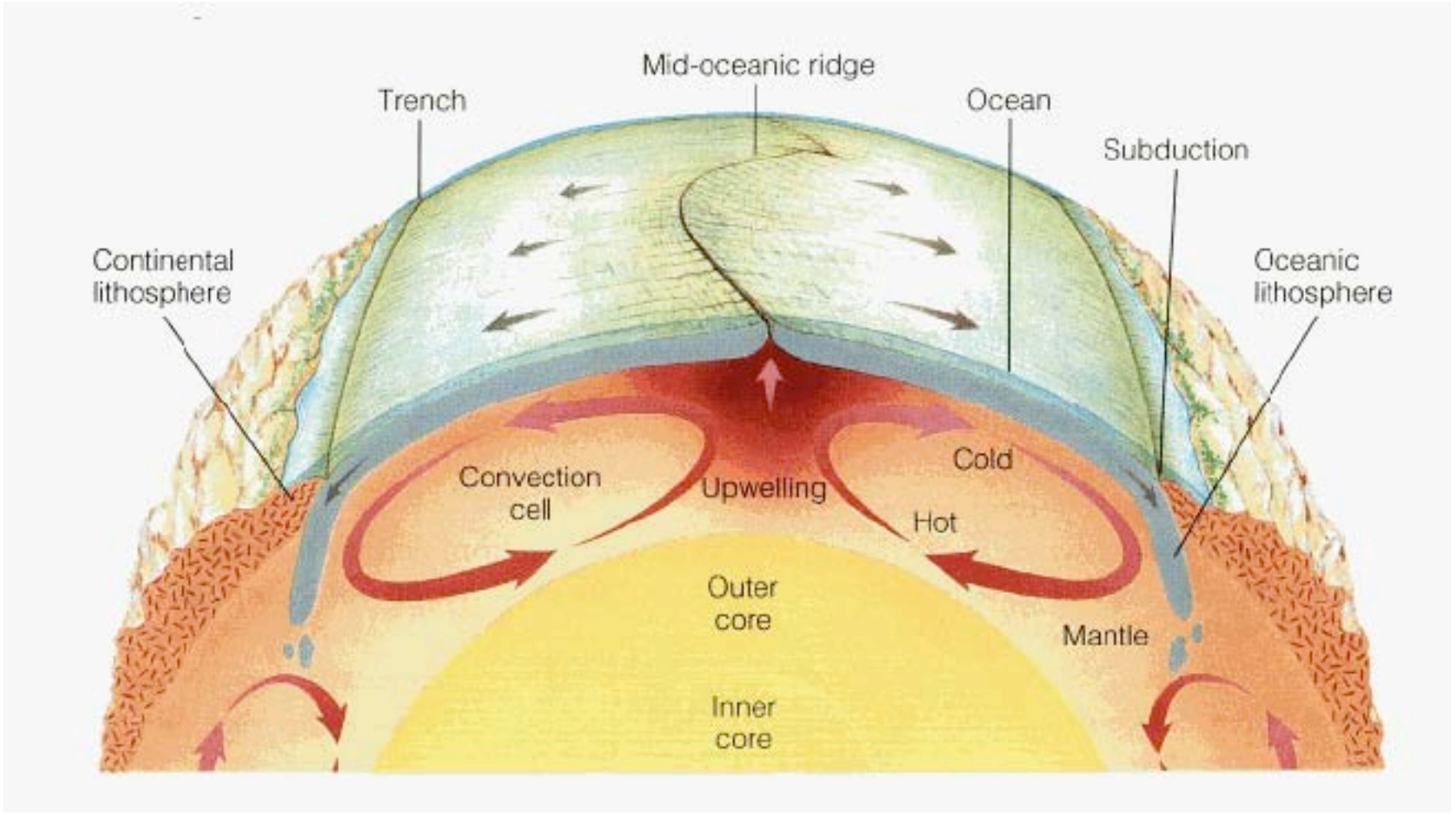
Lord Rayleigh



Henri Benard



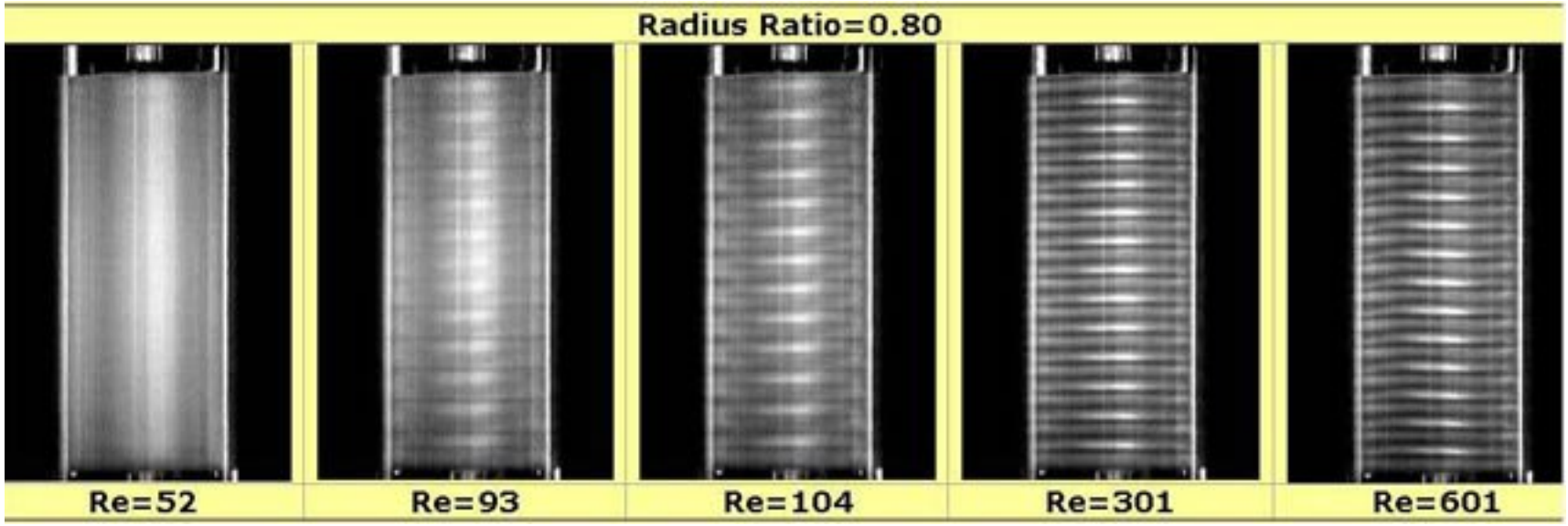

Ridge
Lithosphere
Trench
"SLAB PULL"
Trench
Asthenosphere
Mantle
700 km
Outer core
Inner
core


Mid-oceanic ridge
Trench
Ocean
Subduction
Continental lithosphere
Oceanic lithosphere
Convection cell
Upwelling
Cold
Hot
Outer core
Mantle
Inner core

# Turbulencija

"We will understand the movement of the stars long before we understand canopy turbulence"

Galileo Galilei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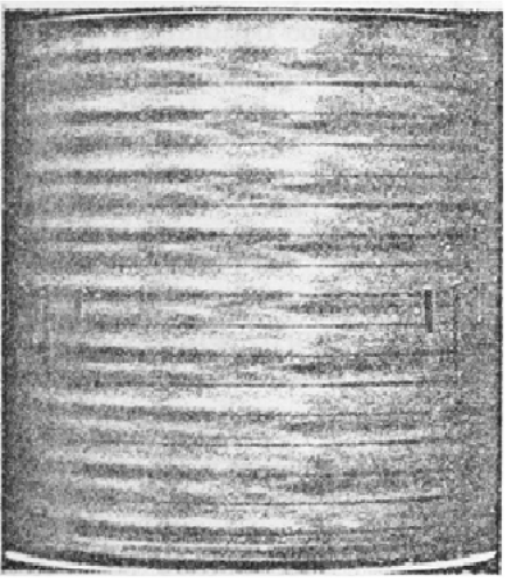
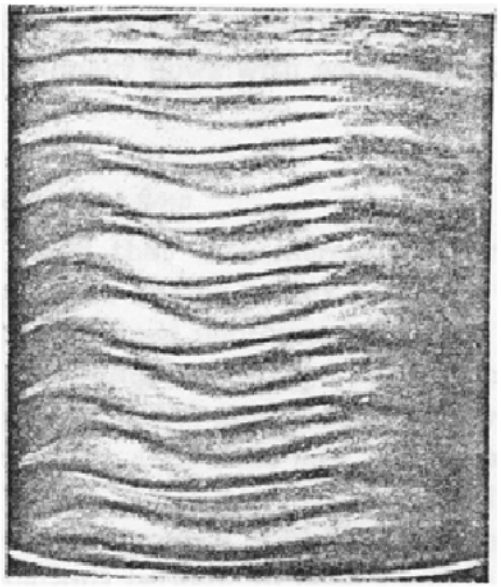
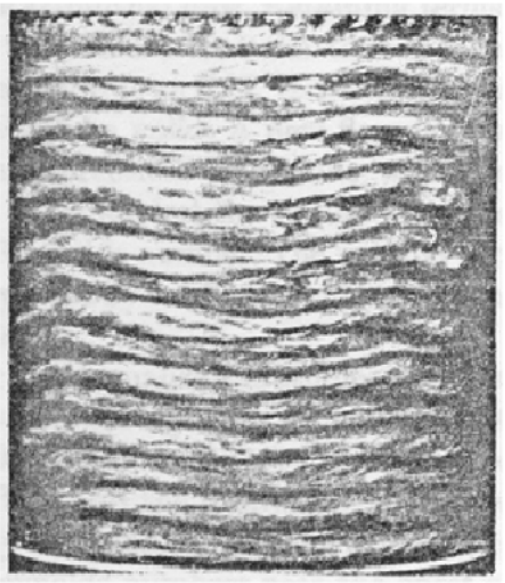
Re=52
Re=93
Re=104
Re=301
Re=601



(a)



(b)



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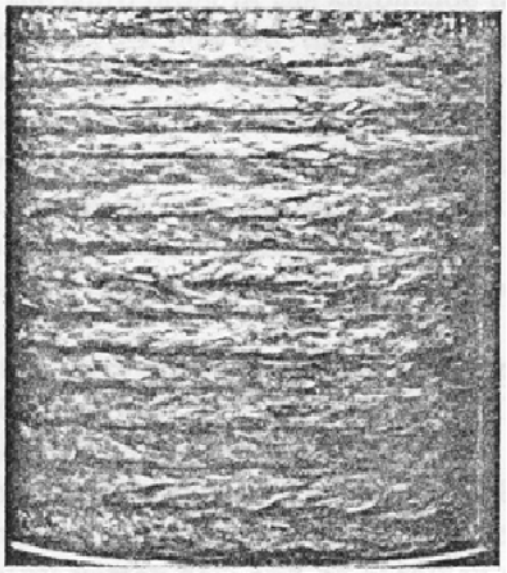
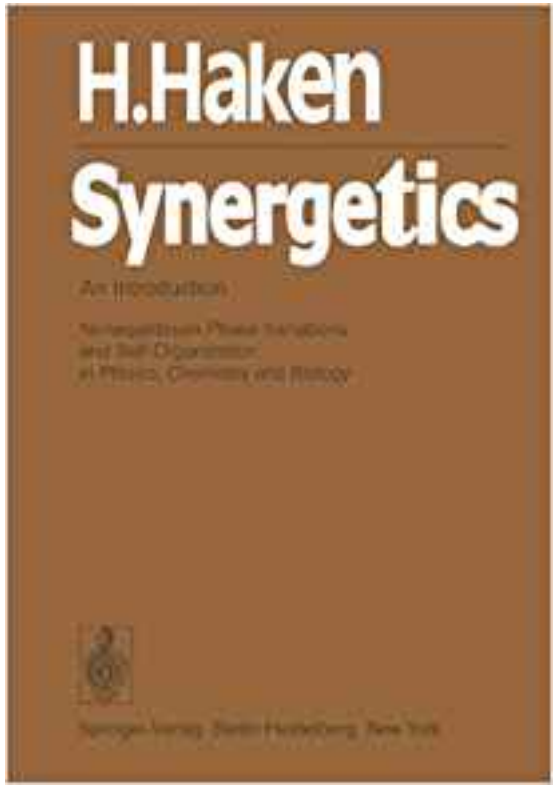


(d)

(e)

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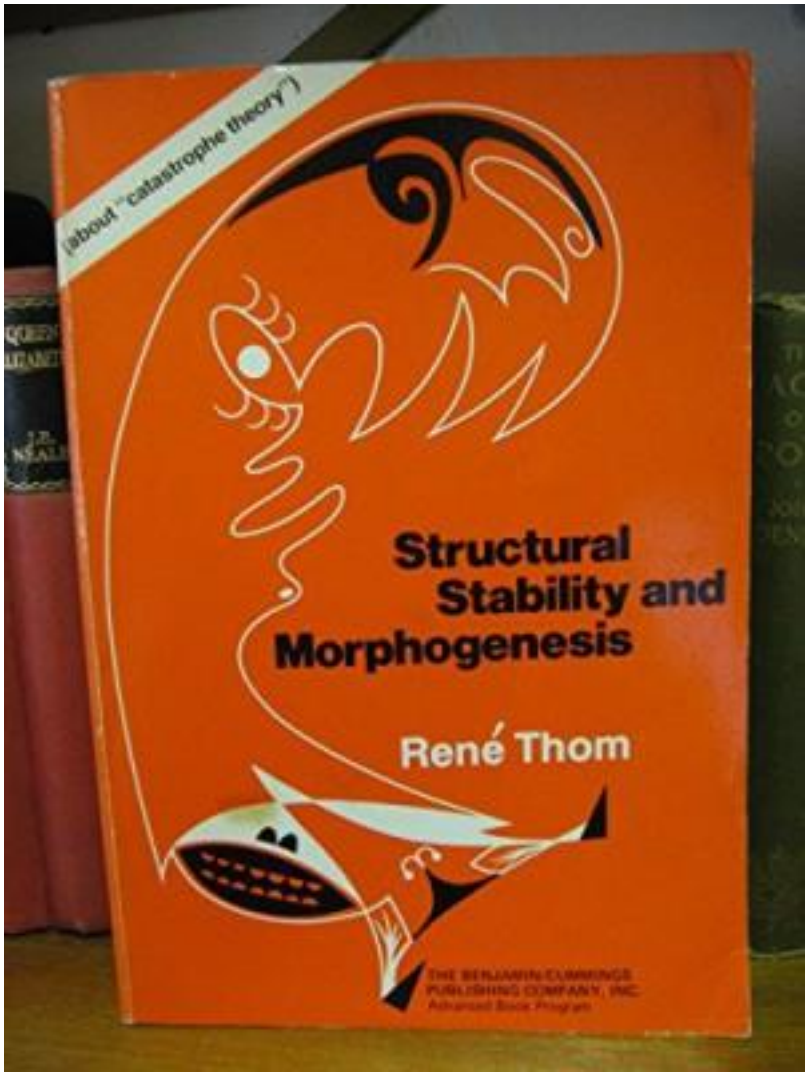
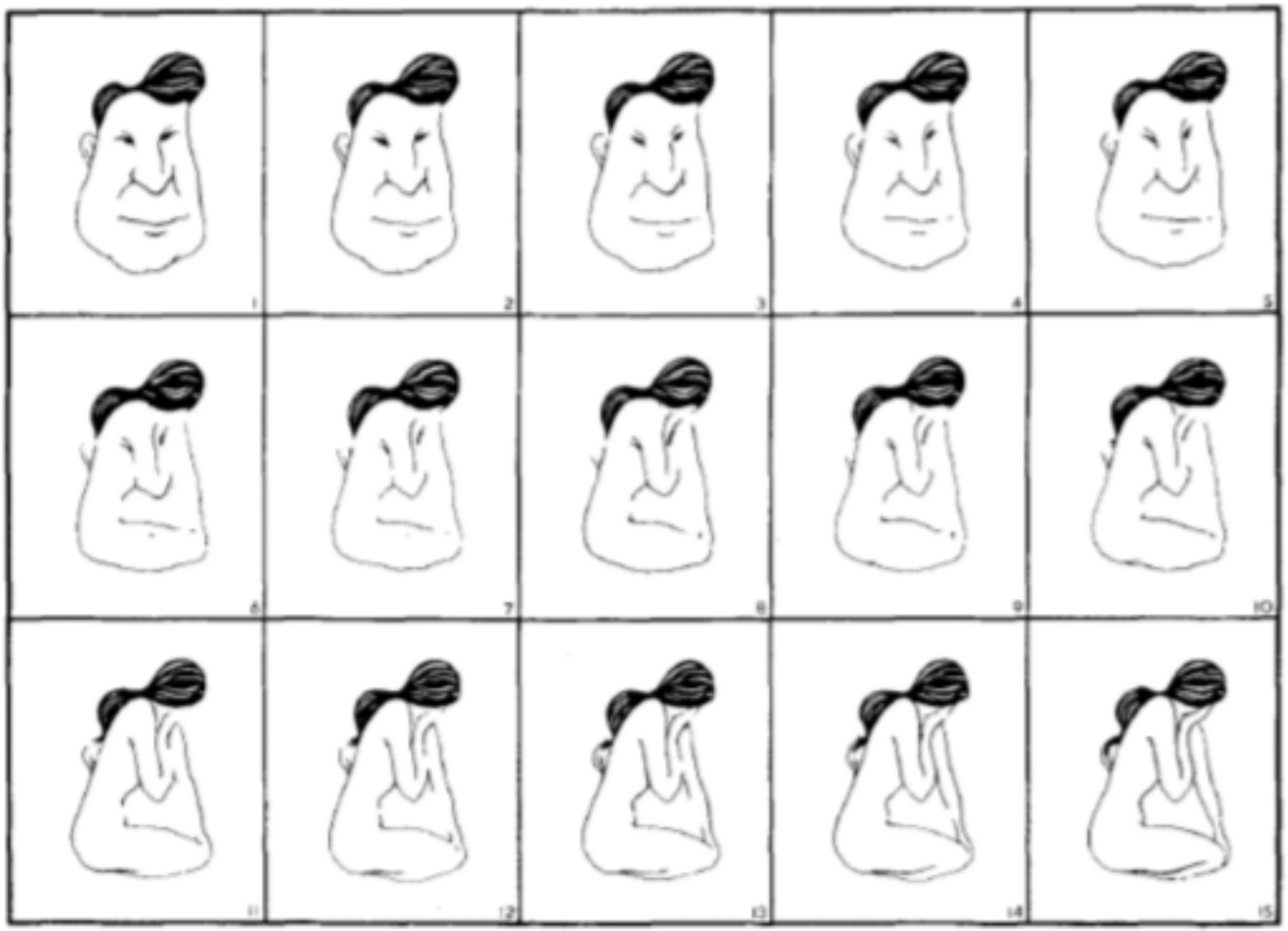
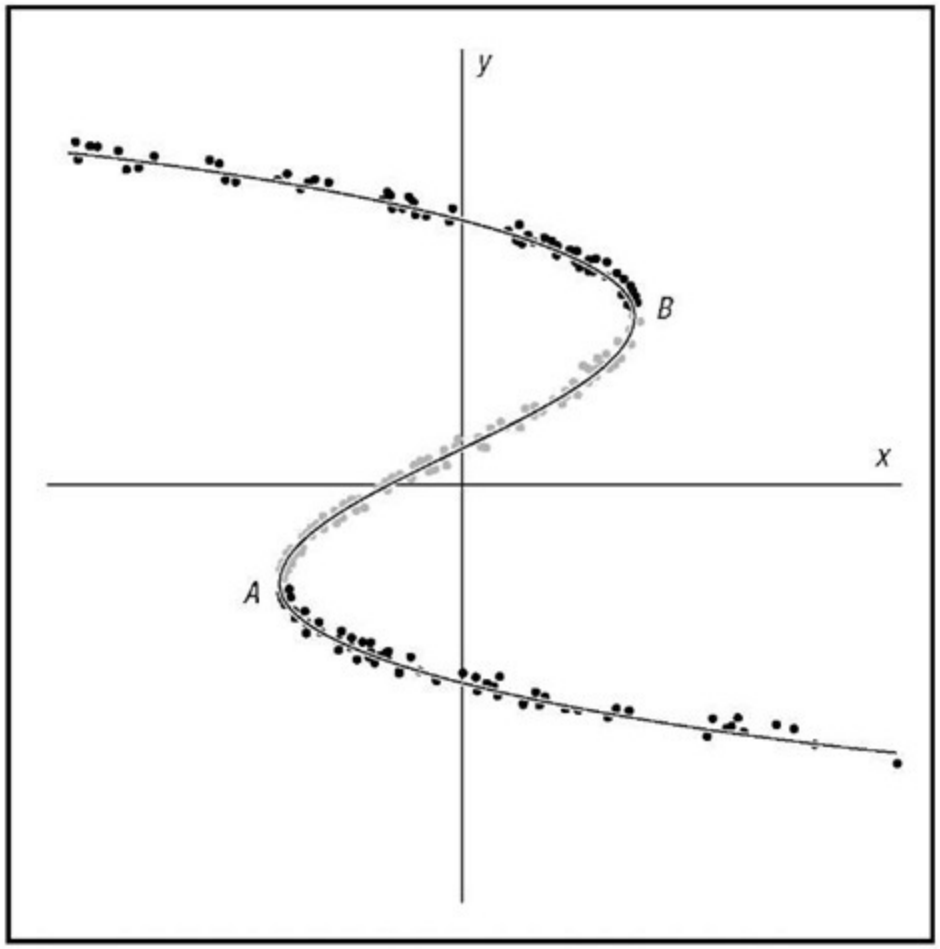
Teorija katastrofa

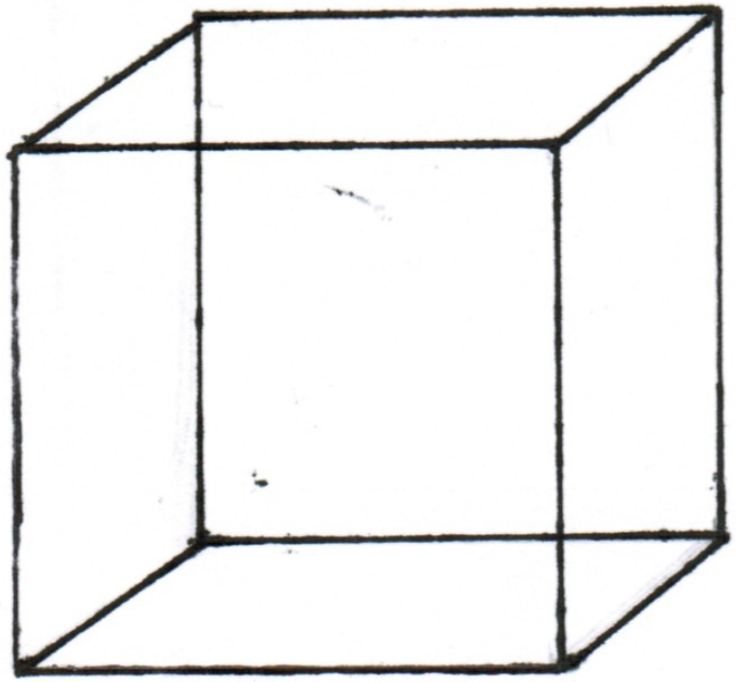



Rene Thom 1923-2002

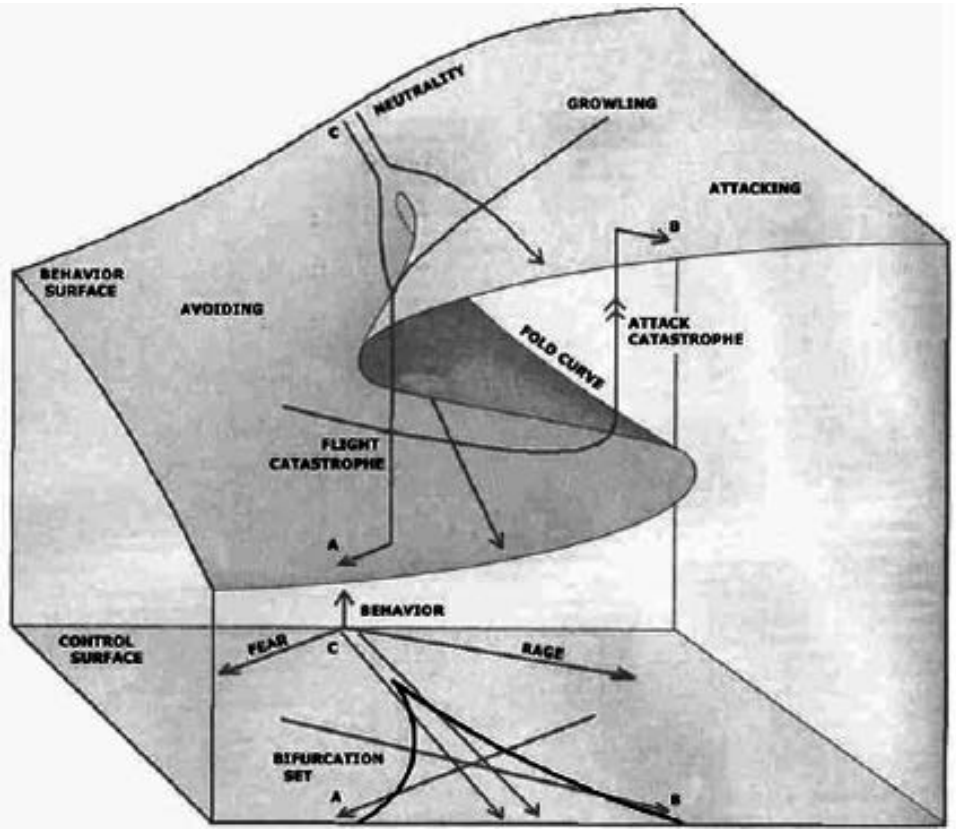


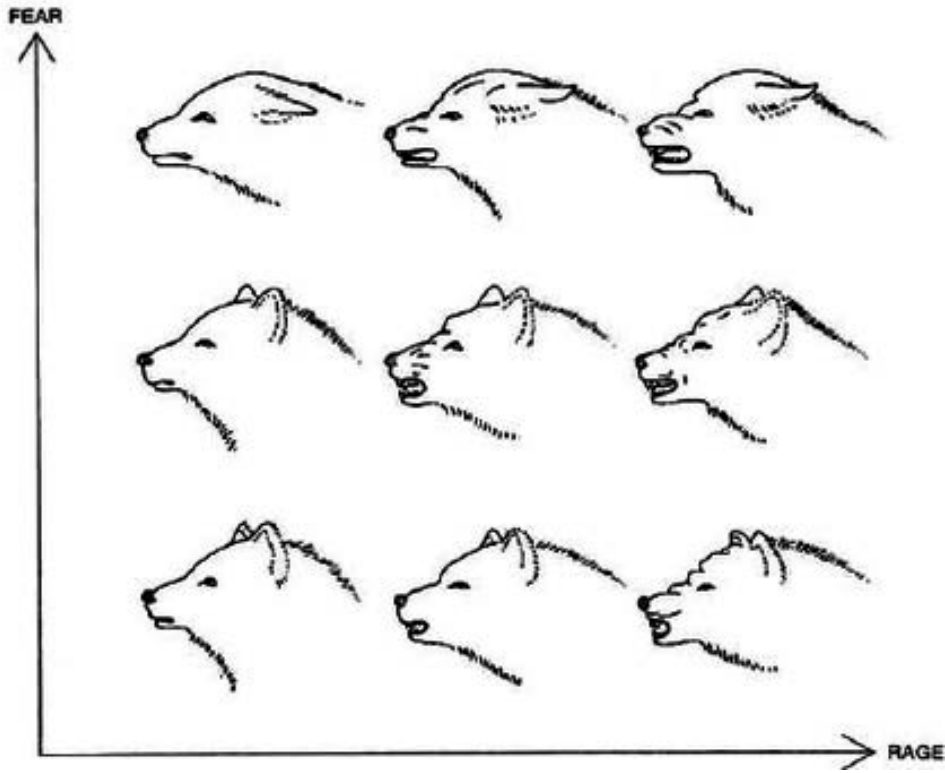
(Fisher, 1967)


y
x
B
A

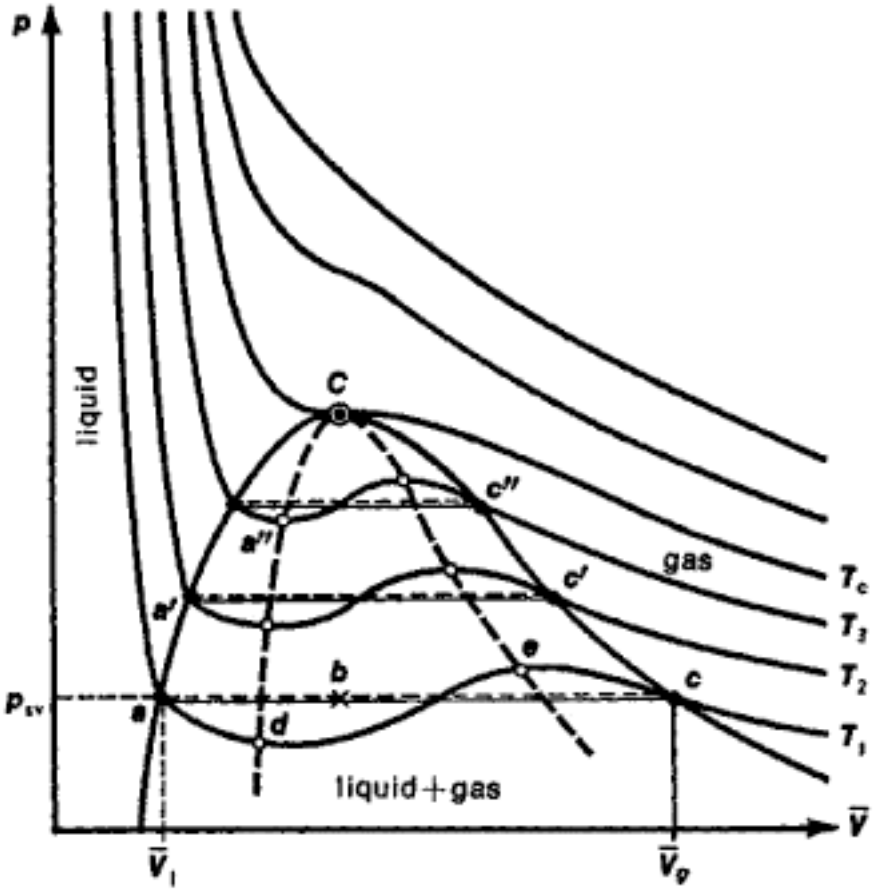


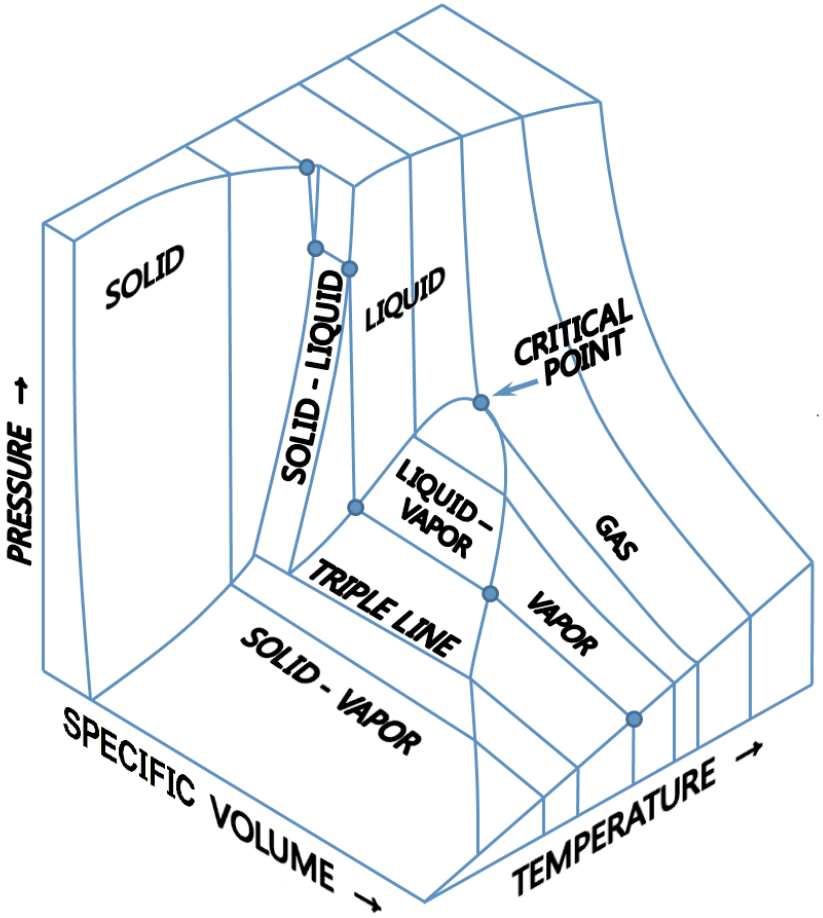
NECKER CUBE


NEUTRALITY
GROWLING
C
ATTACKING
B
BEHAVIOR SURFACE
AVOIDING
ATTACK CATASTROPHE
FOLD CURVE
FLIGHT CATASTROPHE
A
BEHAVIOR
CONTROL SURFACE
FEAR
C
RAGE
BIFURCATION SET
A
B

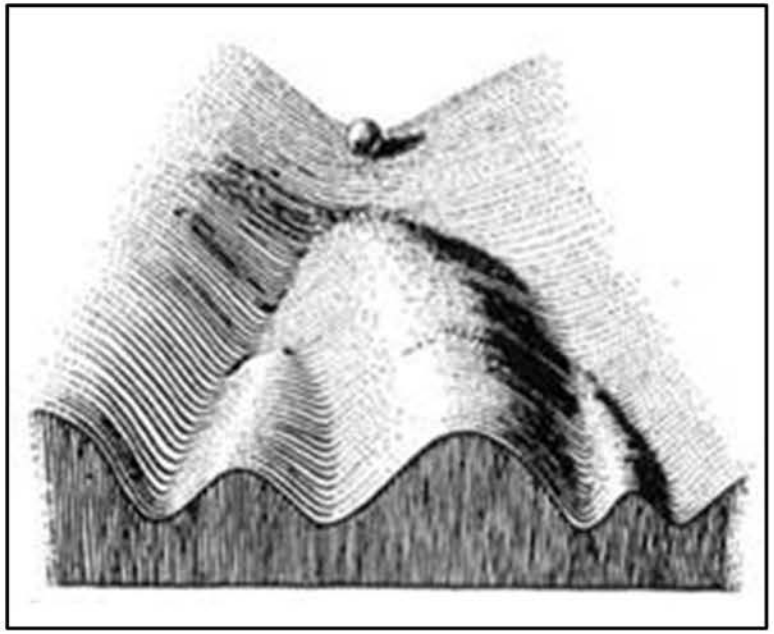

FEAR
RAGE

Fazni dijagram vode

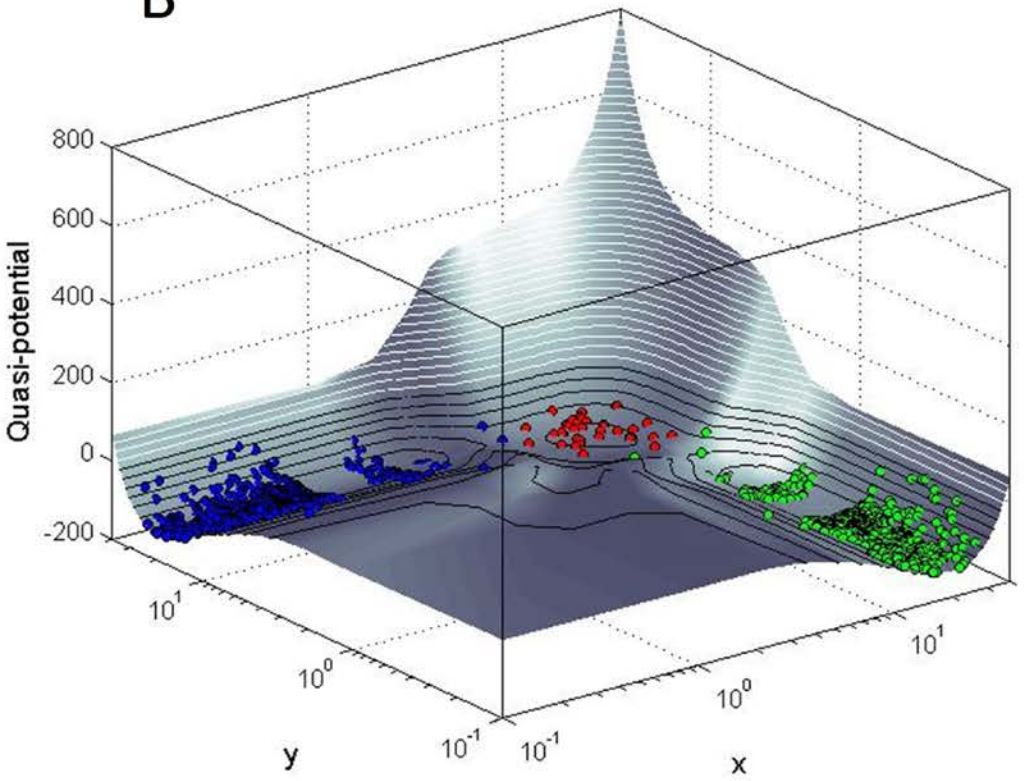


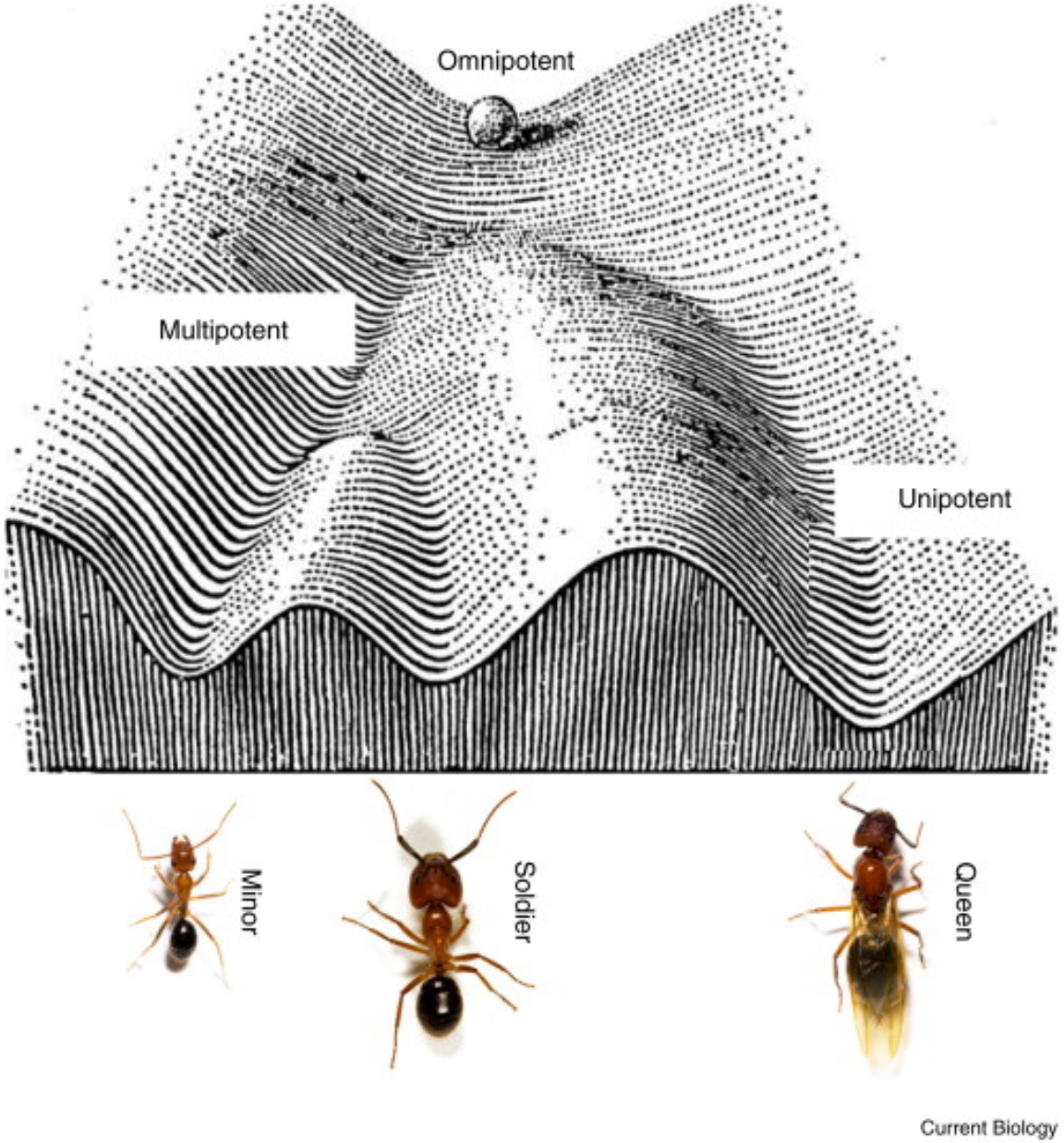
A



B


Quasi-potential
800
600
400
200
0
-200
$10^{1}$
$10^{0}$
$10^{-1}$
y
$10^{-1}$
$10^{0}$
$10^{1}$
x

# Pattern formation



# EVIDENCE OF CHAOTIC MOOD VARIATION IN BIPOLAR DISORDER

**By:** GOTTSCHALK, A (GOTTSCHALK, A); BAUER, MS (BAUER, MS); WHYBROW, PC (WHYBROW, PC)

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## Abstract

Background: Using long-term daily mood records obtained from patients with bipolar disorder and normal subjects, we sought to determine the temporal pattern of mood in bipolar disorder.

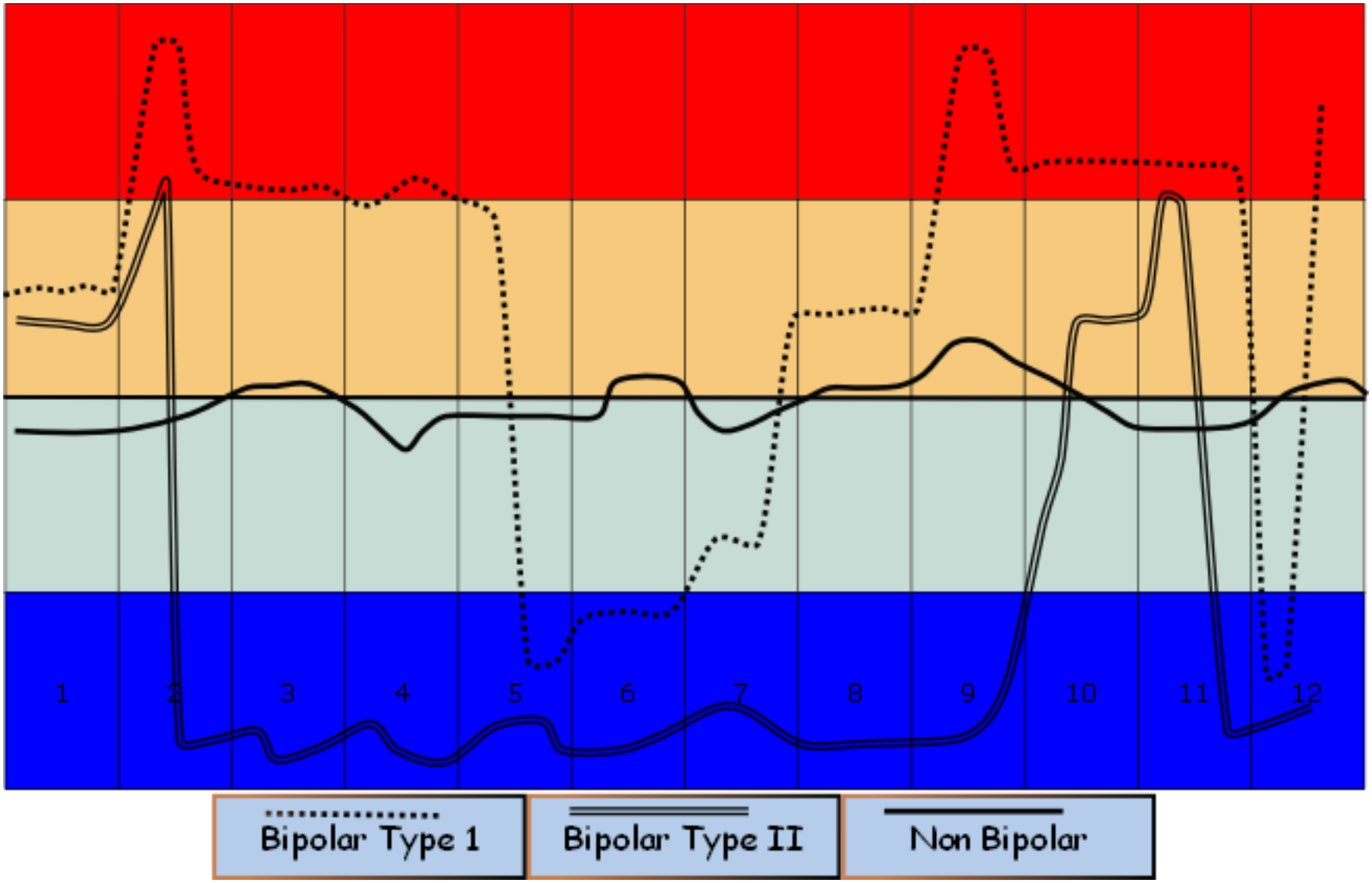
Methods: Time series of 1.0 to 2.5 years from seven rapid-cycling patients with bipolar disorder and 28 normal controls were obtained. These were evaluated with several techniques to identify whether the temporal pattern of mood originates from a periodic, a random, or a deterministic source.

Results: True cyclicity was not apparent in the power spectra of either the normal subjects or the patients with bipolar disorder. Instead, spectra with a broadband "1/f" shape were observed in both groups, and these spectra were significantly flatter in normal subjects (P=.02). Correlation dimension estimates are a measure of nonlinear deterministic structure, and convergent estimates could be obtained for six of the seven patients with bipolar disorder and none of the normal subjects (P<.001). Additional findings are consistent with these results.

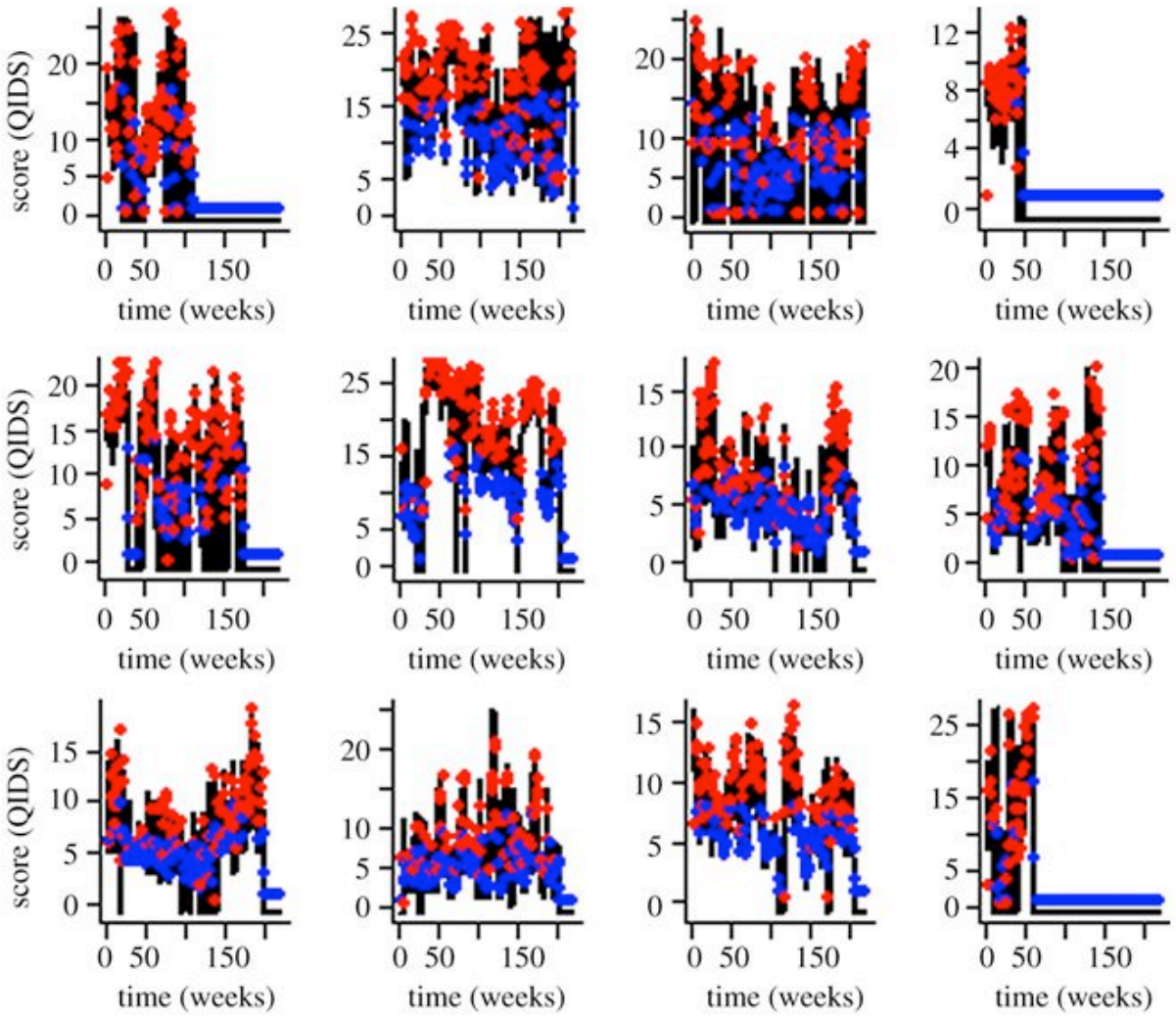
Conclusions: These studies indicate that mood in patients with bipolar disorder is not truly cyclic for extended periods. Nonetheless, self-rated mood in bipolar disorder is significantly more organized than self-rated mood in normal subjects and can be characterized as a low-dimensional chaotic process. This characterization of the dynamics of bipolar disorder provides a unitary theoretical framework that can accommodate neurobiologic and psychosocial data and can reconcile existing models for the pathogenesis of the disorder. Furthermore, consideration of the dynamical structure of bipolar disorder may lead to new methods for predicting and controlling pathologic mood.

## Keywords

**KeyWords Plus:** MANIC-DEPRESSIVE ILLNESS; SMALL DATA SETS; STRANGE ATTRACTORS; DYNAMICAL-SYSTEMS; TIME-SERIES; DIMENSION; SENSITIZATION; VALPROATE; CYCLES


1
2
3
4
5
6
7
8
9
10
11
12
Bipolar Type 1
Bipolar Type II
Non Bipolar

**Mood score time series for individual patients from the unstable group (black lines) with fitted threshold autoregressive model (equations (3.3) and (3.4); red and blue points).**




M. B. Bonsall et al. Proc. R. Soc. B 2012;279:916-924



PROCEEDINGS OF THE ROYAL SOCIETY B

MEMOIRS

OF EXTRAORDINARY

# POPULAR DELUSIONS.

BY CHARLES MACKAY.

AUTHOR OF

"THE THAMES AND ITS TRIBUTARIES," "THE HOPE OF THE WORLD," ETC.

"Il est bon de connaître les défauts de l'esprit humain. Chaque peuple a ses folies plus ou moins grandes."

MALLET.

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Publisher in Ordinary to Her Majesty.
1841.

**Extraordinary Popular Delusions and the Madness of Crowds**


Semper Augustus

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150
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50

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