Black Swans, Dragons-Kings and Prediction

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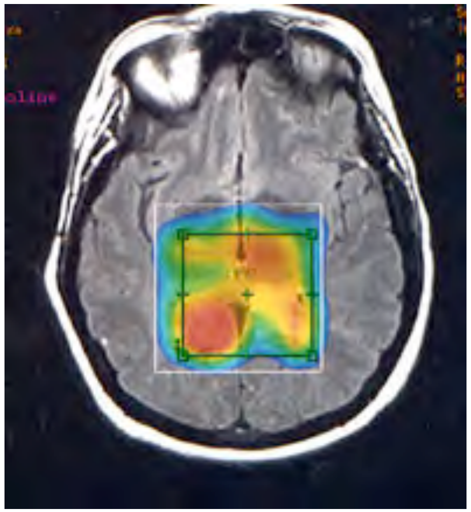

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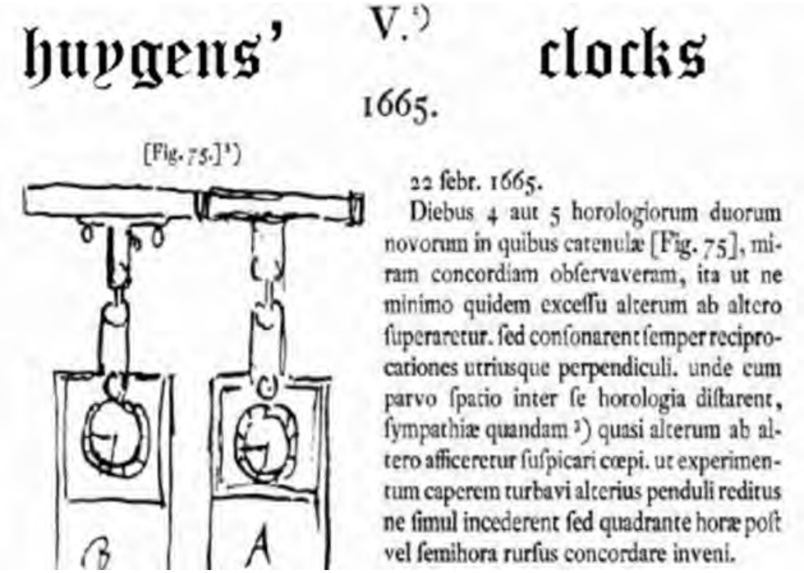
SYNCHRONISATION AND COLLECTIVE EFFECTS IN EXTENDED STOCHASTIC SYSTEMS



V.[1])

1665.

[Fig. 75.][2])

22 febr. 1665.

Diebus 4 aut 5 horologiorum duorum novorum in quibus catenulæ [Fig. 75], miram concordiam obfervaveram, ita ut ne minimo quidem exceffu alterum ab altero fuperaretur. fed confonarent femper reciprocationes utriusque perpendiculi. unde cum parvo fpatio inter fe horologia diftarent, fympathiæ quandam [3]) quasi alterum ab altero afficeretur fufpicari cœpi. ut experimentum caperem turbavi alterius penduli reditus ne fimul incederent fed quadrante horæ poft vel femihora rurfus concordare inveni.

Fireflies

Earthquake-fault model

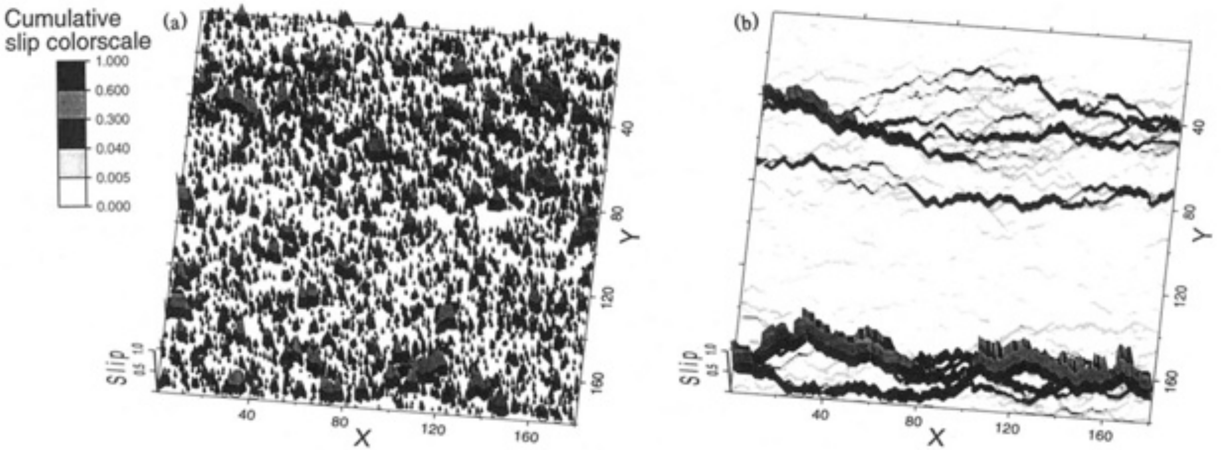
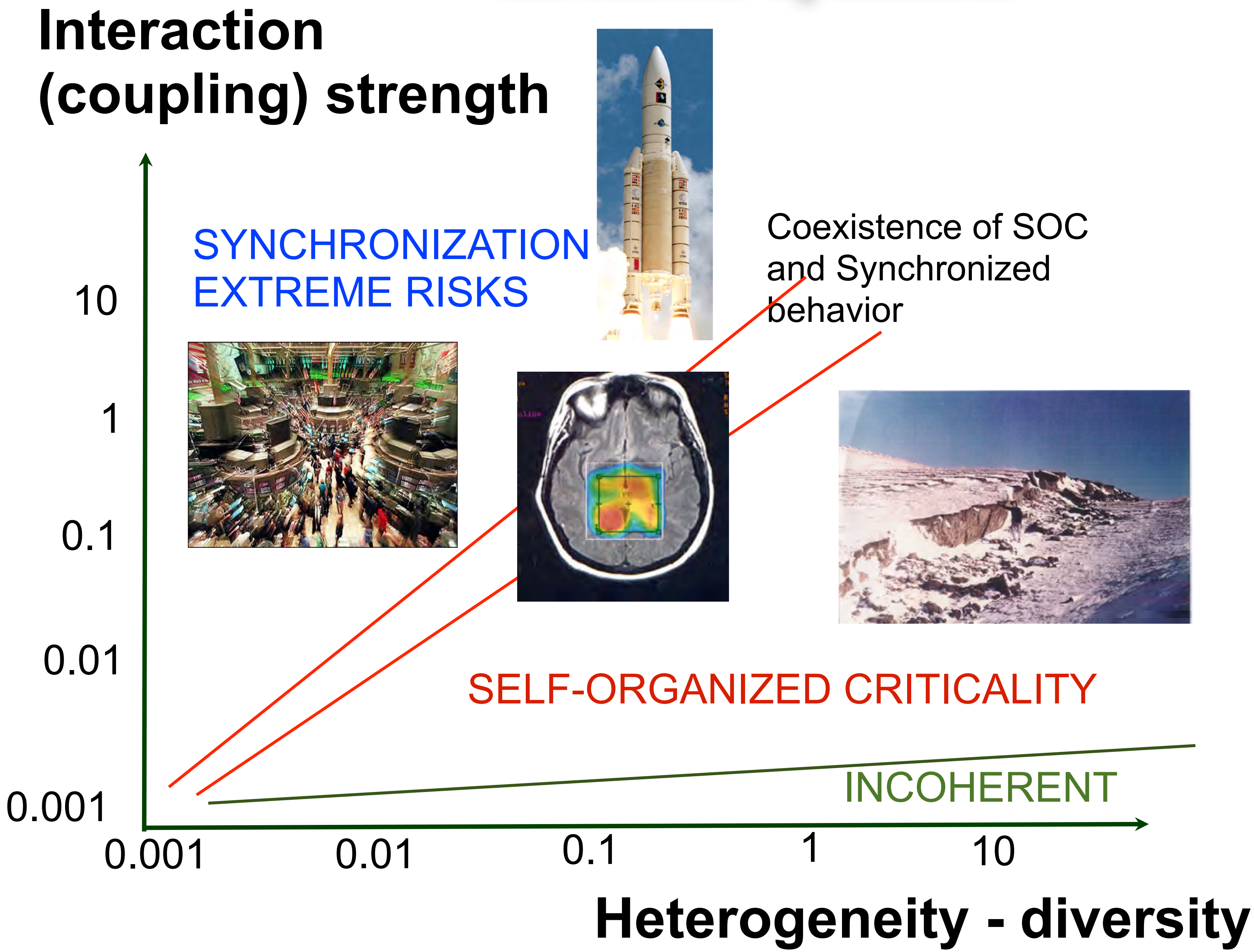


FIG. 1. Evolution of the cumulative earthquake slip, represented along the vertical axis in the white to black color code shown above the picture, at two different times: (a) early time and (b) long time, in a system of size $L=90$ by $L=90$, where $\Delta\sigma=1.9$ and $\beta=0.1$.

Miltenberger et al. (1993)

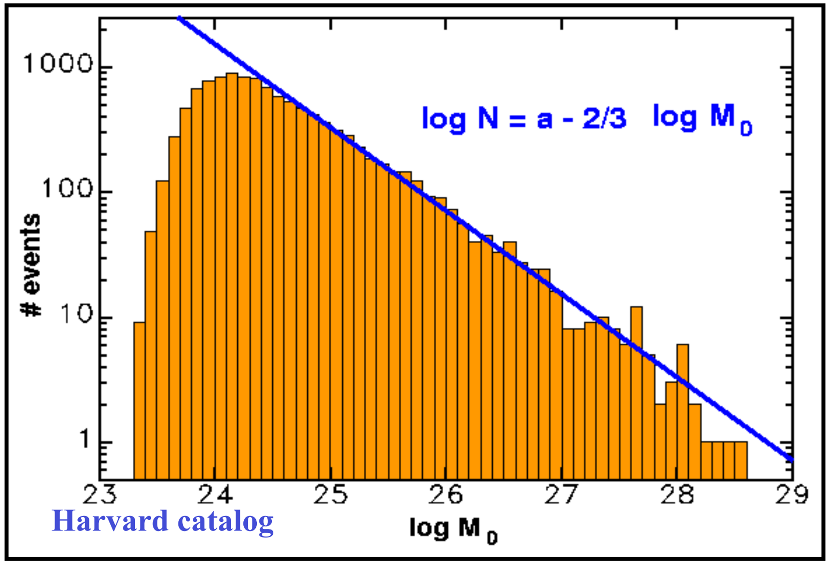
(Prof. R.E. Amritkar)

Generic diagram for coupled agents with threshold dynamics

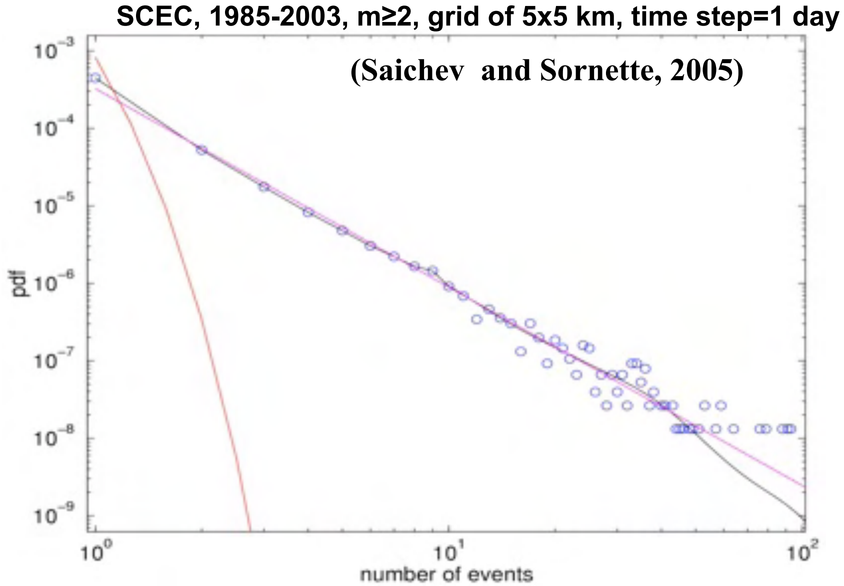


“fat-tail events”？

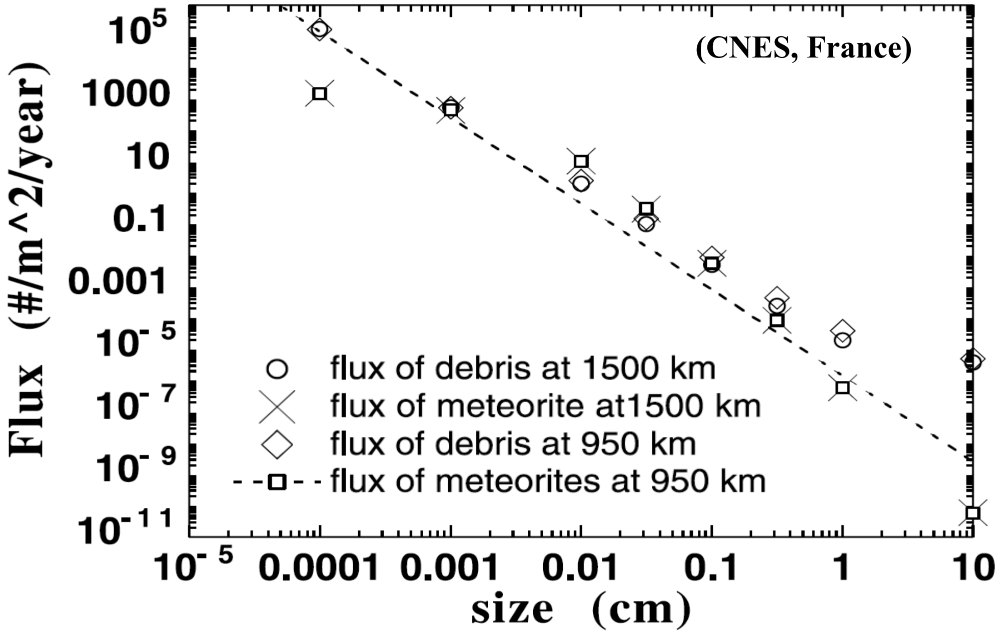
Heavy tails in pdf of earthquakes



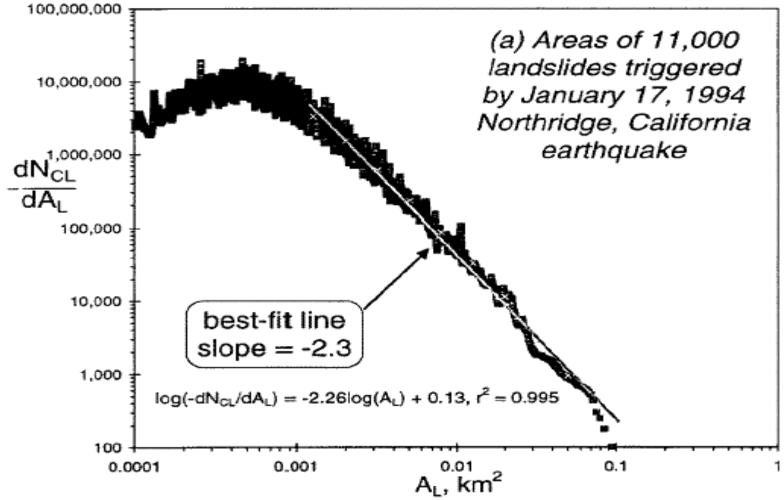
Heavy tails in pdf of seismic rates



Heavy tails in ruptures



Heavy tails in pdf of rock falls, Landslides, mountain collapses



Turcotte (1999)

Heavy tails in pdf of forest fires

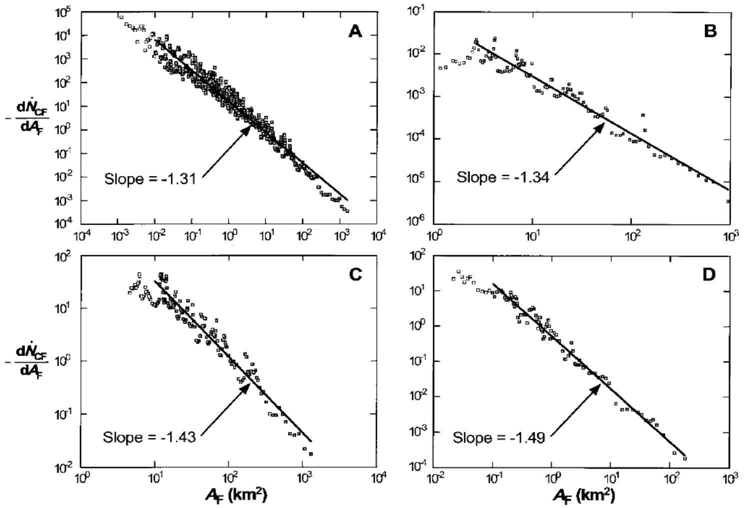
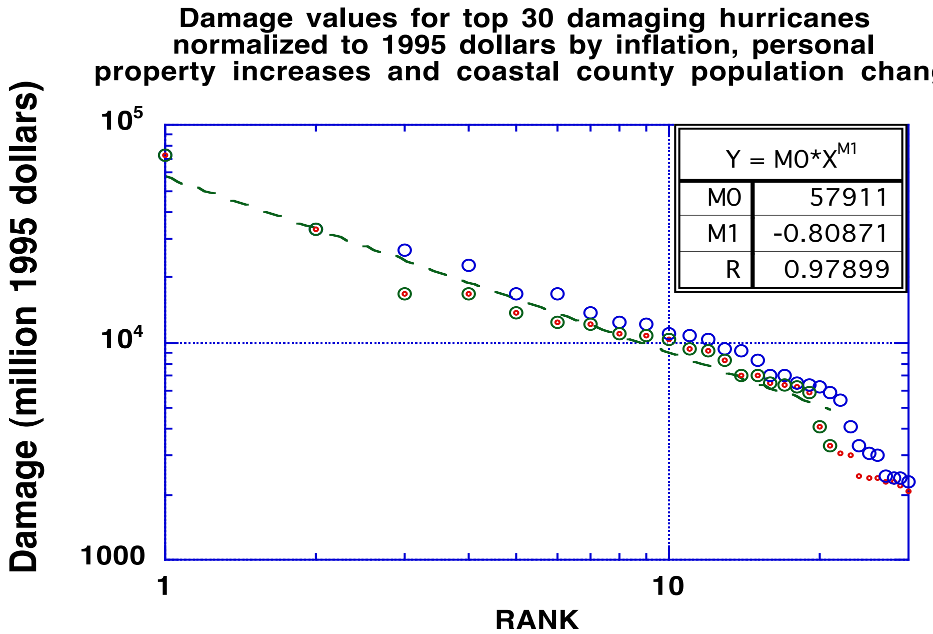


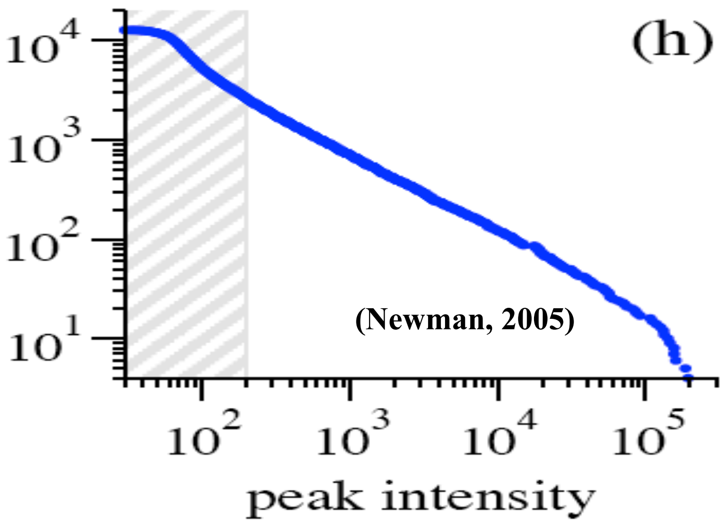
Fig. 2. Noncumulative frequency-area distributions for actual forest fires and wildfires in the United States and Australia: (**A**) 4284 fires on U.S. Fish and Wildlife Service lands (1986–1995) (*9*), (**B**) 120 fires in the western United States (1150–1960) (*10*), (**C**) 164 fires in Alaskan boreal forests (1990–1991) (*11*), and (**D**) 298 fires in the ACT (1926–1991) (*12*). For each data set, the noncumulative number of fires per year ($-d\dot{N}_{CF}/dA_F$) with area (A_F) is given as a function of A_F (*13*). In each case, a reasonably good correlation over many decades of A_F is obtained by using the power-law relation (Eq. 1) with α = 1.31 to 1.49; $-\alpha$ is the slope of the best-fit line in log-log space and is shown for each data set.

Malamud et al., Science 281 (1998)

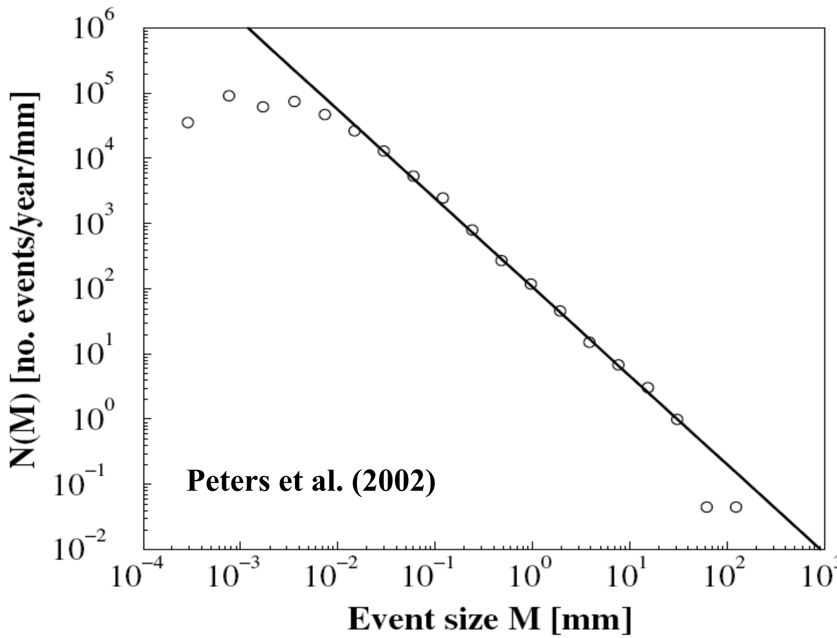
Heavy tails in pdf of Hurricane losses



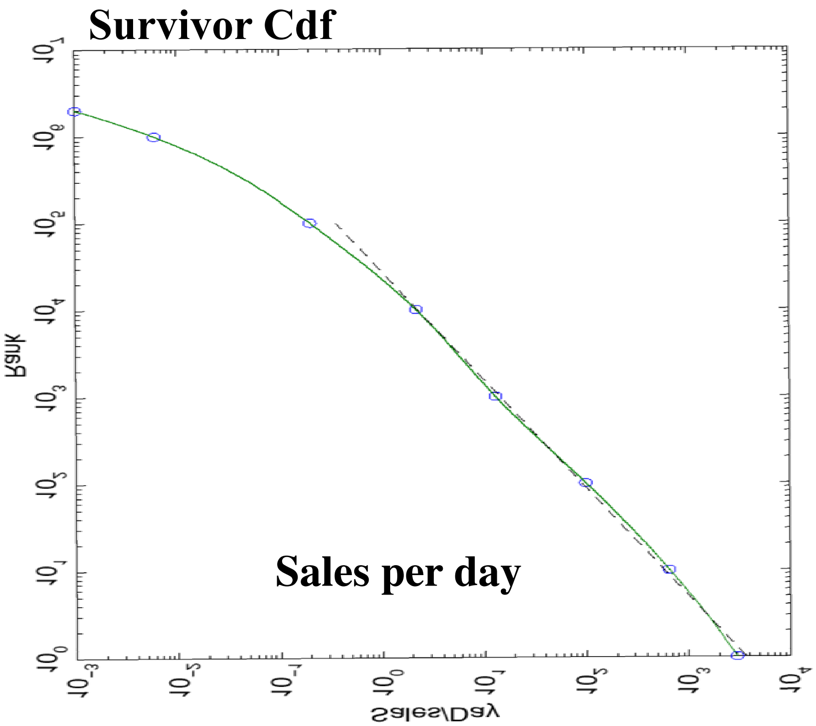
Heavy tails in pdf of Solar flares



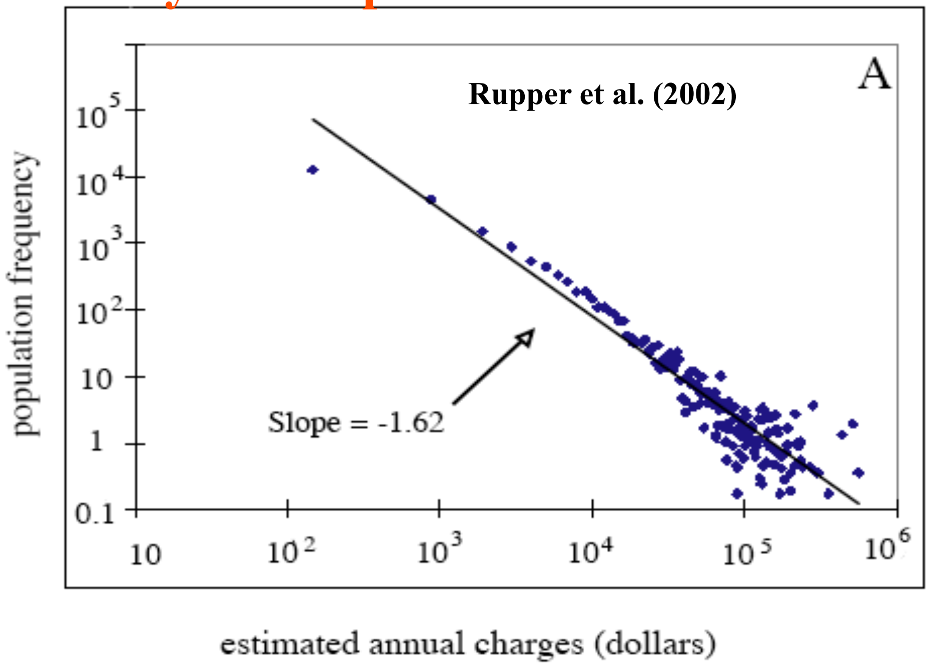
Heavy tails in pdf of rain events



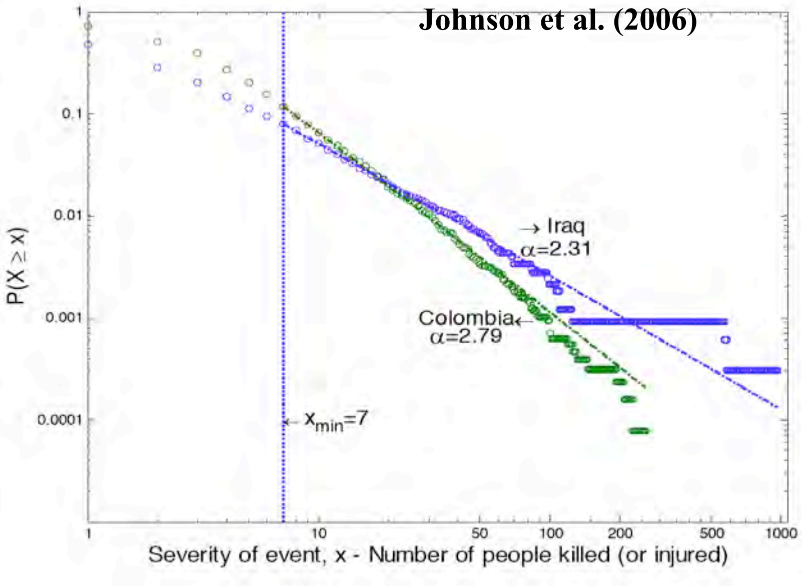
Heavy-tail of pdf of book sales



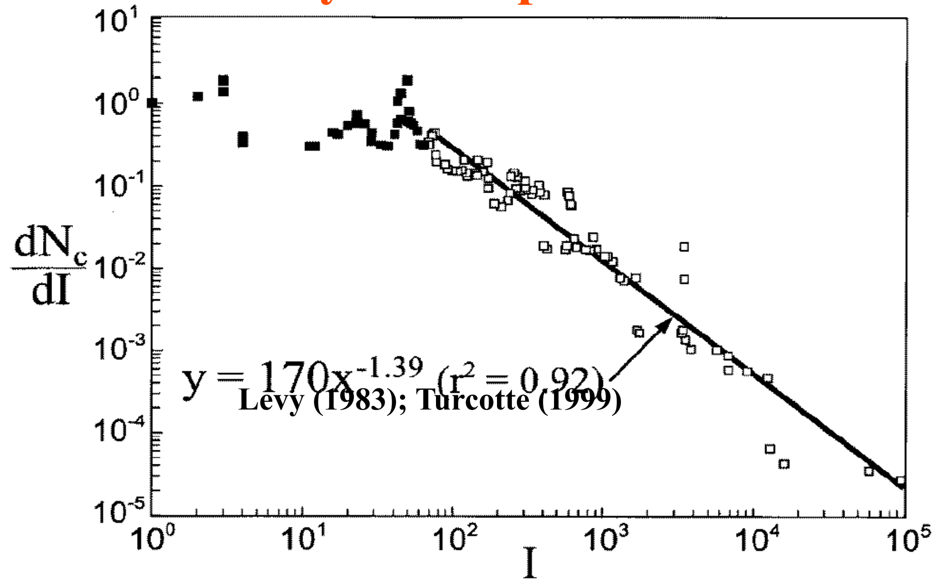
Heavy-tail of pdf of health care costs



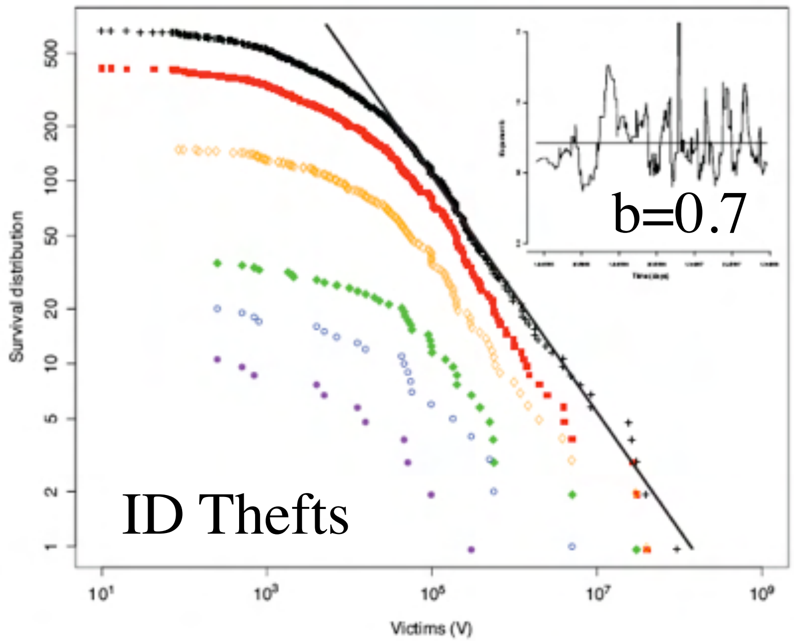
Heavy-tail of pdf of terrorist intensity



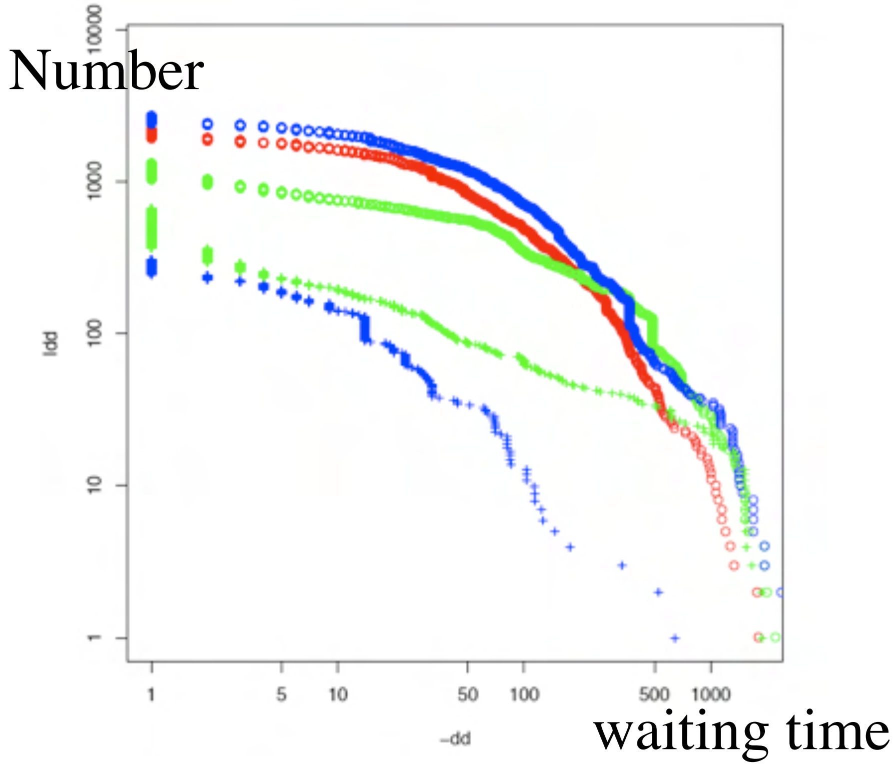
Heavy-tail of pdf of war sizes



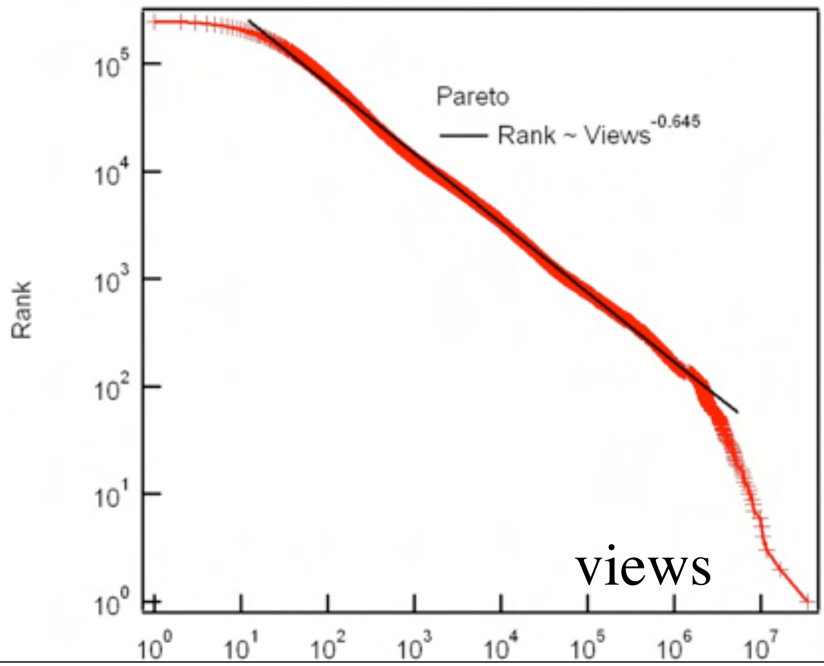
Heavy-tail of cdf of cyber risks



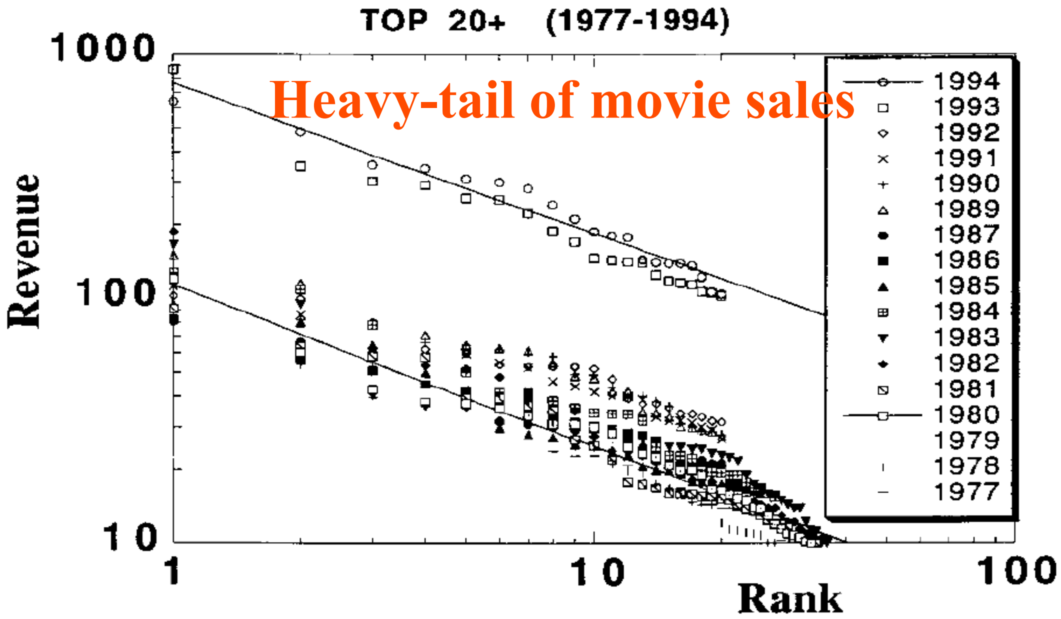
Software vulnerabilities



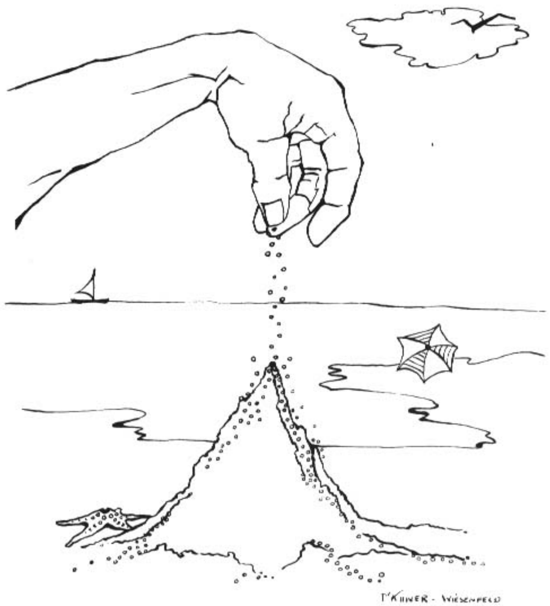
Heavy-tail of YouTube view counts



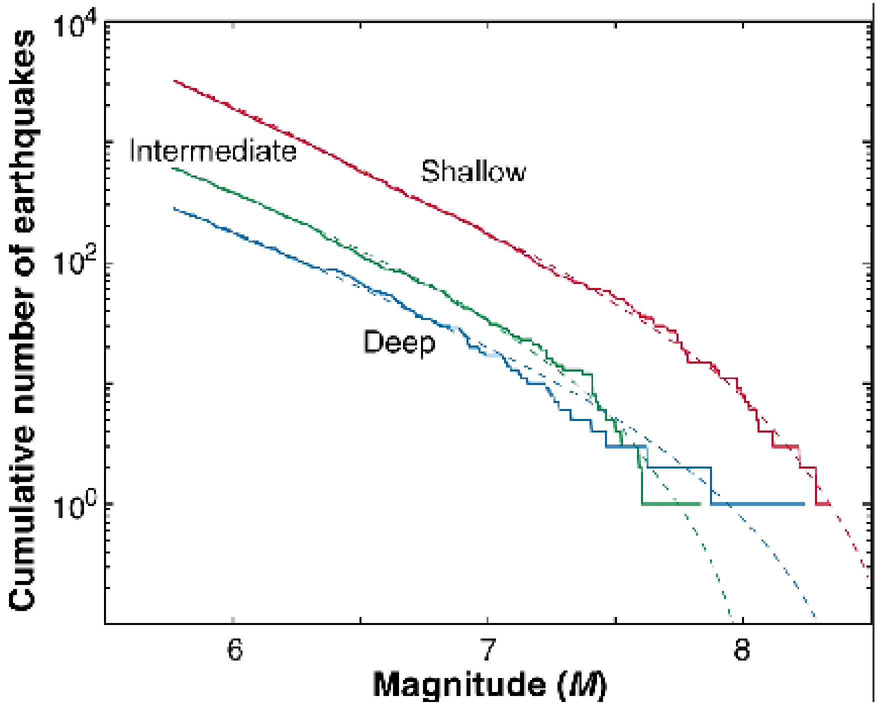
Heavy-tail of movie sales



Self-organized criticality

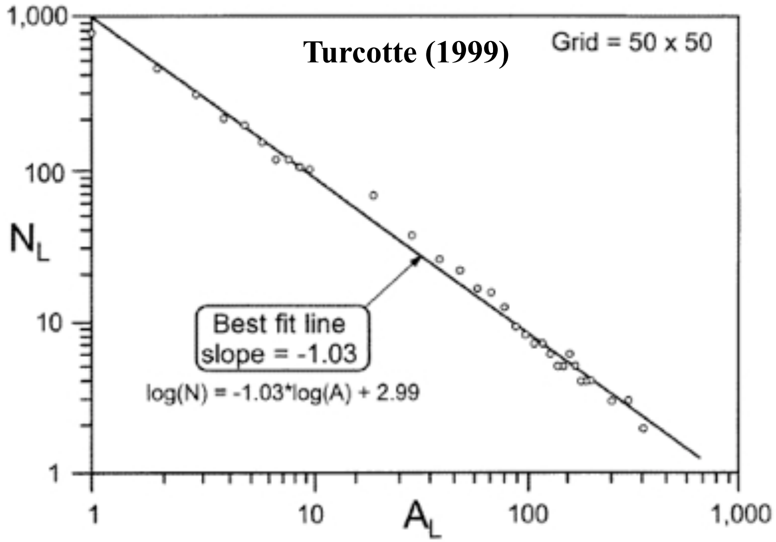


(Bak, Tang, Wiesenfeld, 1987)



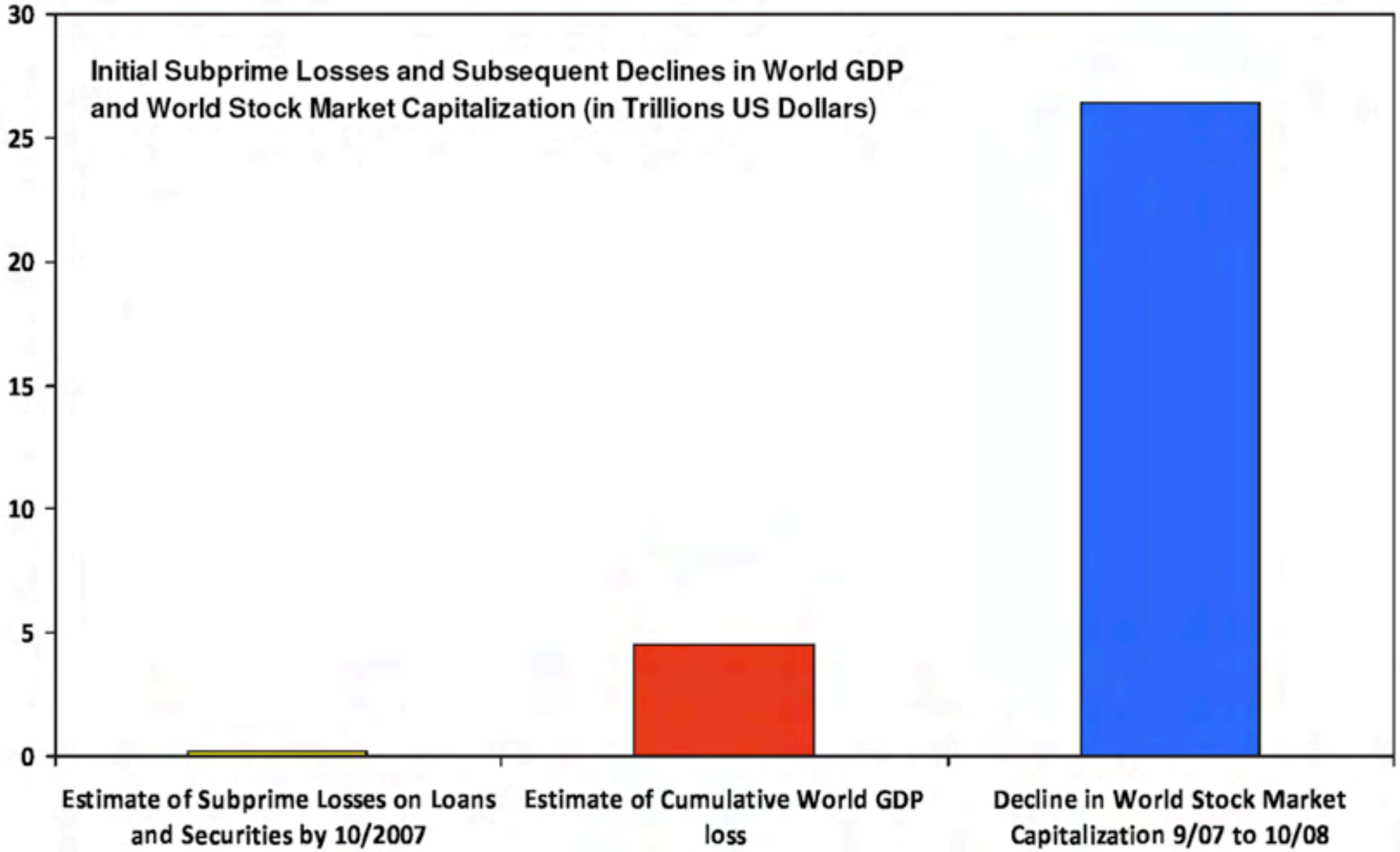
Earthquakes Cannot Be Predicted

Robert J. Geller, David D. Jackson, Yan Y. Kagan, Francesco Mulargia
Science 275, 1616-1617 (1997)



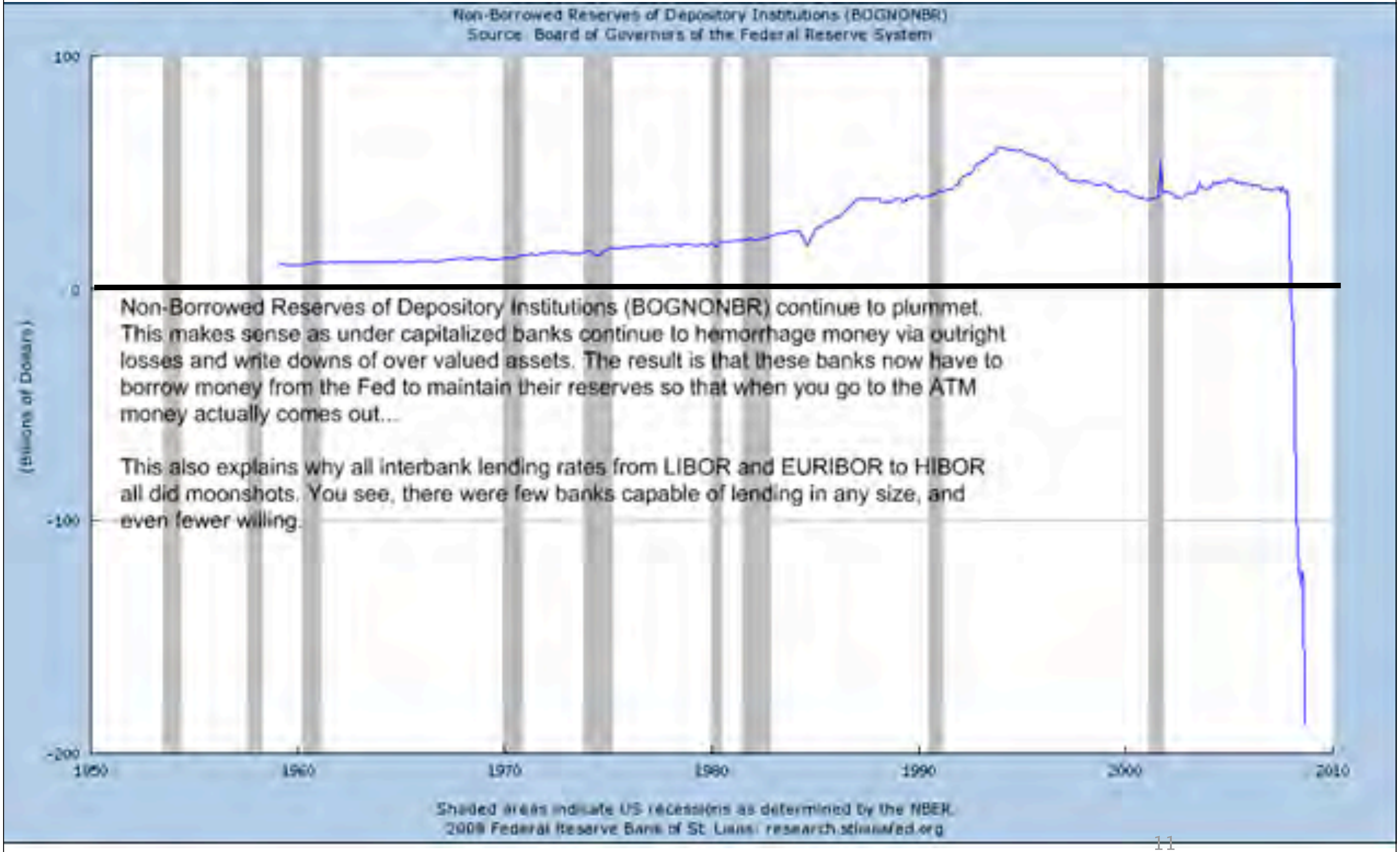
The Paradox of the 2007-20XX Crisis

(trillions of US$)



Source: IMF Global Financial Stability Report; World Economic Outlook November update and estimates; World Federation of Exchanges.

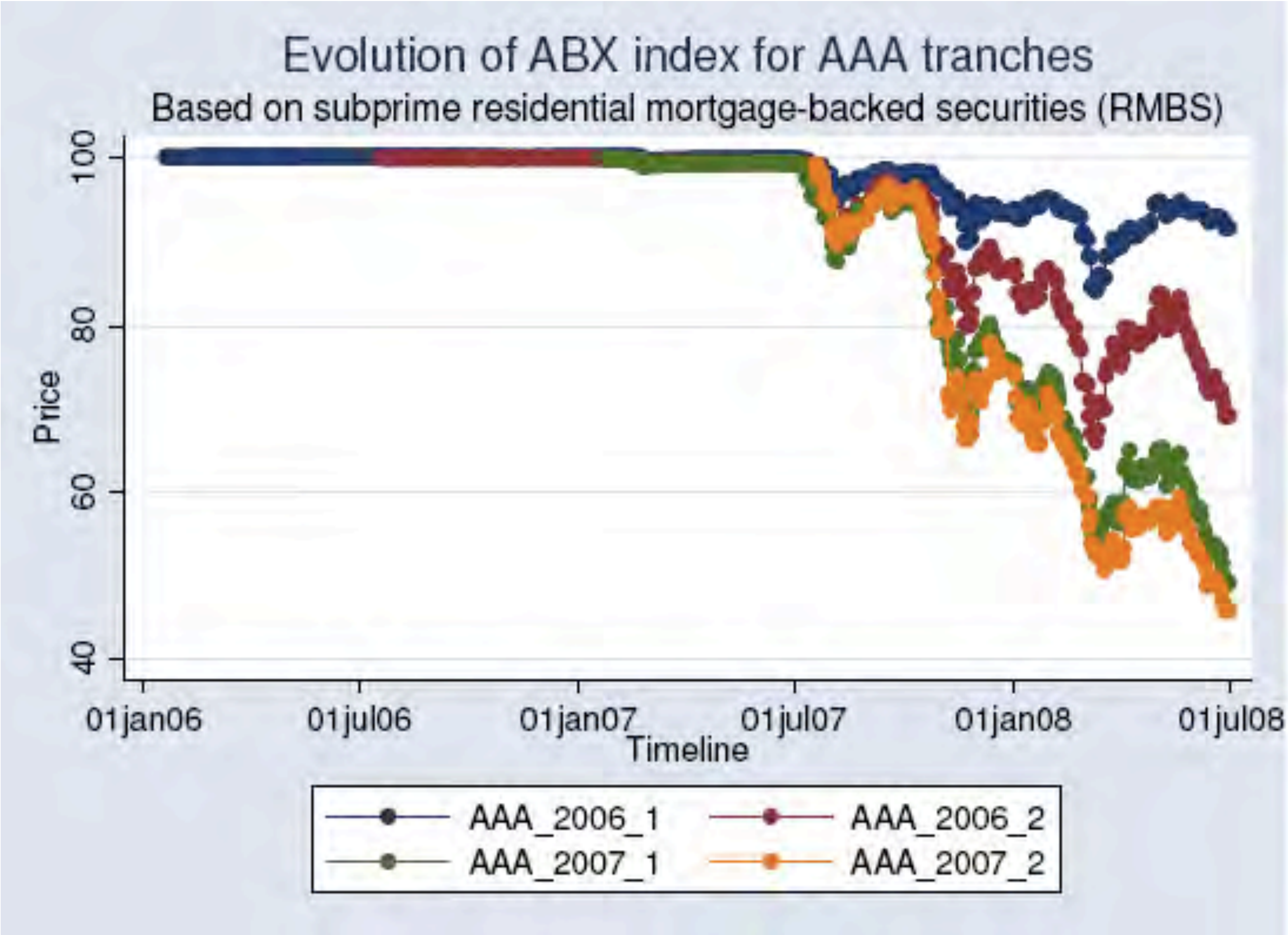
2008 FINANCIAL CRISIS



Non-Borrowed Reserves of Depository Institutions (BOGNONBR) continue to plummet. This makes sense as under capitalized banks continue to hemorrhage money via outright losses and write downs of over valued assets. The result is that these banks now have to borrow money from the Fed to maintain their reserves so that when you go to the ATM money actually comes out...

This also explains why all interbank lending rates from LIBOR and EURIBOR to HIBOR all did moonshots. You see, there were few banks capable of lending in any size, and even fewer willing.

2008 FINANCIAL CRISIS



Dragon-king hypothesis

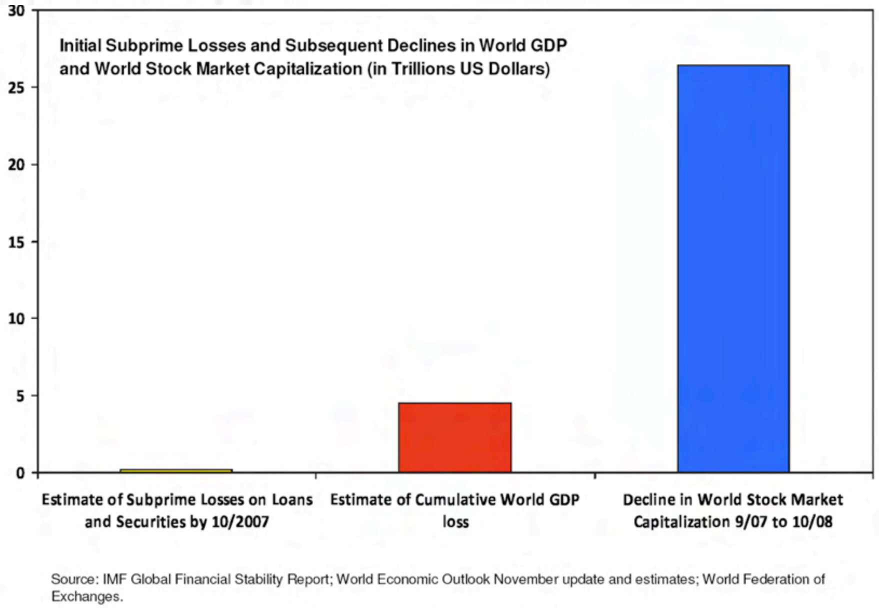
Crises are not

but

“Dragon-kings”

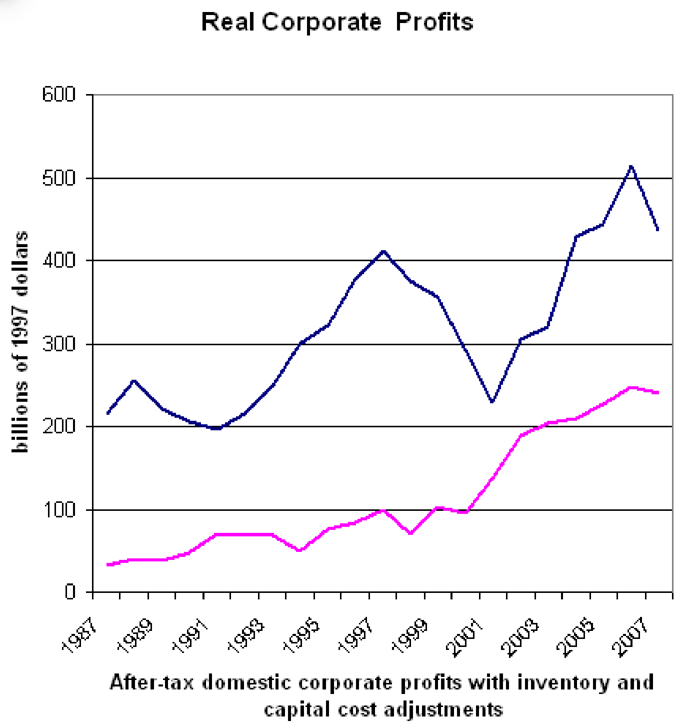
Black Swan story

- Unknown unknowable event
    - ★ cannot be diagnosed in advance, cannot be quantified, no predictability
- No responsability (“wrath of God”)
- One unique strategy: long put options and insurance



Dragon-king hypothesis

- Most crises are "endogenous"
  - ★ can be diagnosed in advance,
    can be quantified, (some) predictability
- Moral hazard, conflict of interest, role of regulations
- Responsibility, accountability
- Strategic vs tactical time-dependent strategy
- Weak versus global signals



http://www.businessweek.com/the_thread/economicsunbound/archives/2009/03/a_bad_decade_fo.html Michael Mandel

Beyond power laws: 7 examples of "Dragons"

Financial economics: Outliers and dragons in the distribution of financial drawdowns.

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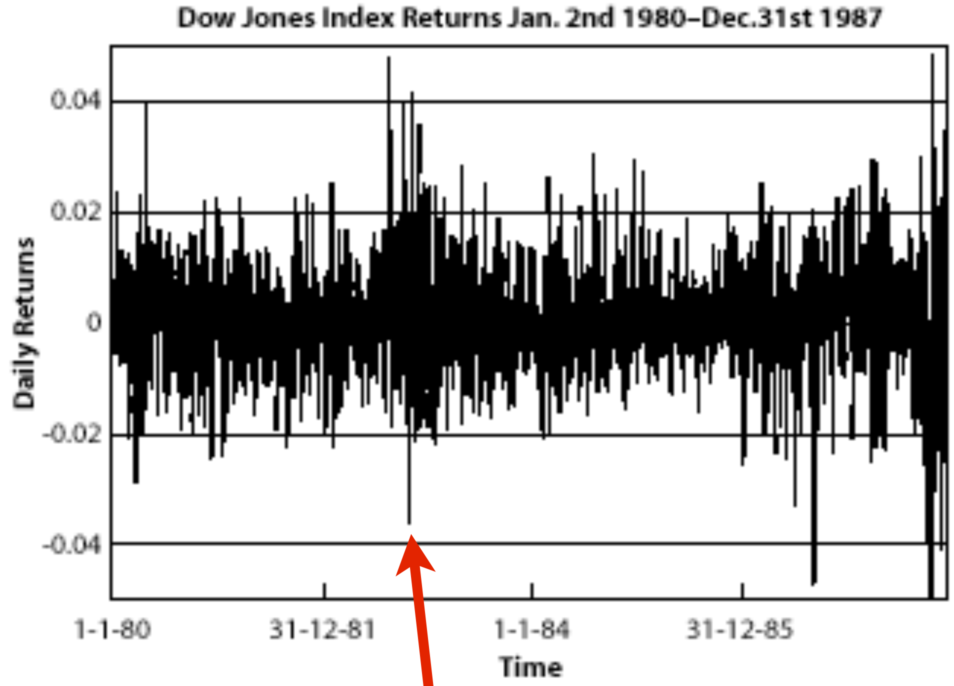
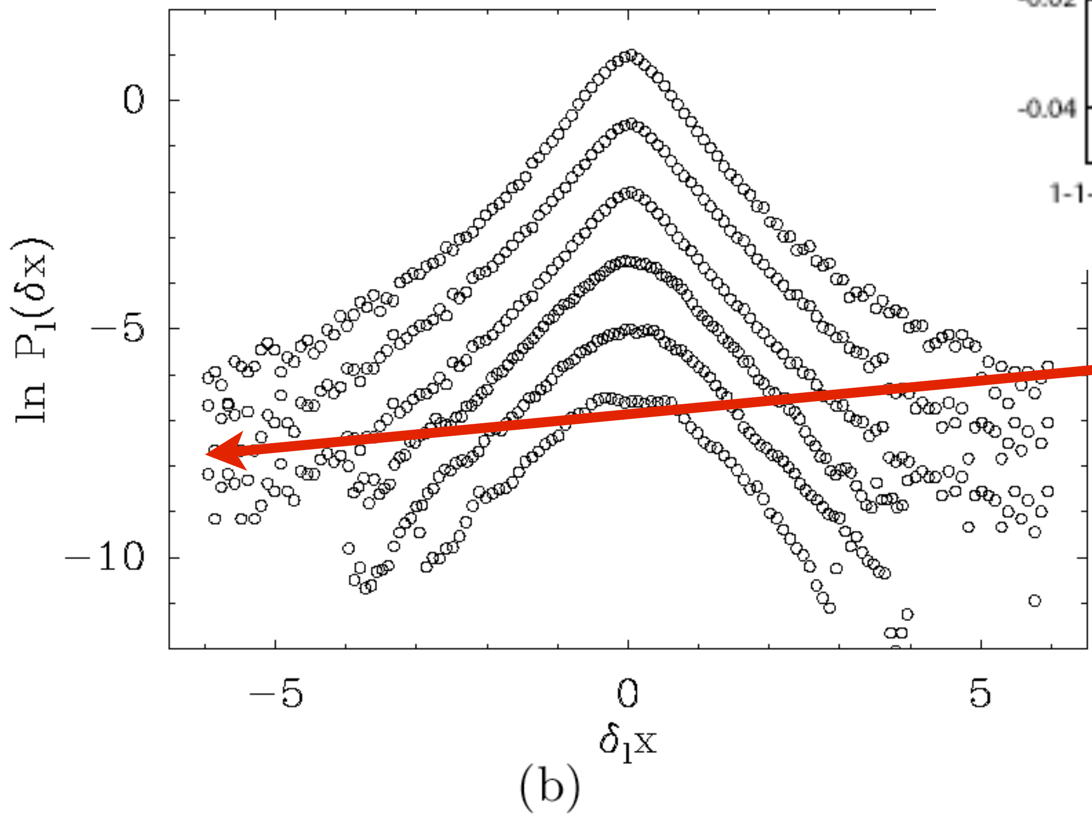
Brain medicine: Epileptic seizures

Geophysics: Characteristic earthquakes? Great avalanches? Floods? Mountain collapses? Meteological events? and so on

Financial crashes as “Black swans”?

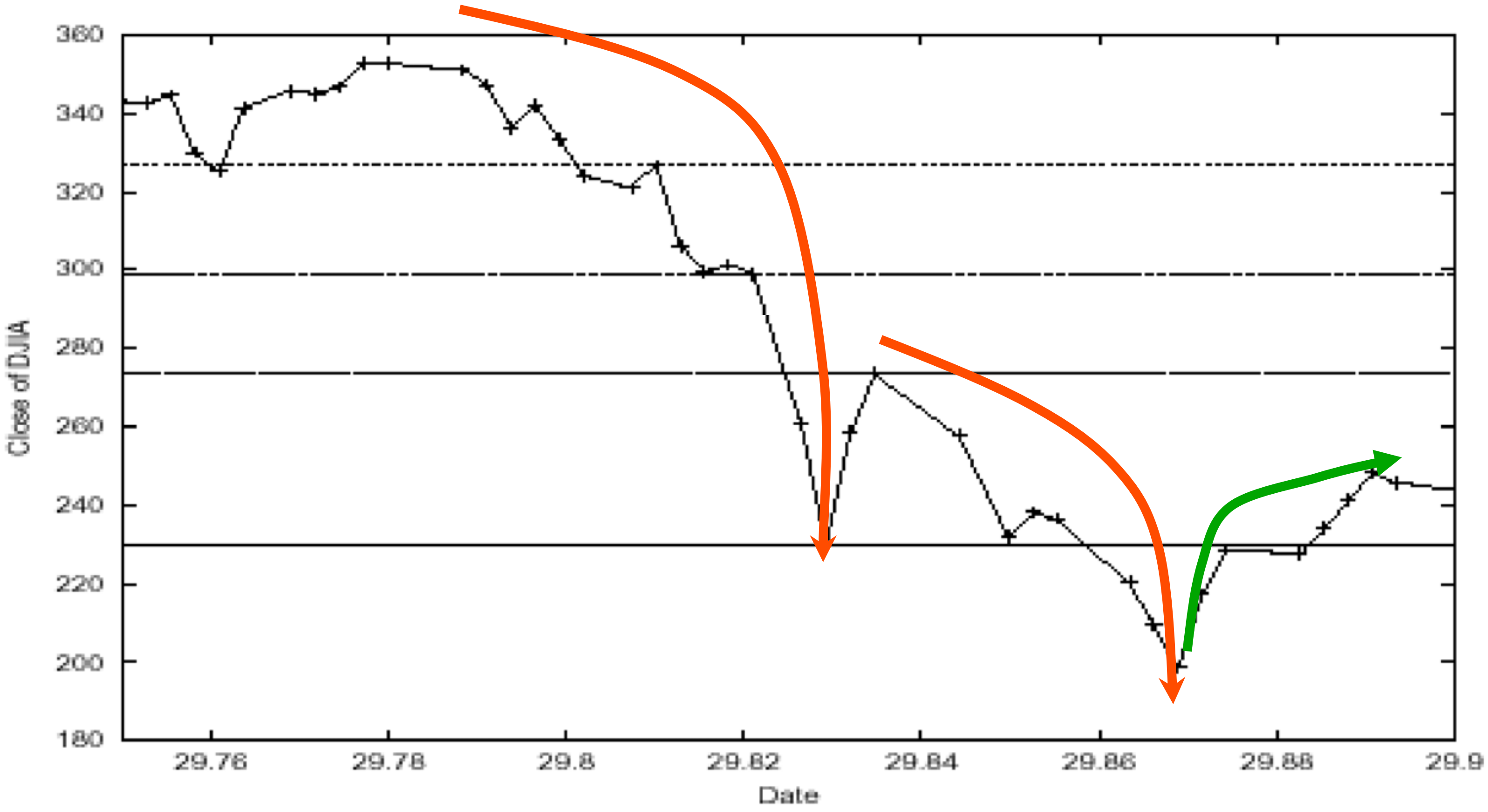


Traditional emphasis on Daily returns do not reveal any anomalous events

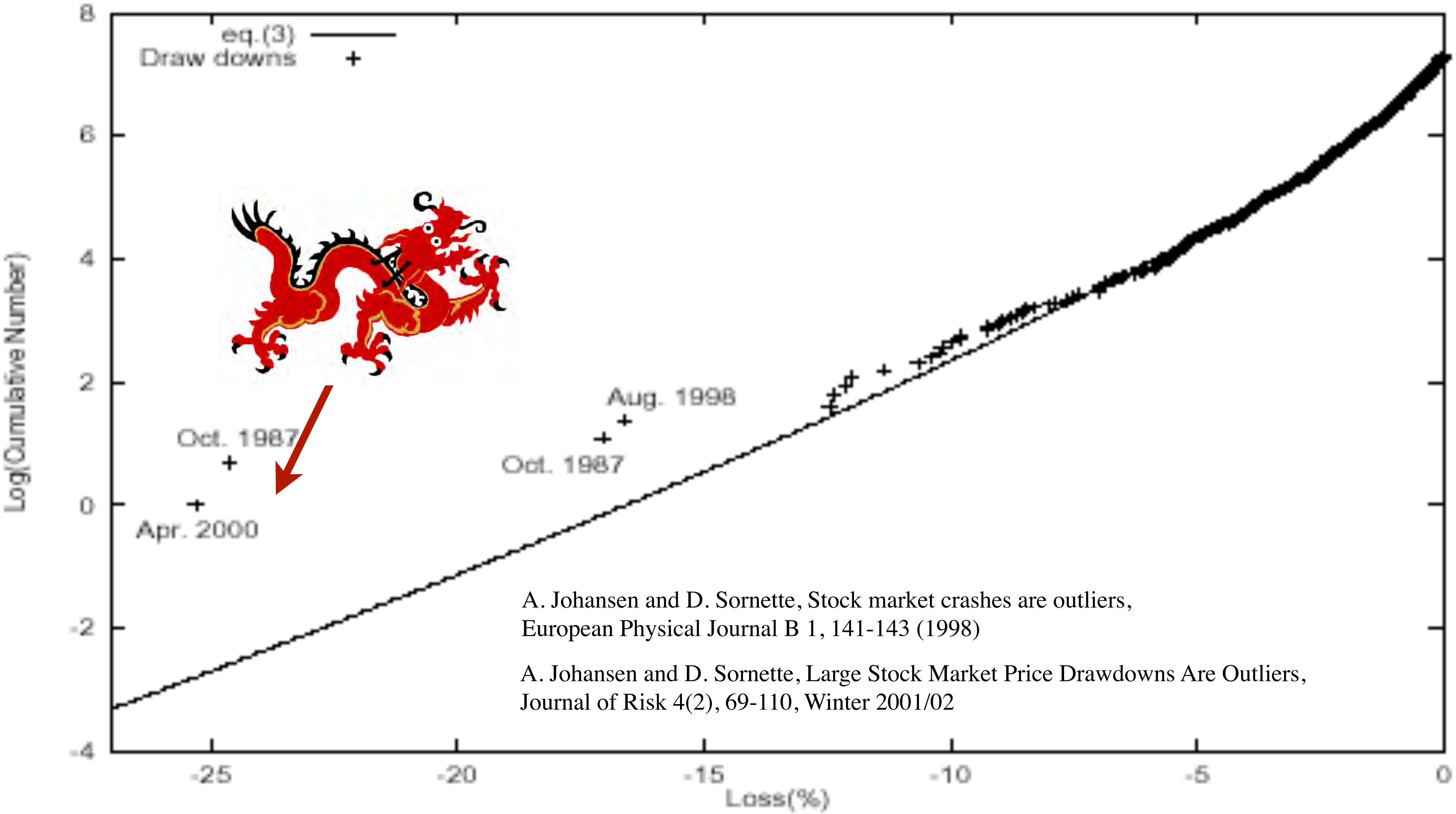


“Black swans”

Better risk measure: drawdowns



“Dragons” of financial risks



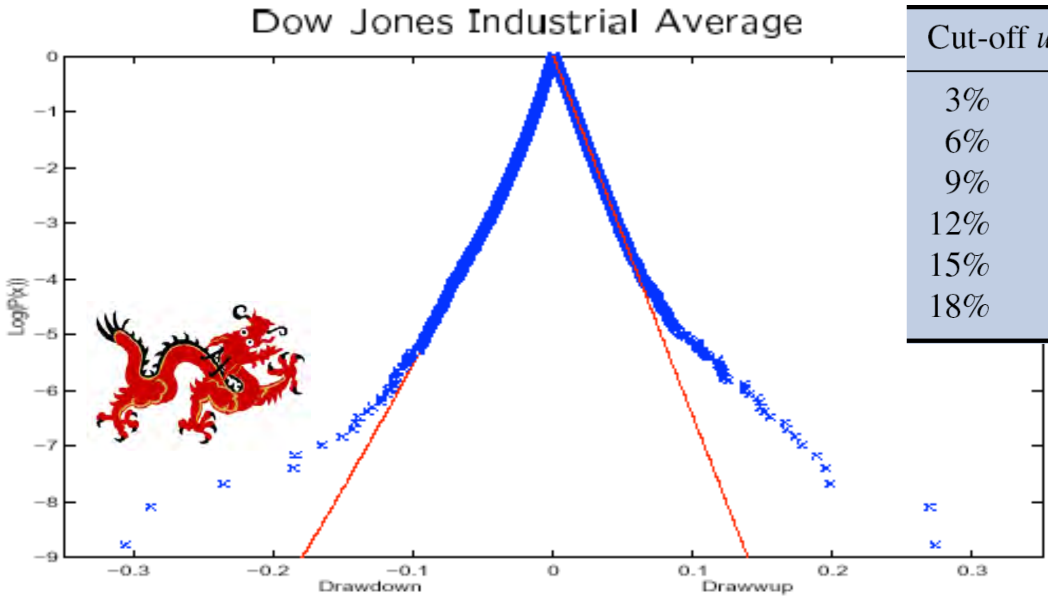
A. Johansen and D. Sornette, Stock market crashes are outliers, European Physical Journal B 1, 141-143 (1998)

A. Johansen and D. Sornette, Large Stock Market Price Drawdowns Are Outliers, Journal of Risk 4(2), 69-110, Winter 2001/02

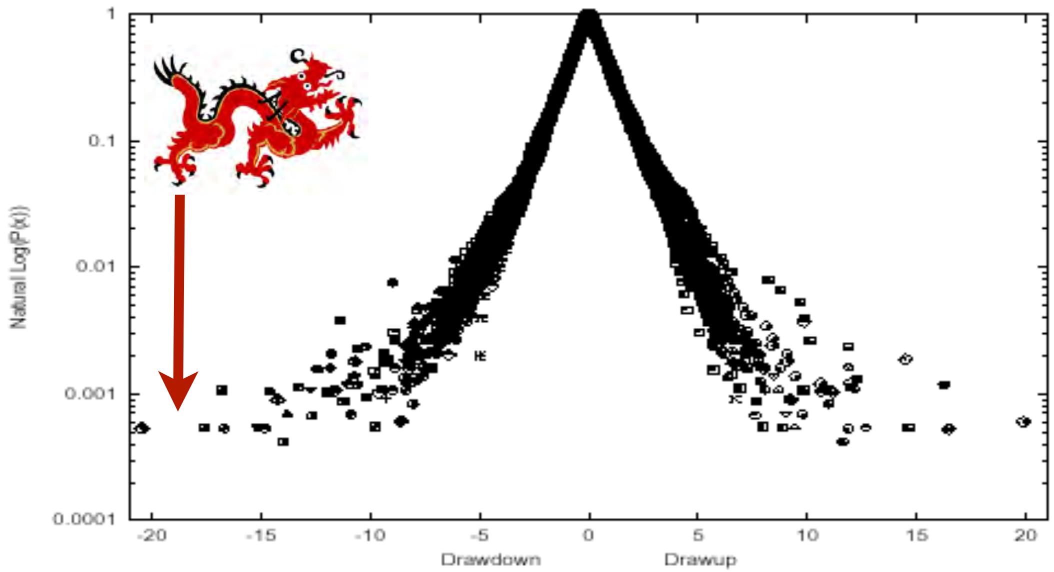
$$N(DD) = A \exp\left(-\left(|DD|/\chi\right)^z\right).$$

"Dragons" of financial risks

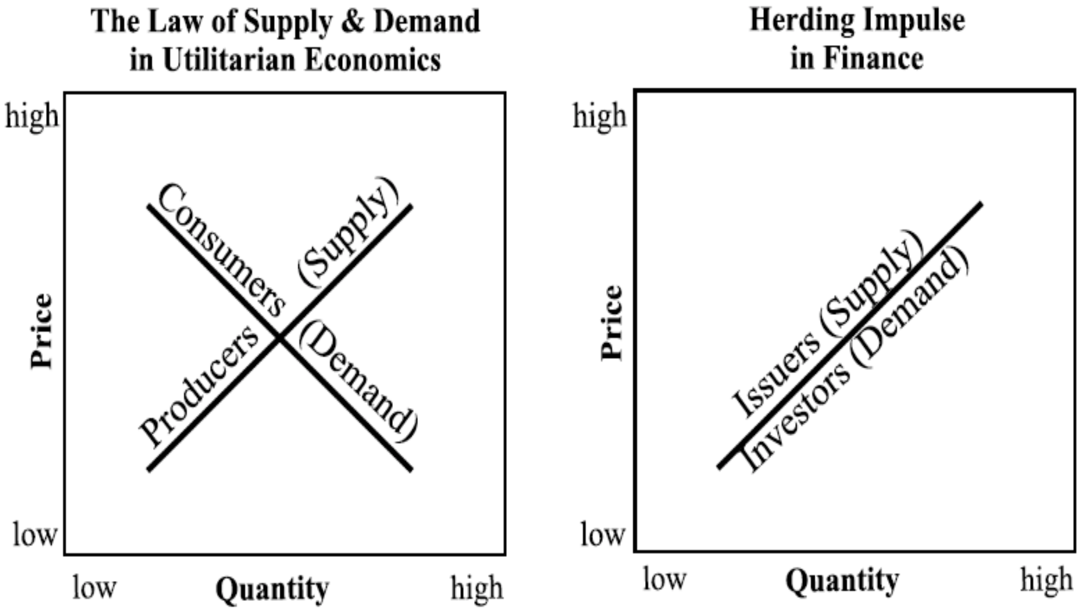
(require special mechanism and may be more predictable)



Cut-off u	Quantile	z	$\ln(L_0)$	$\ln(L_1)$	T	Proba
3%	87%	0.916, 0.940	4890.36	4891.16	1.6	20.5%
6%	97%	0.875, 0.915	4944.36	4947.06	5.4	2.0%
9%	99.0%	0.869, 0.918	4900.75	4903.66	5.8	1.6%
12%	99.7%	0.851, 0.904	4872.47	4877.46	10.0	0.16%
15%	99.7%	0.843, 0.898	4854.97	4860.77	11.6	0.07%
18%	99.9%	0.836, 0.890	4845.16	4851.94	13.6	0.02%



Positive feedbacks



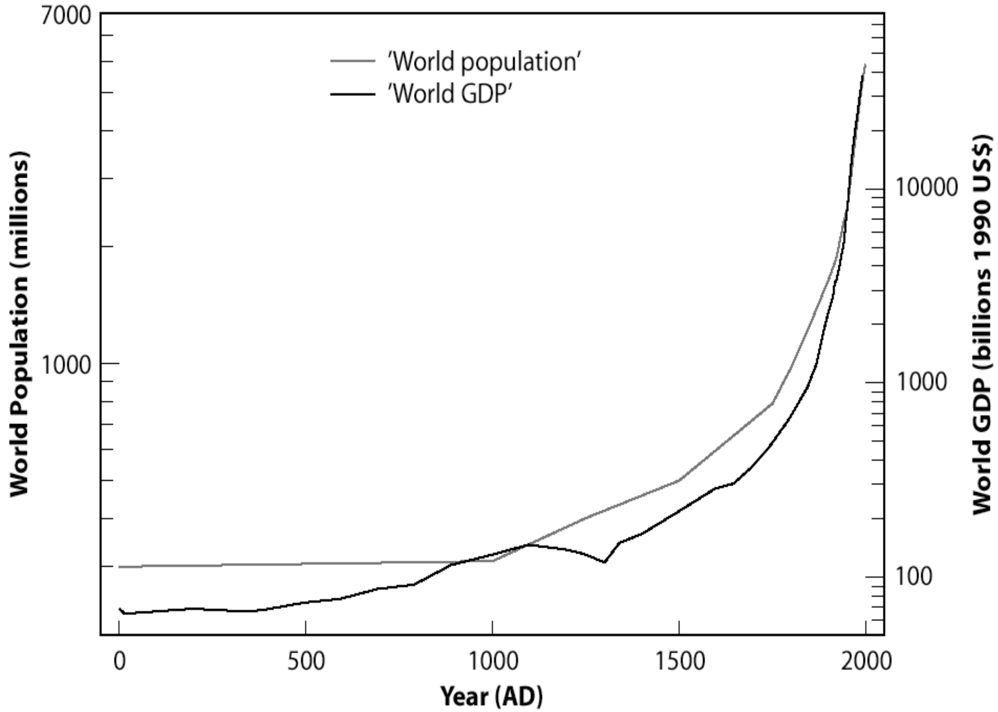
© 2003 Robert R. Prechter, The Socionomics Institute

-bubble phase
-crash phase

$$\frac{dp}{dt} = cp^d$$

$$p(t) = \left(\frac{c}{m}\right)^{-m} (t_c - t)^{-m}$$

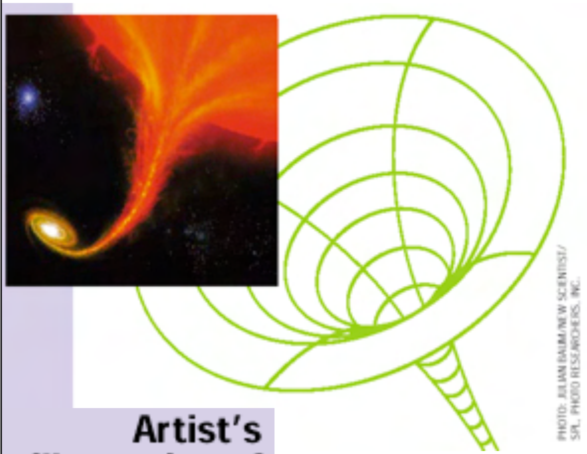
$$m = 1/(d-1) > 0 \text{ and } t_c = t_0 + mp_0^{1-d}/c.$$



Bubble preparing a crisis:
Faster than exponential
transient unsustainable
growth of price

Finite-time Singularity

as a result of positive feedbacks



Artist's illustration of matter from a red giant star being pulled toward a black hole.

- Planet formation in solar system by run-away accretion of planetesimals
- PDE's: Euler equations of inviscid fluids and relationship with turbulence
- PDE's of General Relativity coupled to a mass field leading to the formation of black holes
- Zakharov-equation of beam-driven Langmuir turbulence in plasma
- rupture and material failure
- Earthquakes (ex: slip-velocity Ruina-Dieterich friction law and accelerating creep)
- Models of micro-organisms chemotaxis, aggregating to form fruiting bodies
- Surface instability spikes (Mullins-Sekerka), jets from a singular surface, fluid drop snap-off
- Euler's disk (rotating coin)
- Stock market crashes...

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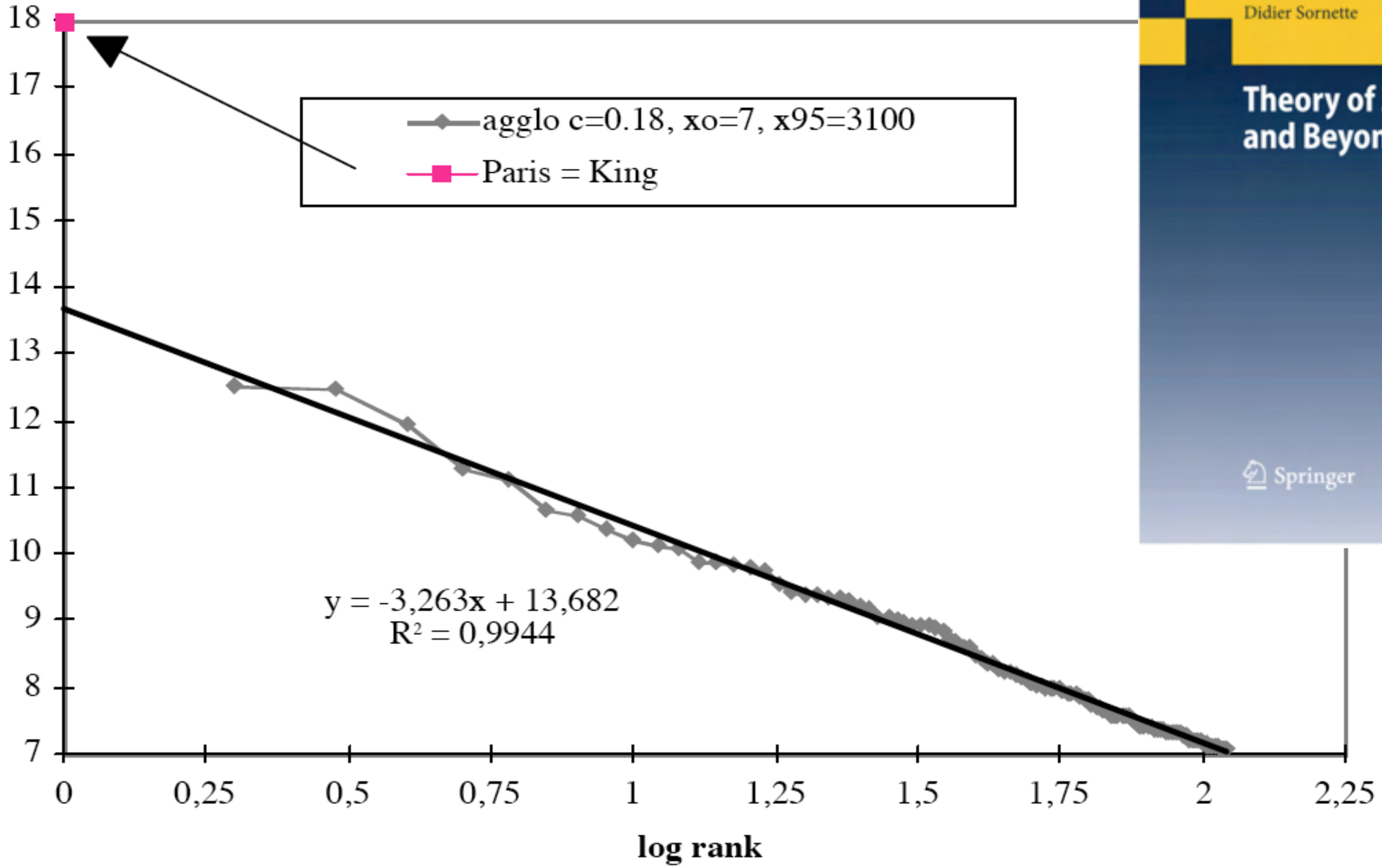
Paris as a king-dragon



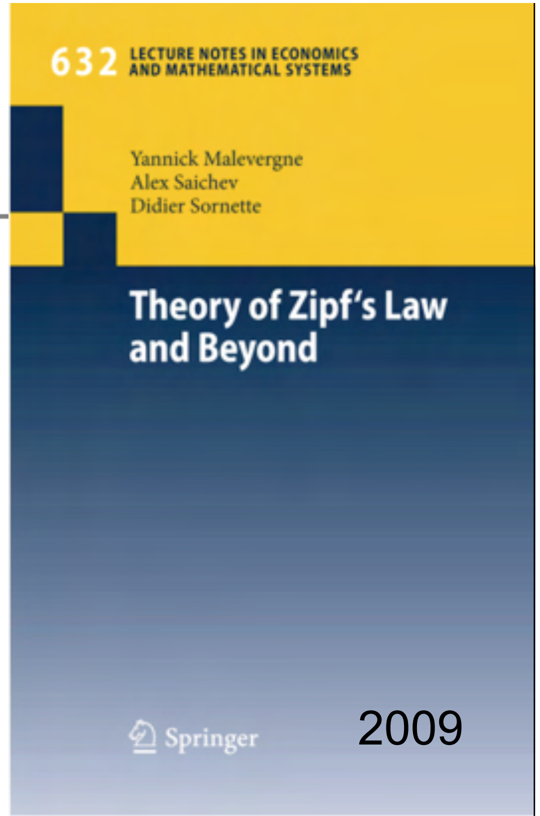


Fig. 7. French agglomerations: stretched exponential and "King effect".

Jean Laherrere and Didier Sornette, Stretched exponential distributions in Nature and Economy: ``Fat tails'' with characteristic scales, European Physical Journal B 2, 525-539 (1998)

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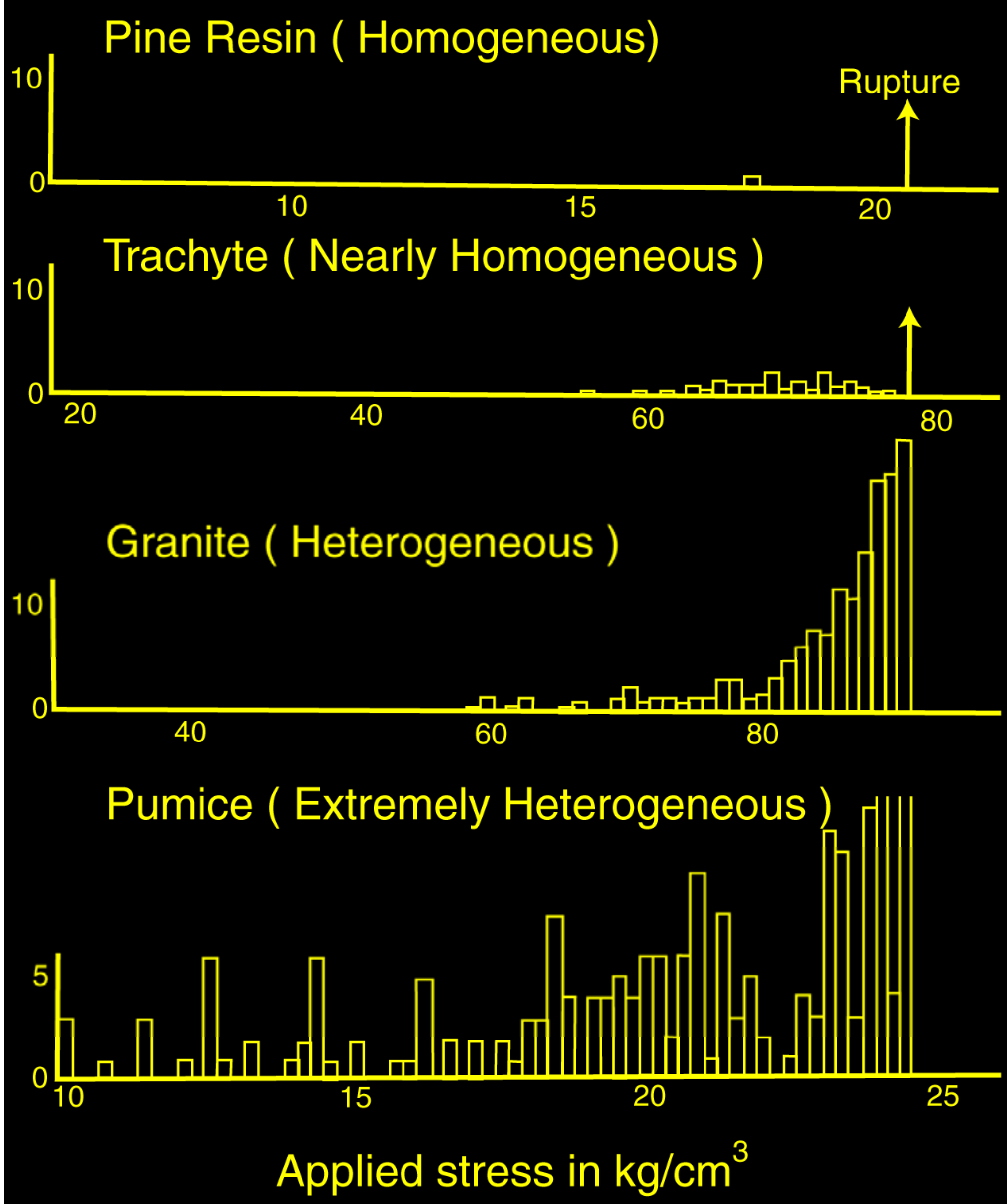
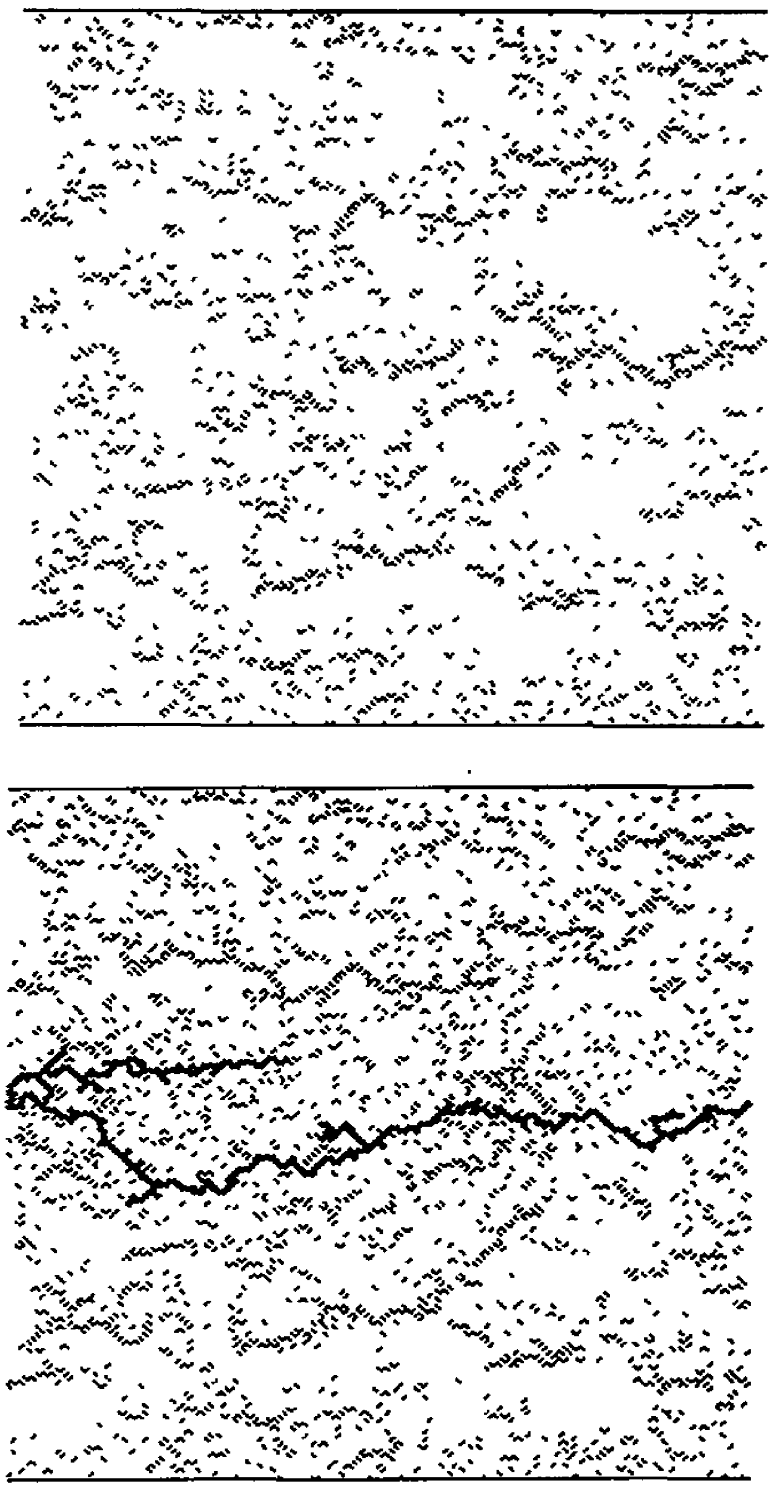
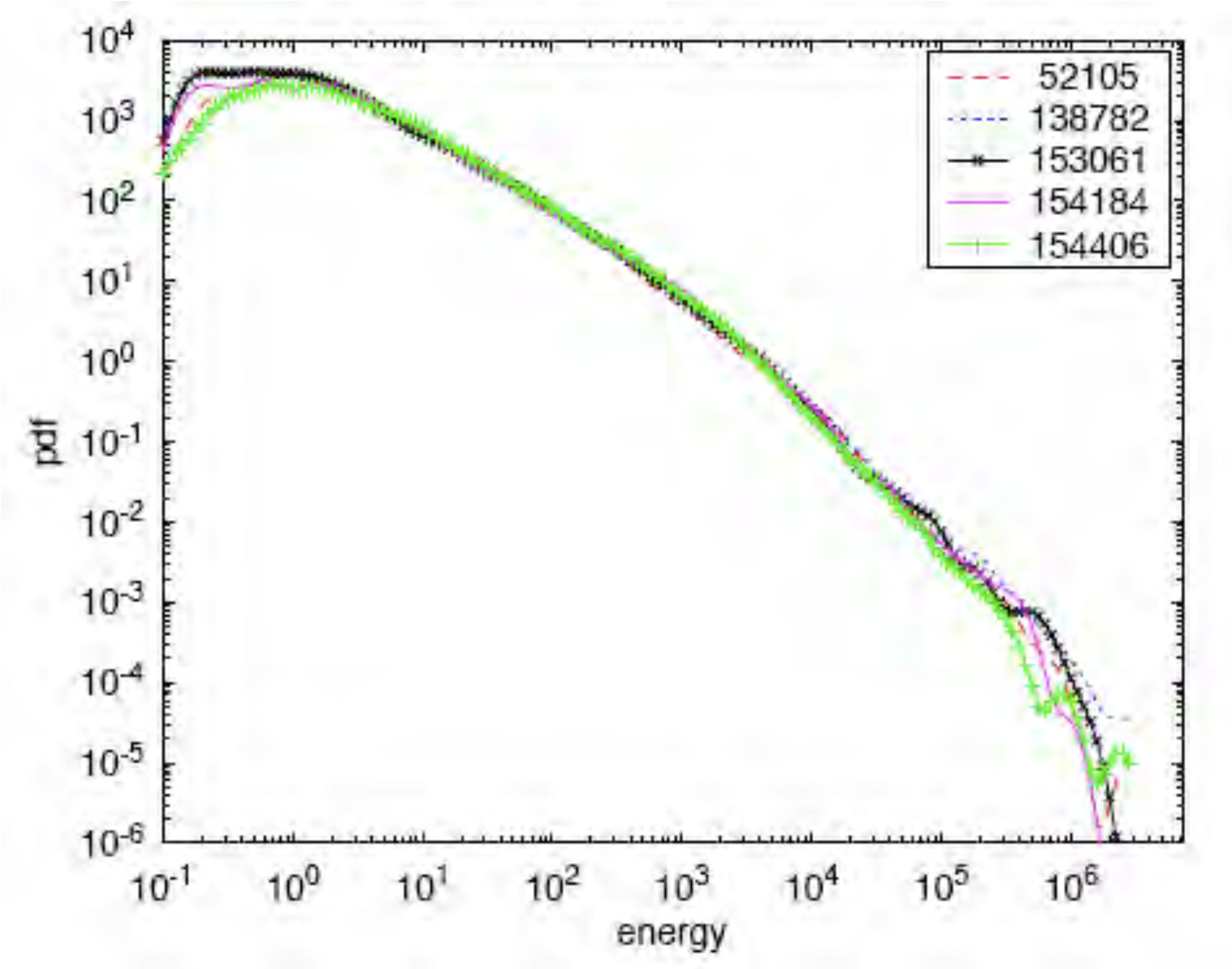


Fig. 4. Frequency of elastic shocks under increasing stresses in materials with different heterogeneity. From Mogi [1962]





H. Nechad, A. Helmstetter, R. El Guerjouma and D. Sornette, Andrade and Critical Time-to-Failure Laws in Fiber-Matrix Composites: Experiments and Model, Journal of Mechanics and Physics of Solids (JMPS) 53, 1099-1127 (2005)

• • •

Energy distribution for the [+-62] specimen #4 at different times, for 5 time windows with 3400 events each. The average time (in seconds) of events in each window is given in the caption.

time-to-failure analysis

S.G. Sammis and D. Sornette, Positive Feedback, Memory and the Predictability of Earthquakes, Proceedings of the National Academy of Sciences USA, V99 SUPP1:2501-2508 (2002 FEB 19)

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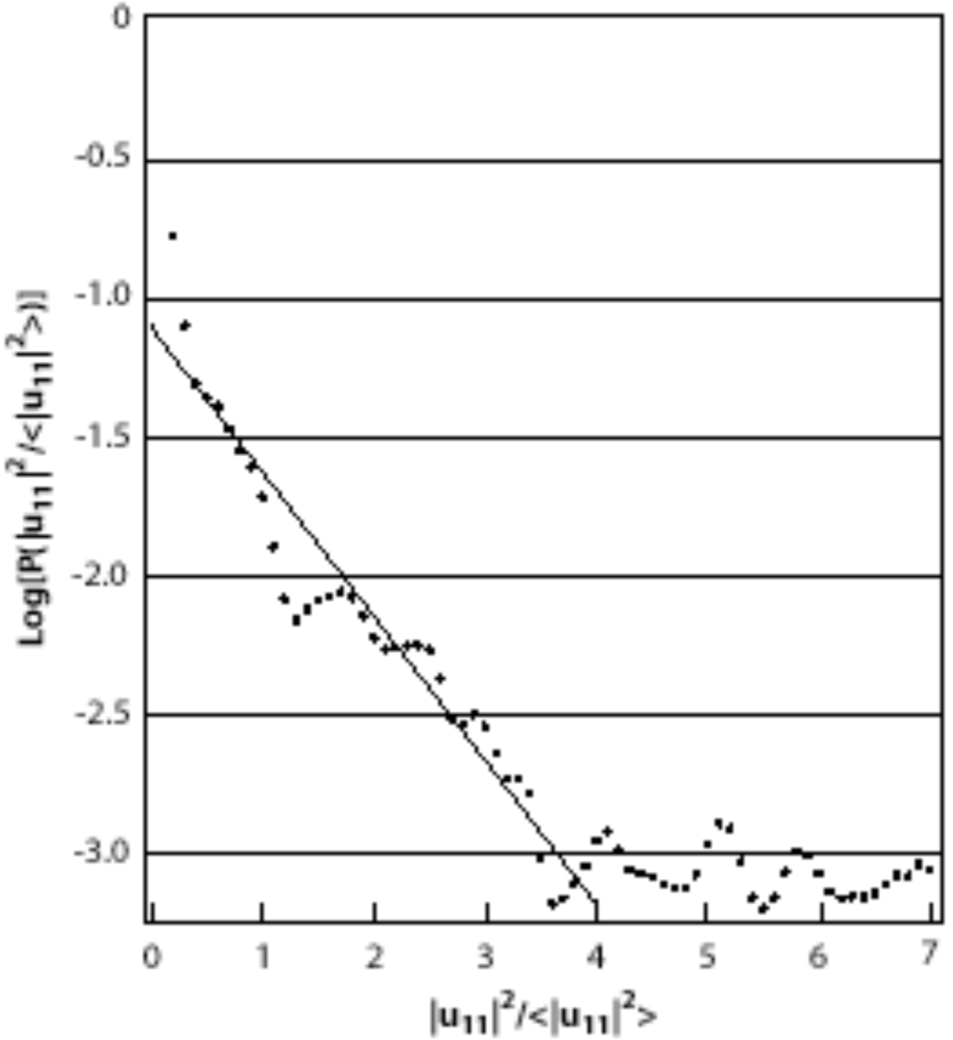
Mathematical Geophysics Conference

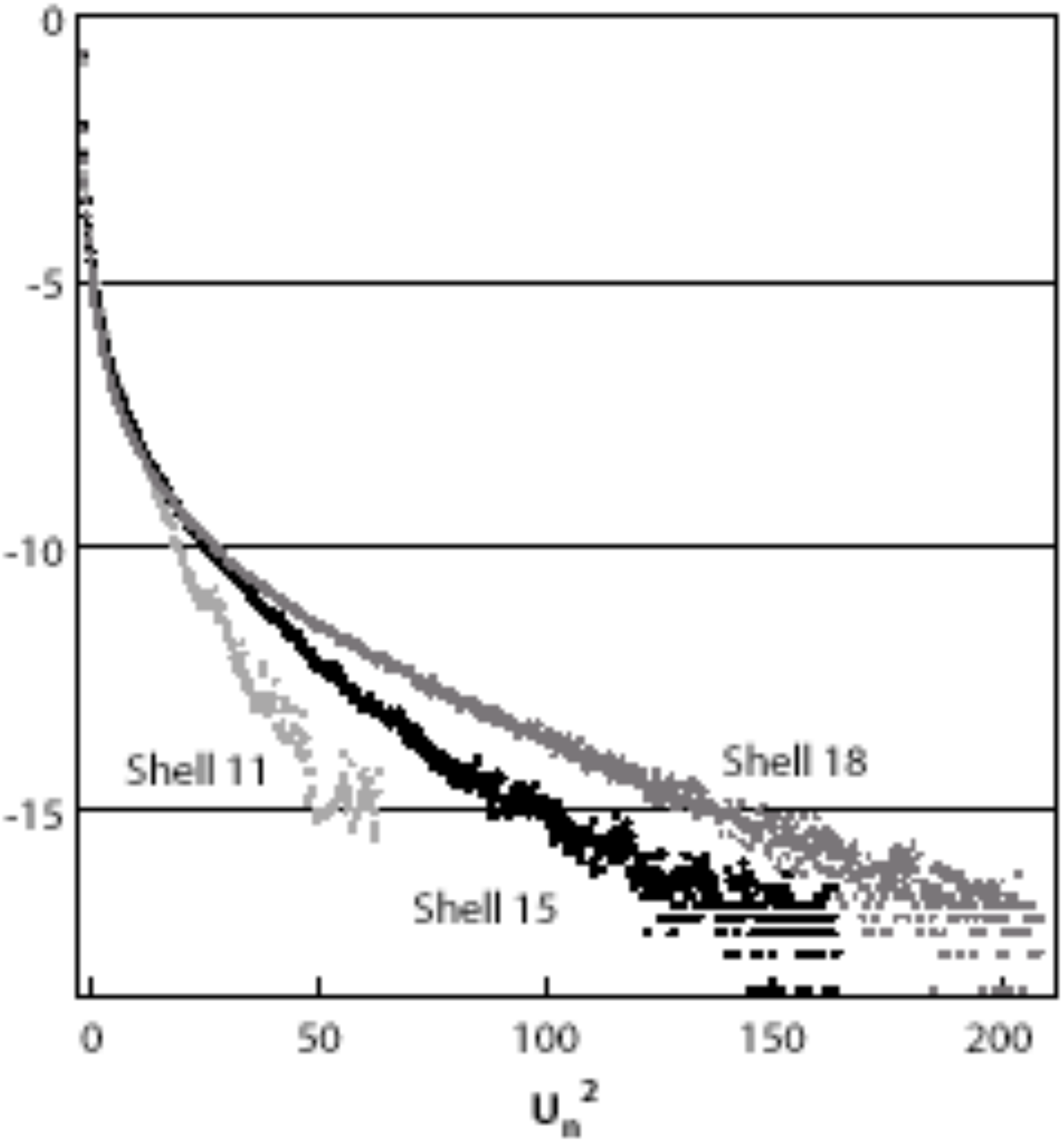
Extreme Earth Events

Villefranche-sur-Mer, 18-23 June 2000



L'vov, V.S., Pomyalov, A. and Procaccia, I. (2001) Outliers, Extreme Events and Multiscaling, Physical Review E 6305 (5), 6118, U158-U166.

FIG. 3.2. Apparent probability distribution function of the square of the fluid velocity, normalized to its time average, in the eleventh shell of the toy model of hydrodynamic turbulence discussed in the text. The vertical axis is in logarithmic scale such that the straight line, which helps the eye, qualifies as an apparent exponential distribution. Note the appearance of extremely sparse and large bursts of velocities at the extreme right above the extrapolation of the straight line. Reproduced from [252].



Pdf of the square of the Velocity as in the previous figure but for a much longer time series, so that the tail of the distributions for large Fluctuations is much better constrained. The hypothesis that there are no outliers is tested here by collapsing the distributions for the three shown layers. While this is a success for small fluctuations, the tails of the distributions for large events are very different, indicating that extreme fluctuations belong to a different class of their own and hence are outliers.

L'vov, V.S., Pomyalov, A. and Procaccia, I. (2001) Outliers, Extreme Events and Multiscaling, Physical Review E 6305 (5), 6118, U158-U166.

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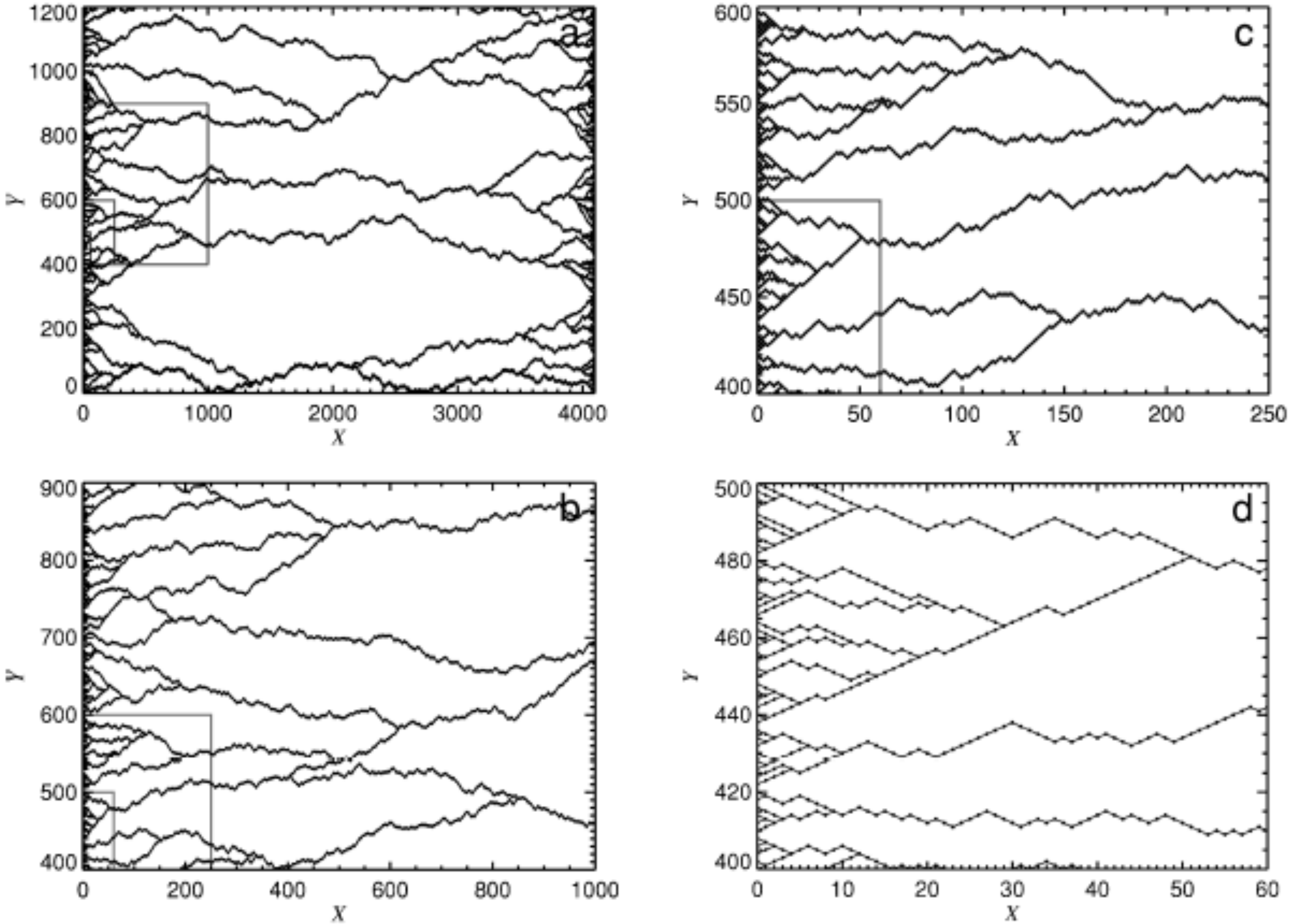
Metastable states in random media

Self-organized critical random directed polymers



P. Jogi and D. Sornette, Self-organized critical random directed polymers, Phys. Rev. E 57, 6931-6943 (1998)

FIG. 1. Typical set of optimal configurations for a RDP of length $W=4096$ and for $0 \leq y \leq 1200$: (a) global system [gray framed boxes outline regions of succeeding plots such that the horizontal and vertical extensions of these boxes follow Eqs. (10) and (8) with $\alpha \approx 0.9$], (b) magnification of the largest box in (a), (c) magnification of the largest box in (b) and (d) magnification of the box in (c). Note, that at each grid point of the lattice we assign an independent random number drawn from an exponential distribution with unit mean and variance.

Definition of "avalanches"

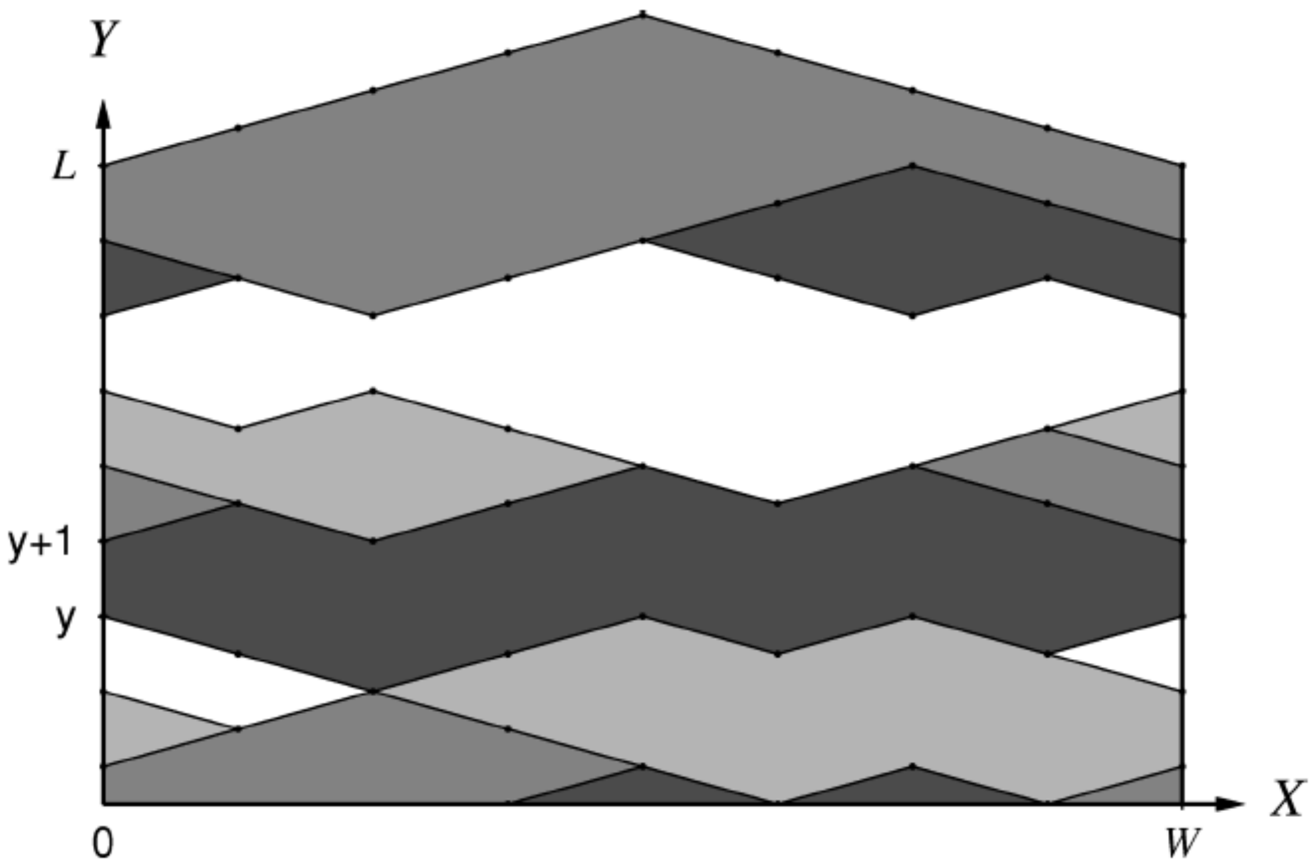


FIG. 2. Schematic representation of optimal RDPs fixed at their two end points. An avalanche is defined by the area S spanned by the transition from the optimal configuration at y to $y+1$, i.e., S is the area interior to the perimeter formed by the union of the two optimal RDP configurations at y and $y+1$ and the two vertical segments $((0,y);(0,y+1))$ and $((W,y);(W,y+1))$. The successive avalanches are represented in different gray scales.

$$P(S)dS \propto \frac{W^{2/3}}{S^{1+\mu}} dS,$$

$$\mu = 2/5.$$

+ characteristic avalanche scale ~ $W^{5/3}$

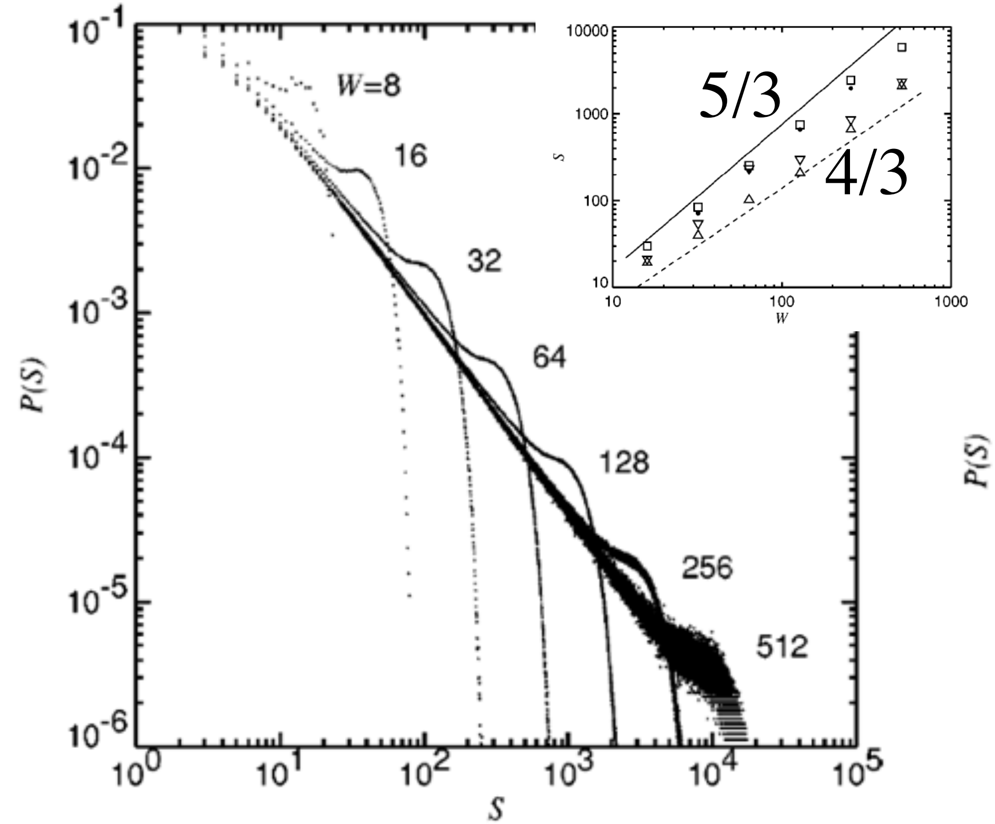


FIG. 3. Distribution $P(S)$ of RDP avalanche sizes obtained numerically for system widths from $W=8$ to 512 on a log-log plot. Here the system lengths L are 2×10^7 (for $W=8$), $3\times10^6(W=16)$, $2\times10^7(W=32)$, $10^8(W=64)$, $2\times10^8(W=128)$, $5\times10^7(W=256)$, and $9\times10^6(W=512)$.

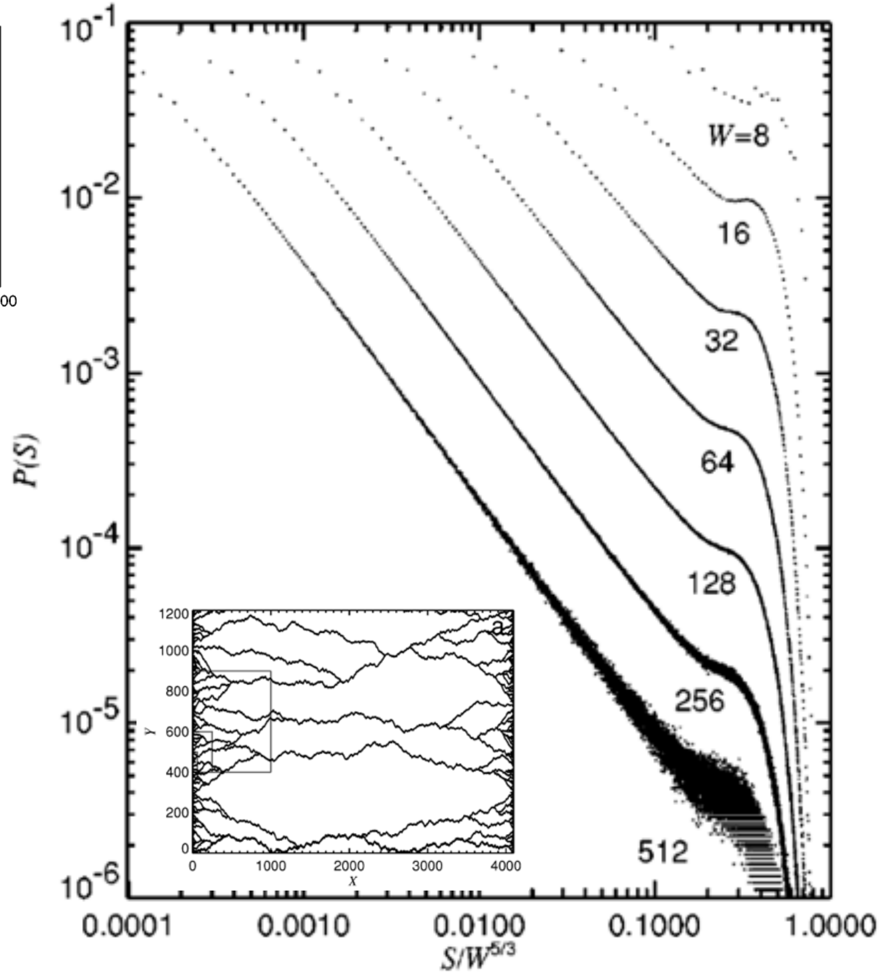


FIG. 4. $P(S)$ as a function of the rescaled variable $S/W^{5/3}$ for $W=8-512$ on a log-log plot.

Beyond power laws: 7 examples of "Dragons"

Financial economics: Outliers and dragons in the distribution of financial drawdowns.

Population geography: Paris as the dragon-king in the Zipf distribution of French city sizes.

Material science: failure and rupture processes.

Hydrodynamics: Extreme dragon events in the pdf of turbulent velocity fluctuations.

Metastable states in random media: Self-organized critical random directed polymers

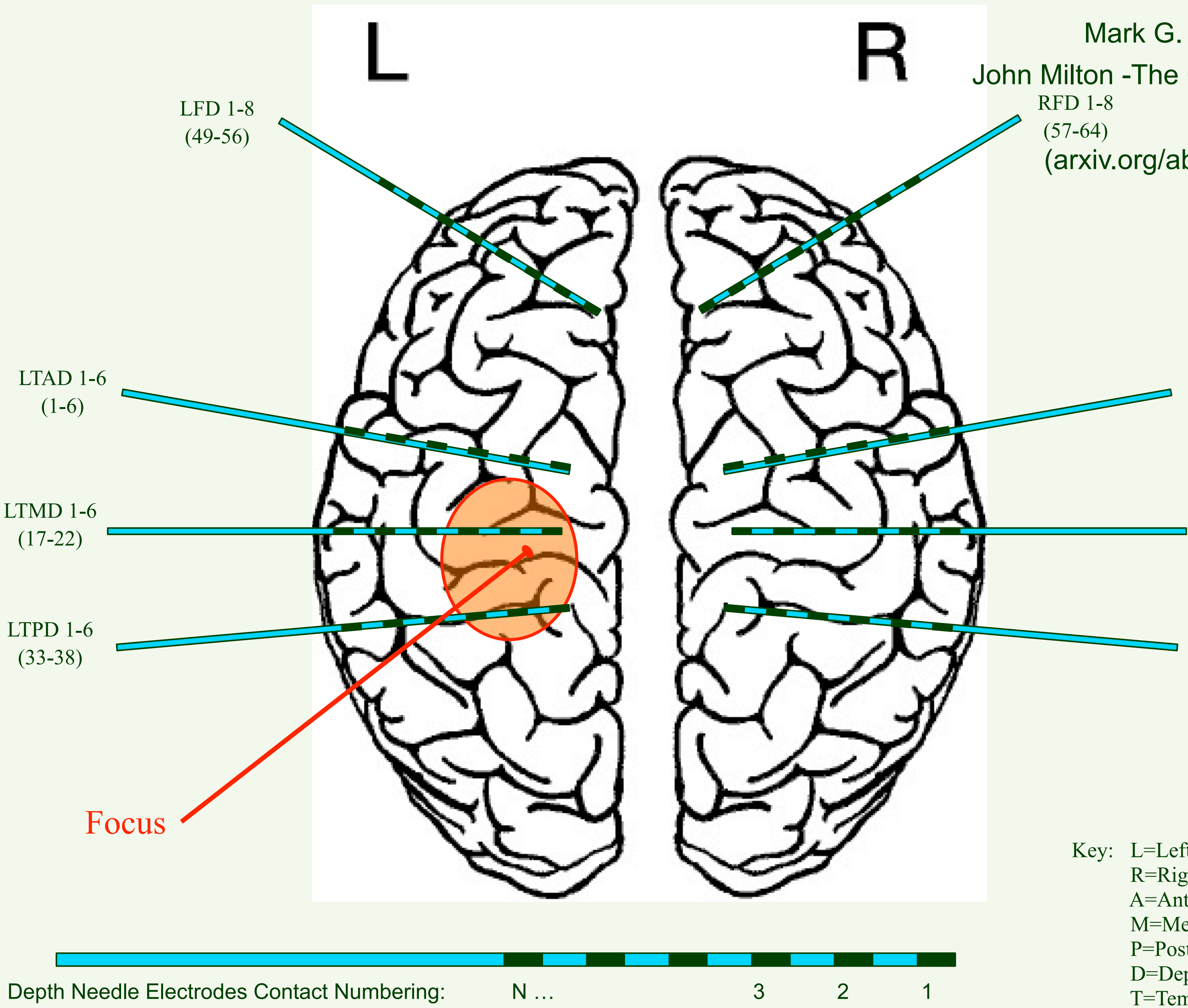
Brain medicine: Epileptic seizures

Geophysics: Gutenberg-Richter law and characteristic earthquakes.

Epileptic Seizures – Quakes of the Brain?

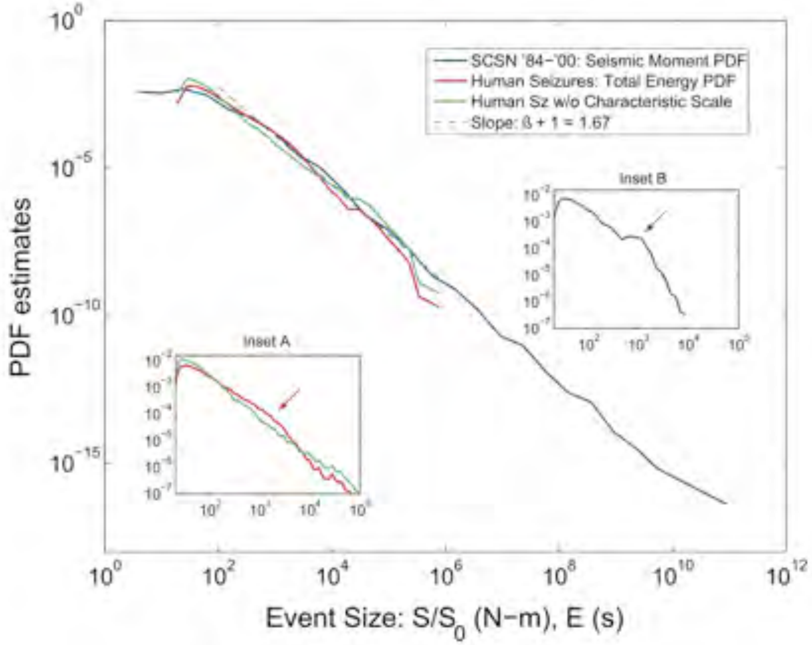
with Ivan Osorio – KUMC & FHS
Mark G. Frei - FHS
John Milton -The Claremont Colleges

(arxiv.org/abs/0712.3929)

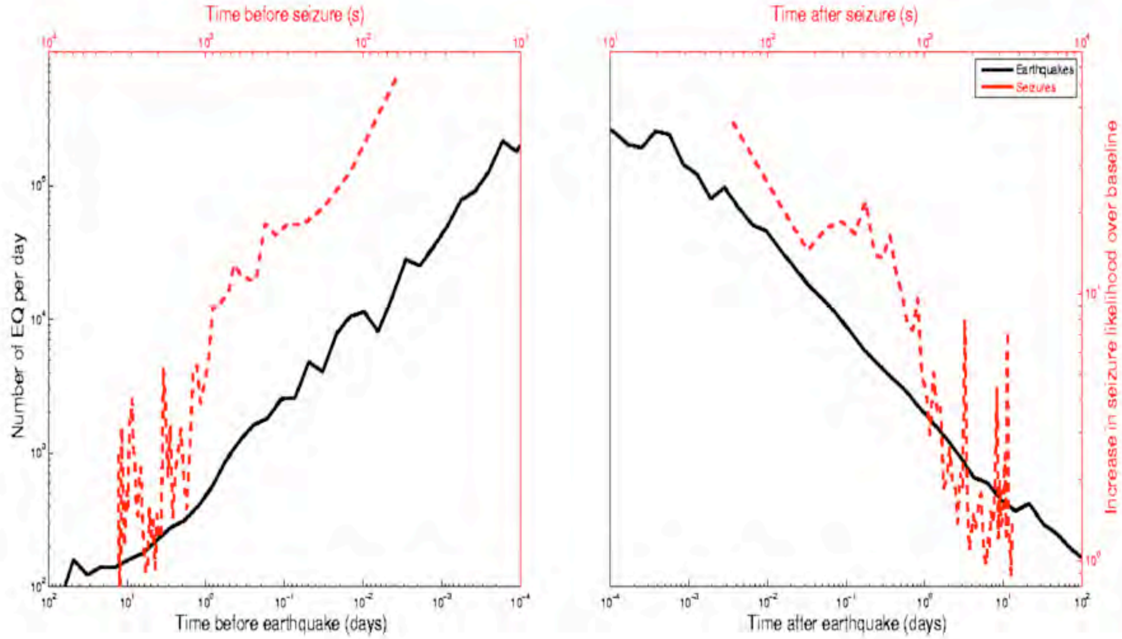


Key: L=Left
R=Right
A=Anterior
M=Mesial
P=Posterior
D=Depth
T=Temporal
F=Frontal

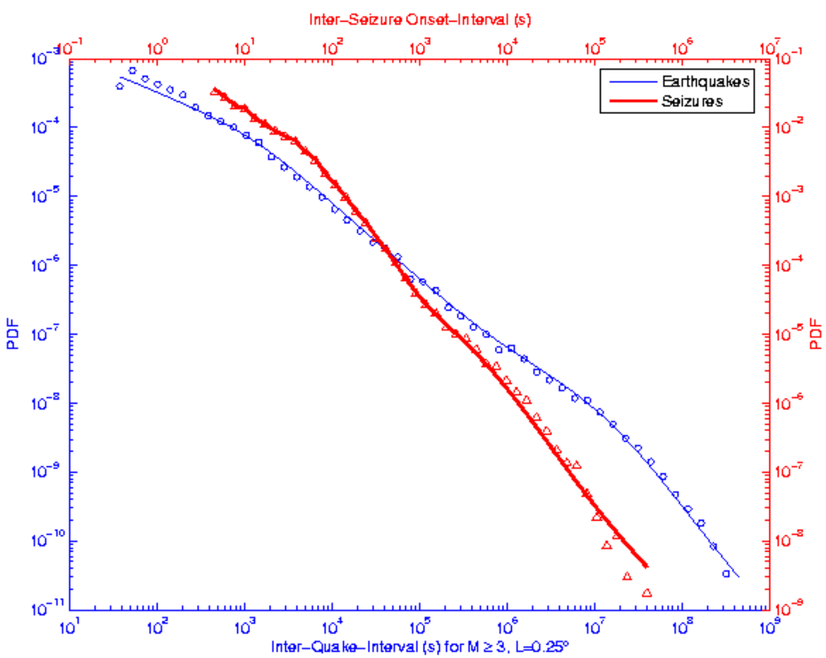
Gutenberg-Richter distribution of sizes



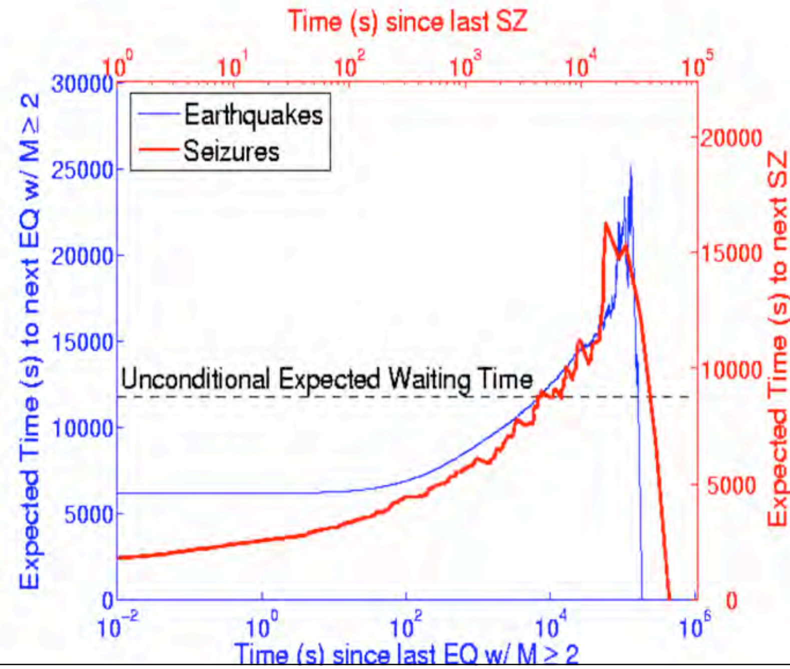
Omori law: Direct and Inverse



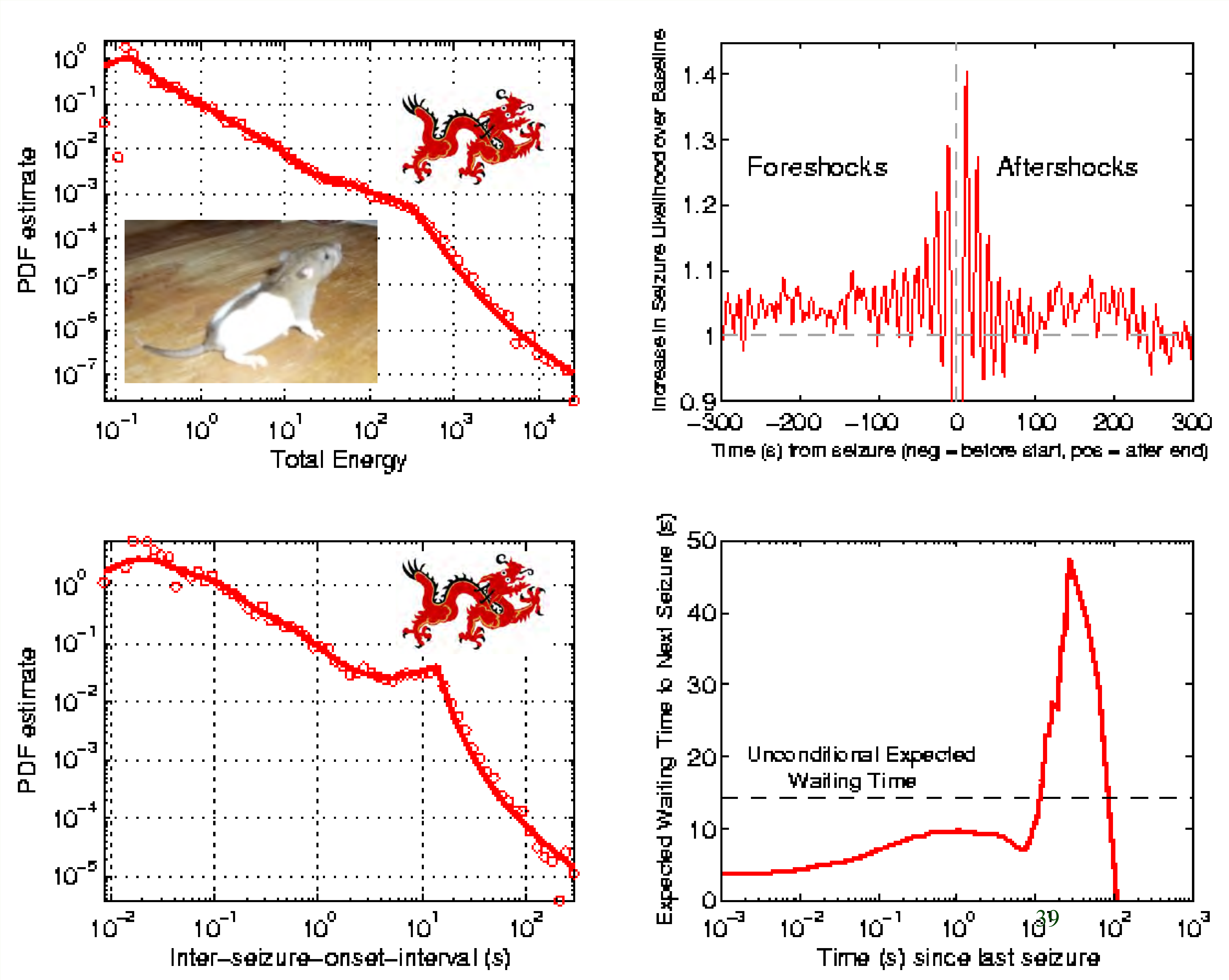
pdf of inter-event waiting times



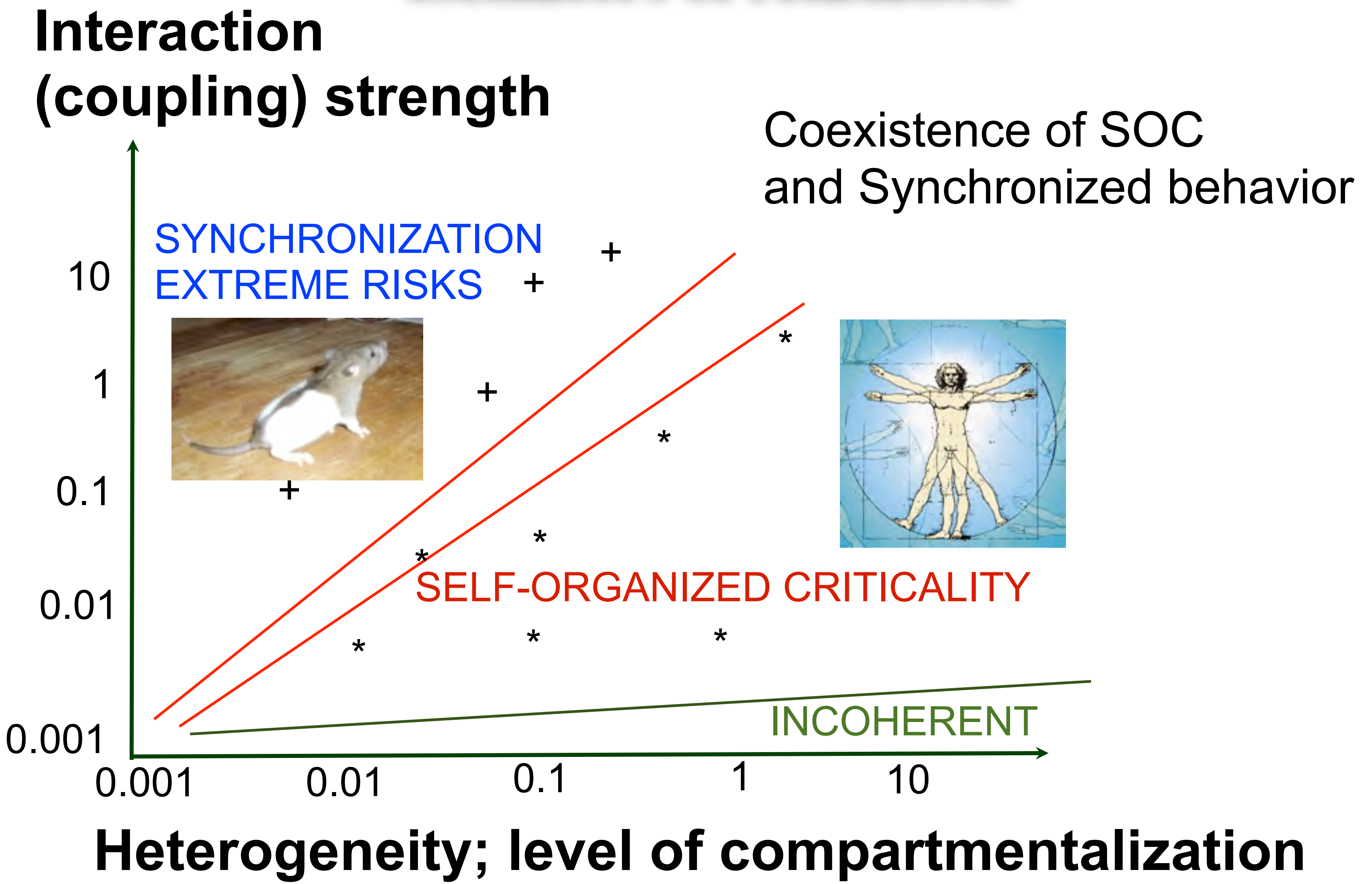
The longer it has been since the last event,
the longer it will be since the next one!



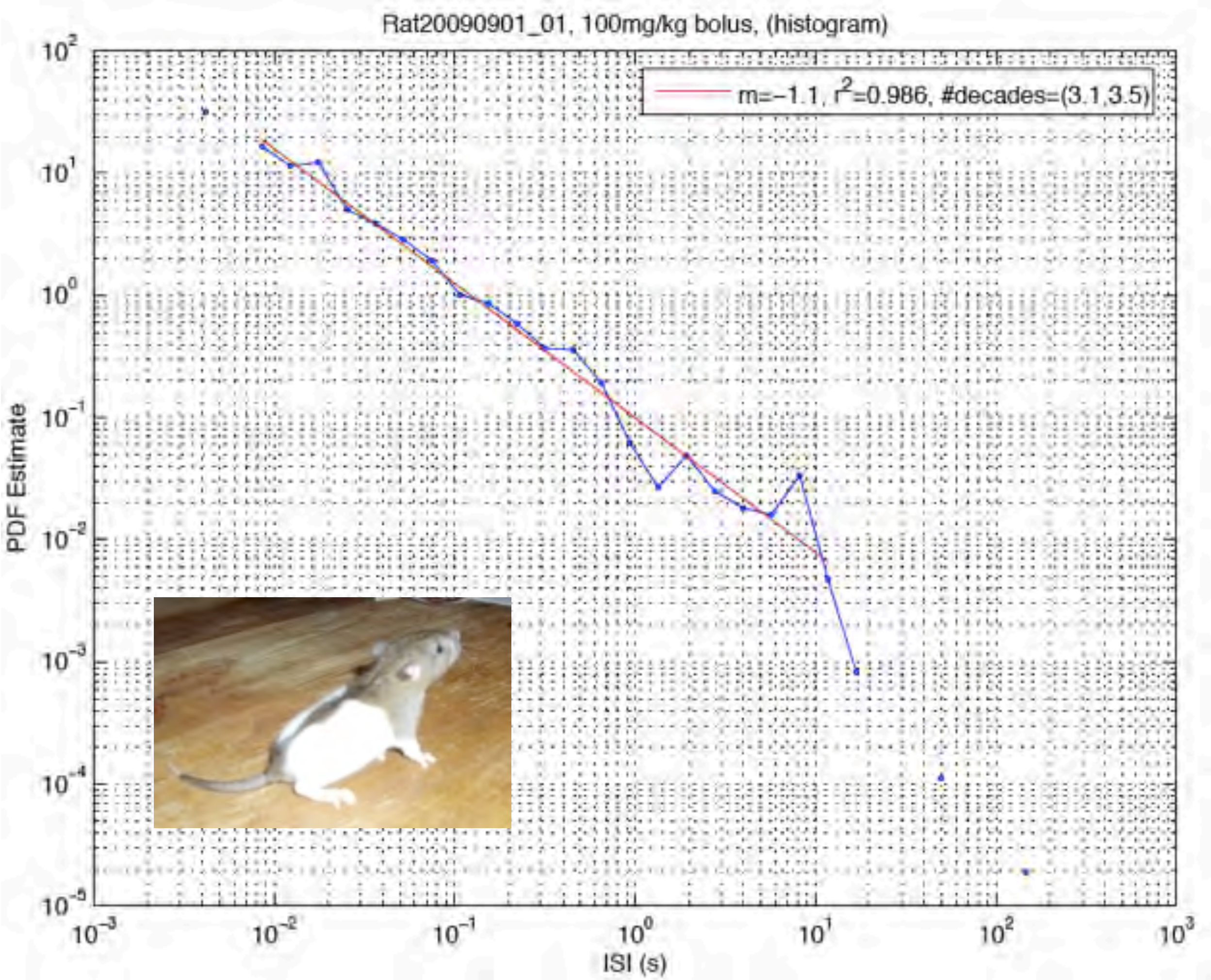
19 rats treated intravenously (2) with the convulsant 3-mercapto-proprionic acid (3-MPA)



Generic diagram for coupled threshold oscillators of relaxation

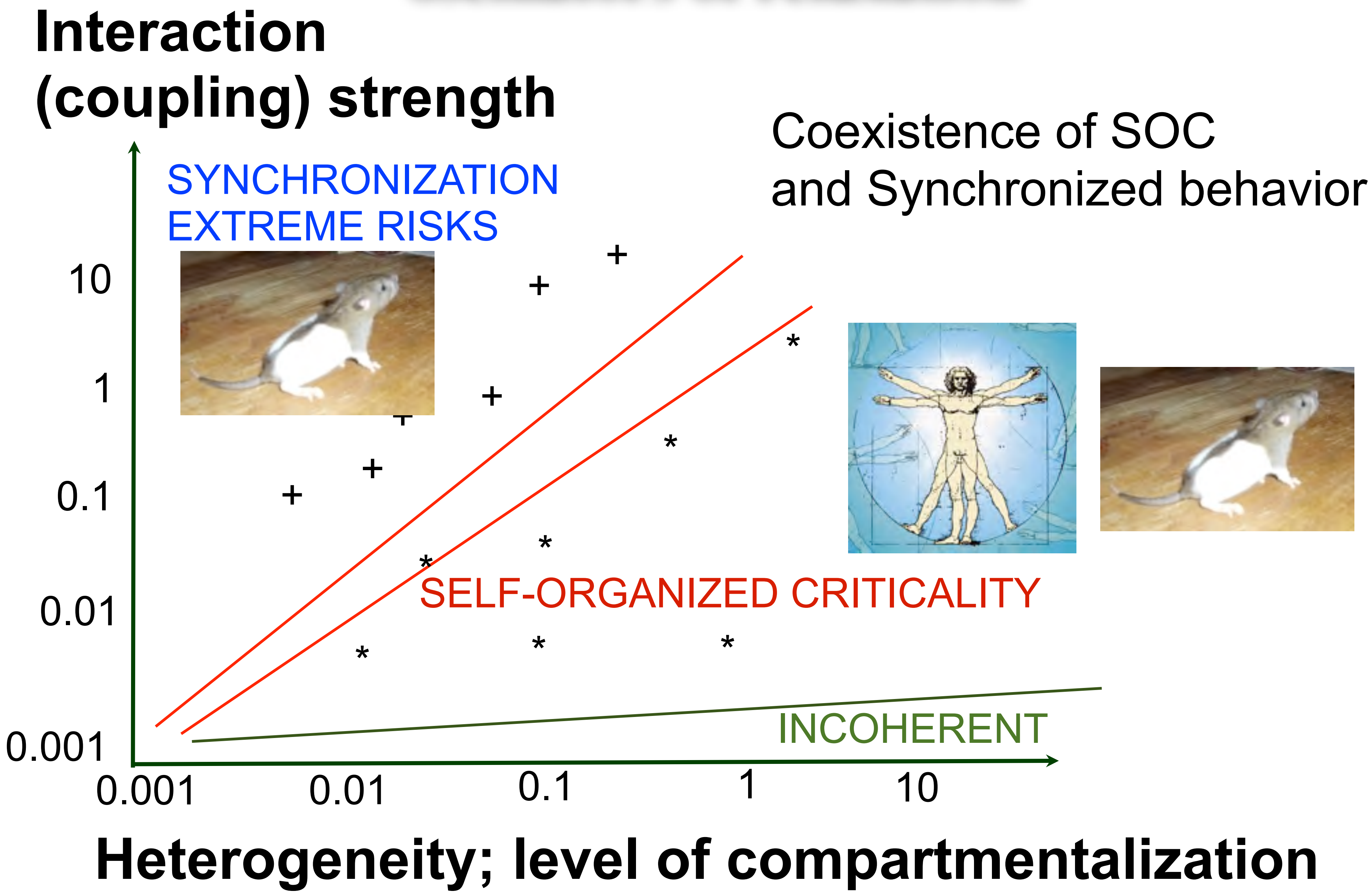


Low dose of convulsant in rats
(like most humans)

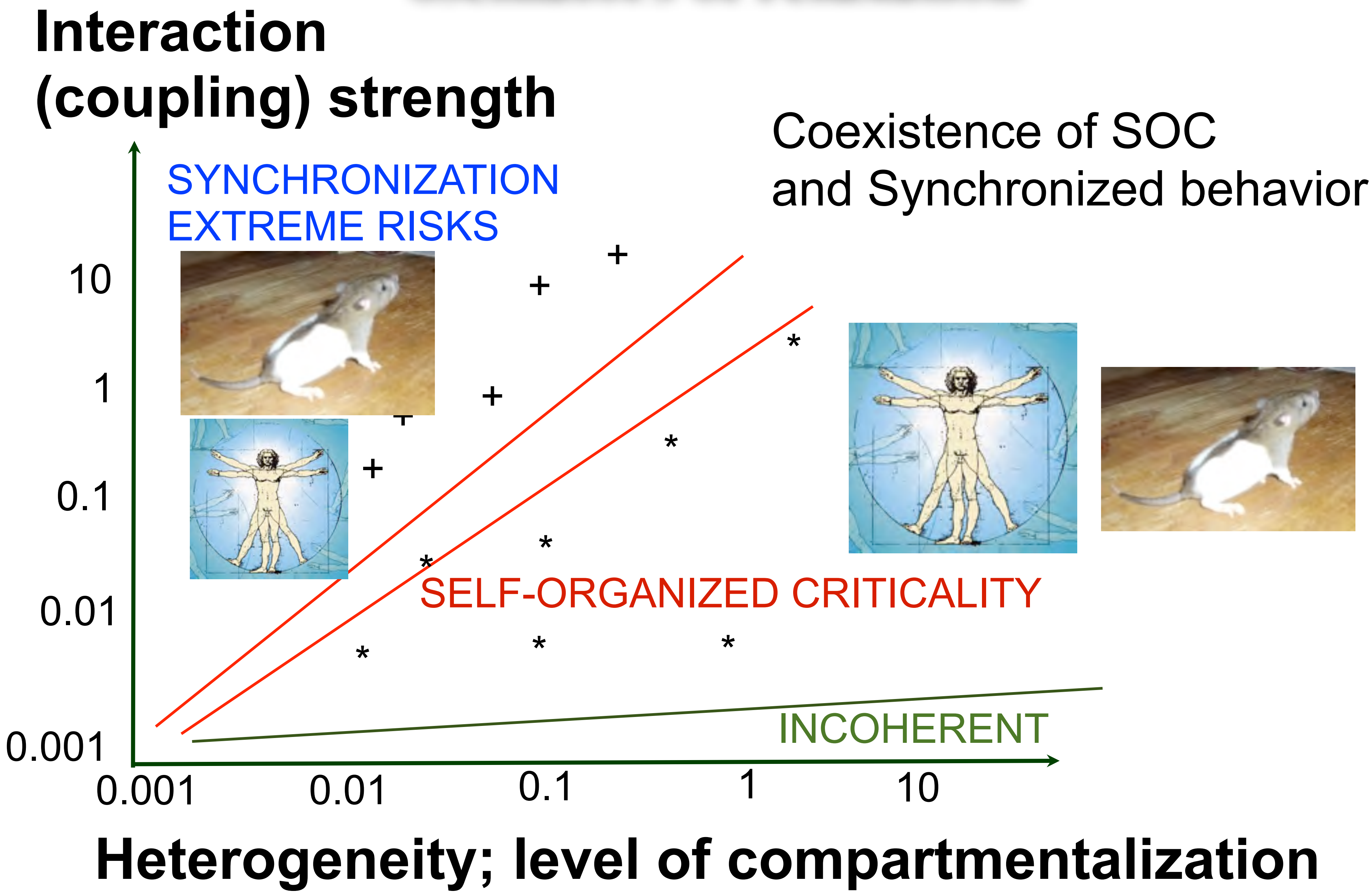


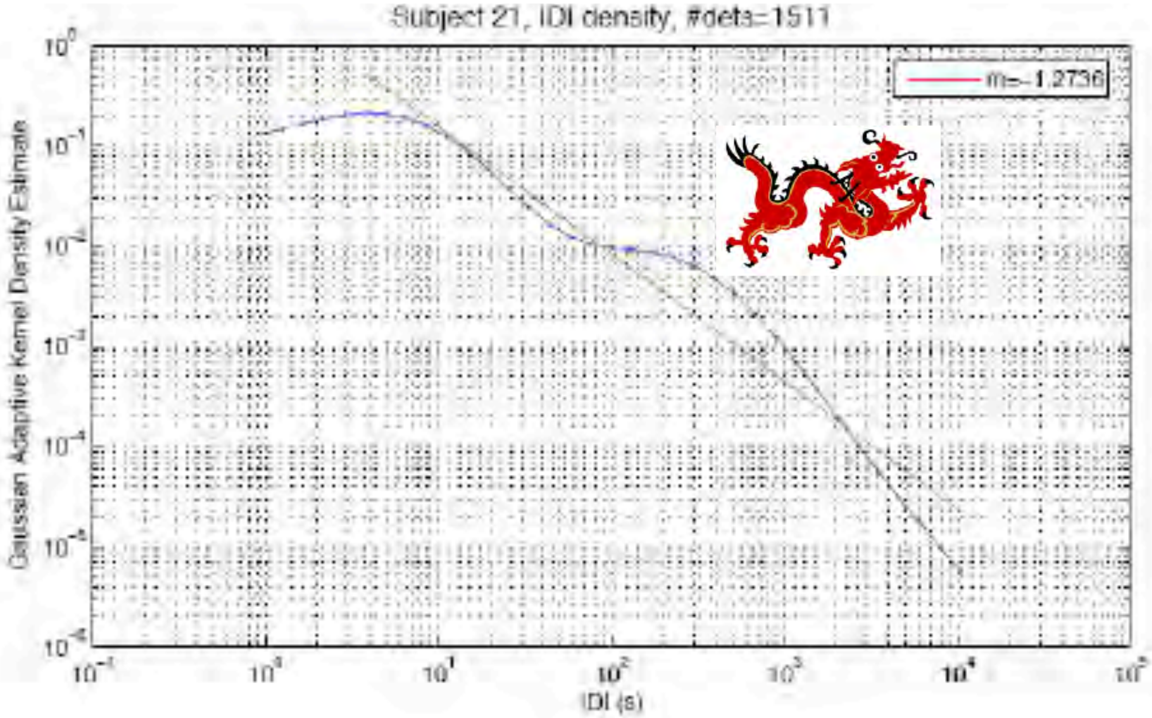
Distribution of inter-seizure time intervals for rat 5, demonstrating a pure power law, which is characteristic of the SOC state. This scale-free distribution should be contrasted with the pdf's obtained for the other rats, which are marked by a strong shoulder associated with a characteristic time scale, which reveals the periodic regime.

Generic diagram for coupled threshold oscillators of relaxation



Generic diagram for coupled threshold oscillators of relaxation

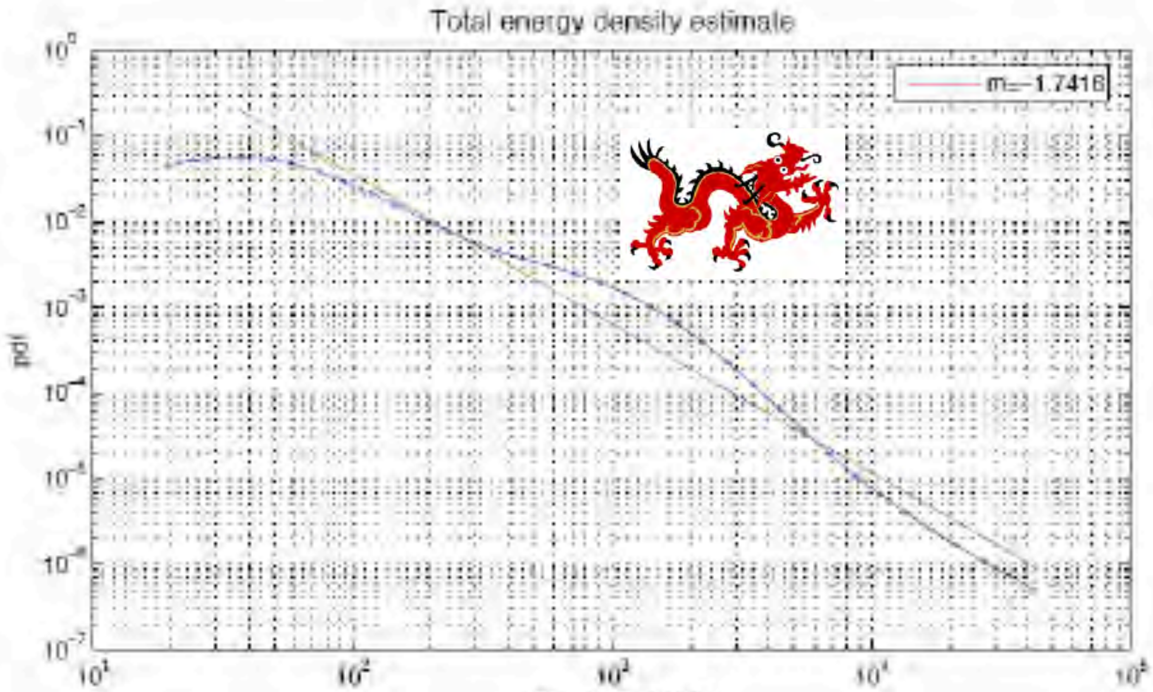




Some humans are like rats with large doses of convulsant

The pdf's of the seizure energies and of the inter-seizure waiting times for subject 21.

Note the shoulder in each distribution, demonstrating the presence of a characteristic size and time scale, qualifying the periodic regime.



Mechanisms for Dragon-kings

- Generalized correlated percolation
- Partial global synchronization
- A kind of condensation (a la Bose-Einstein)

Landau-Ginzburg Theory of Self-Organized Criticality and of Dragon-kings!

Dynamics of an order parameter (OP) and of the corresponding *control* parameter (CP): within the sandpile picture, $\frac{\partial h}{\partial x}$ is the slope of the sandpile, h being the local height, and S is the state variable distinguishing between static grains ($S = 0$) and rolling grains ($S \neq 0$).

L. Gil and D. Sornette "Landau-Ginzburg theory of self-organized criticality", Phys. Rev.Lett. 76, 3991-3994 (1996)

Normal form of sub-critical bifurcation

$$\frac{\partial S}{\partial t} = \chi \{\mu S + 2\beta S^3 - S^5\} \qquad (1)$$

where

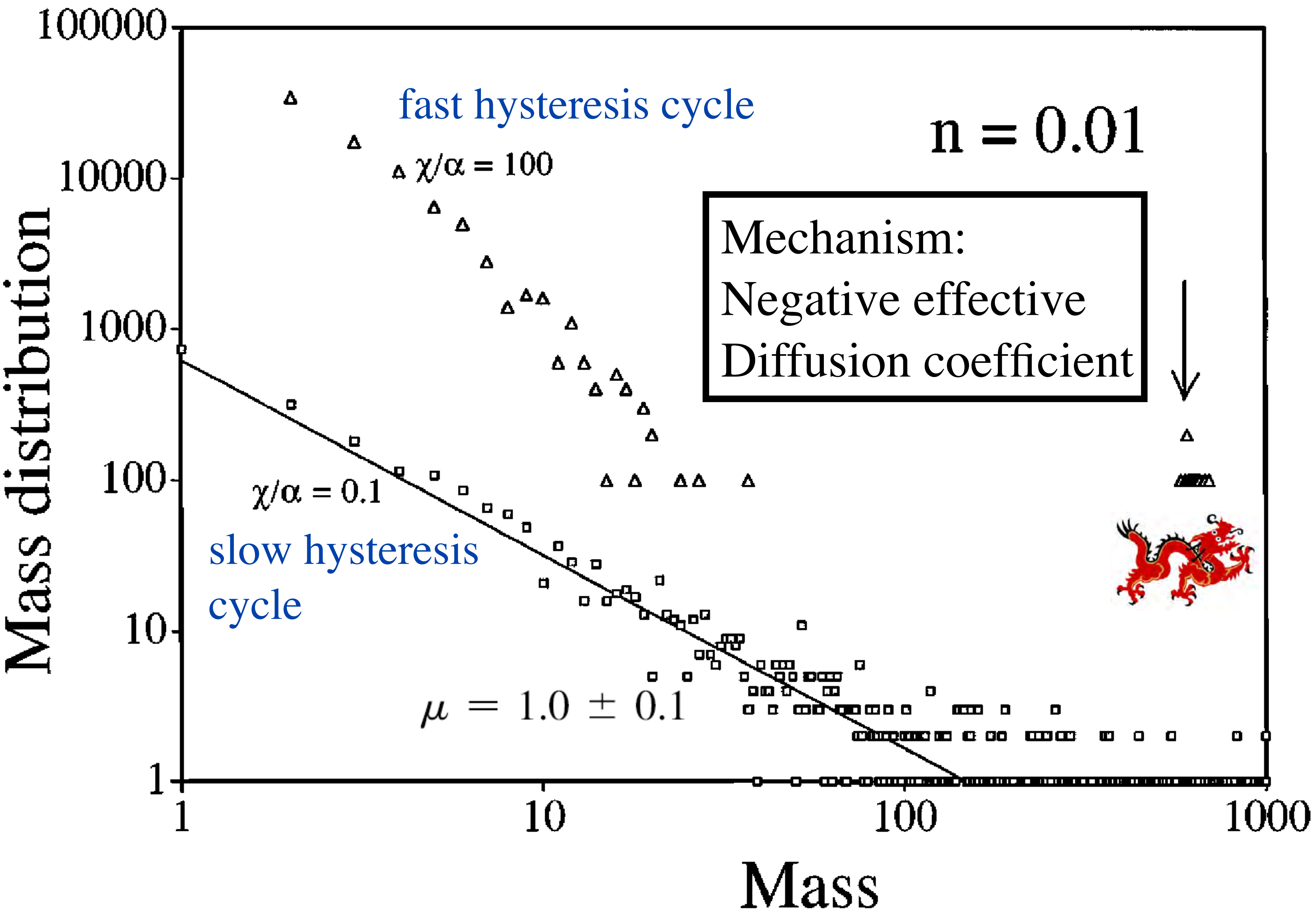
$$\mu = \left[\left(\frac{\partial h}{\partial x}\right)^2 - \left(\frac{\partial h}{\partial x}|_c\right)^2\right] \qquad (2)$$

and $\beta > 0$ (subcritical condition).

$$F\left(S, \frac{\partial h}{\partial x}\right) = -\alpha \frac{\partial h}{\partial x} S^2, \qquad \alpha > 0$$

Diffusion equation

$$\frac{\partial h}{\partial t} = -\frac{\partial F\left(S, \frac{\partial h}{\partial x}\right)}{\partial x} + \Phi \qquad (3)$$



System sizes range from $L/a = 64$ to 2048.

$$P(M)dM \simeq M^{-(1+\mu)}dM,$$

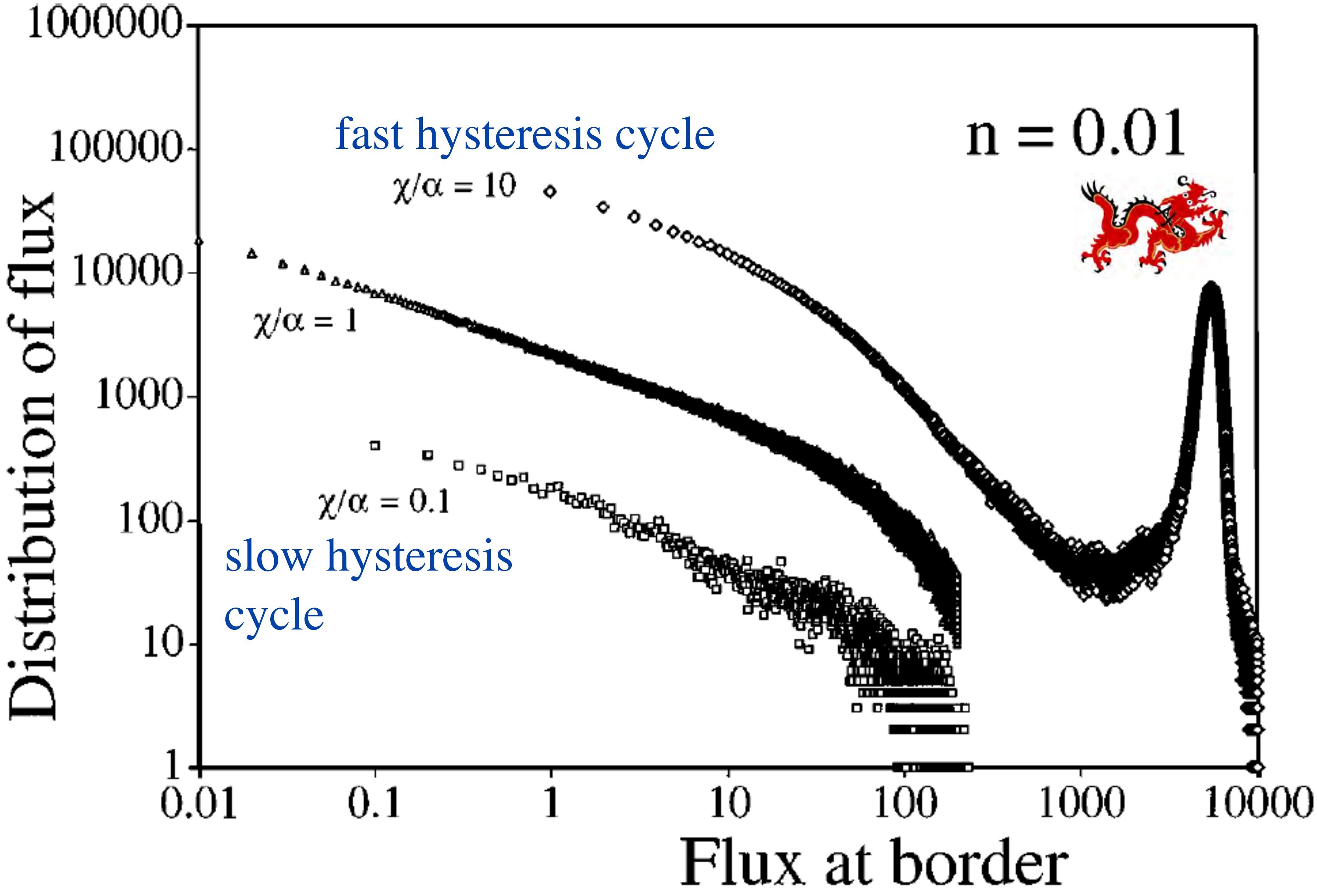
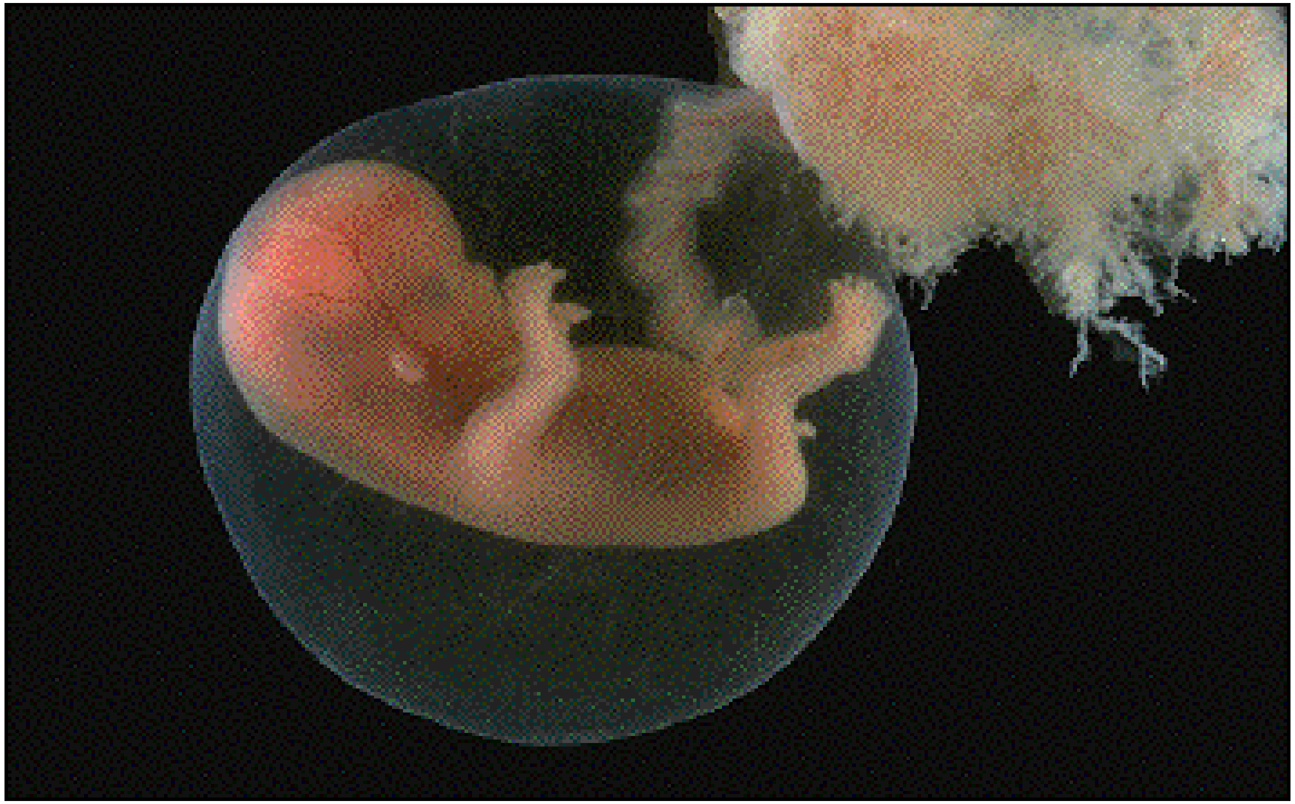


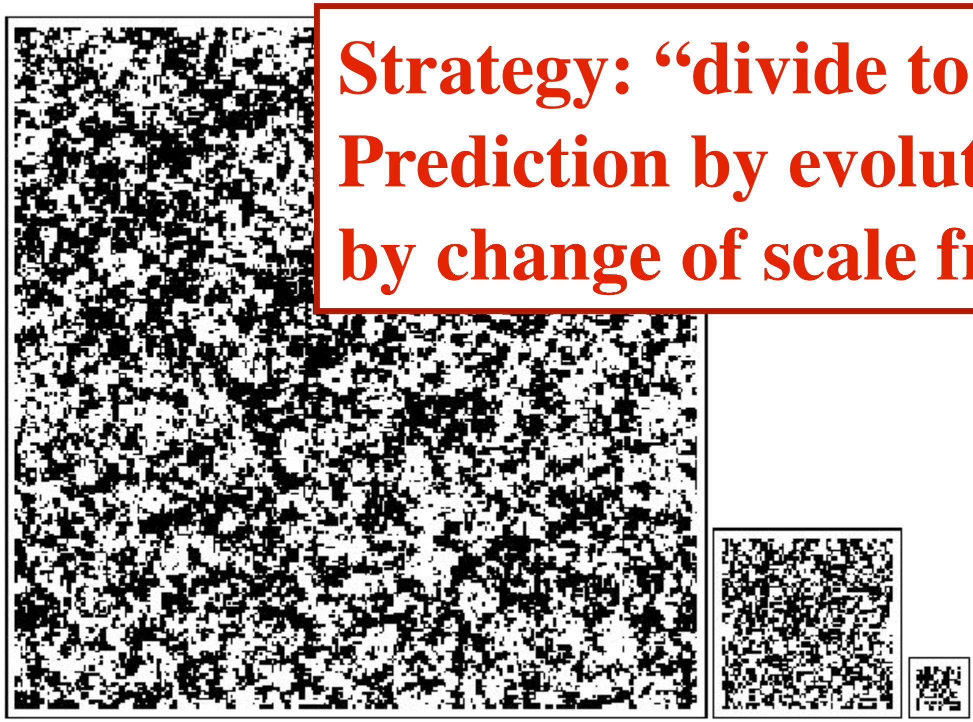
FIG. 3. Distribution $P(J)$ of flux amplitudes at the right border, in the same conditions as for Fig. 1.

Predictability of catastrophic events: Material rupture, earthquakes, turbulence, financial crashes, and human birth

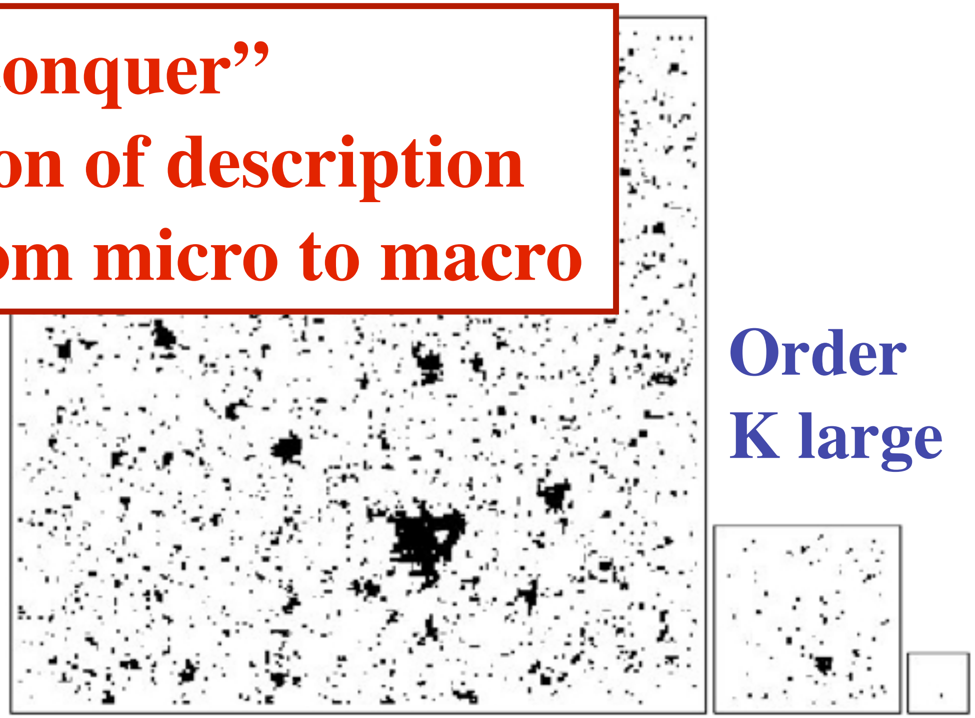
D. Sornette 2522–2529 | PNAS | February 19, 2002 | vol. 99 | suppl. 1



Strategy: “divide to conquer”
Prediction by evolution of description by change of scale from micro to macro

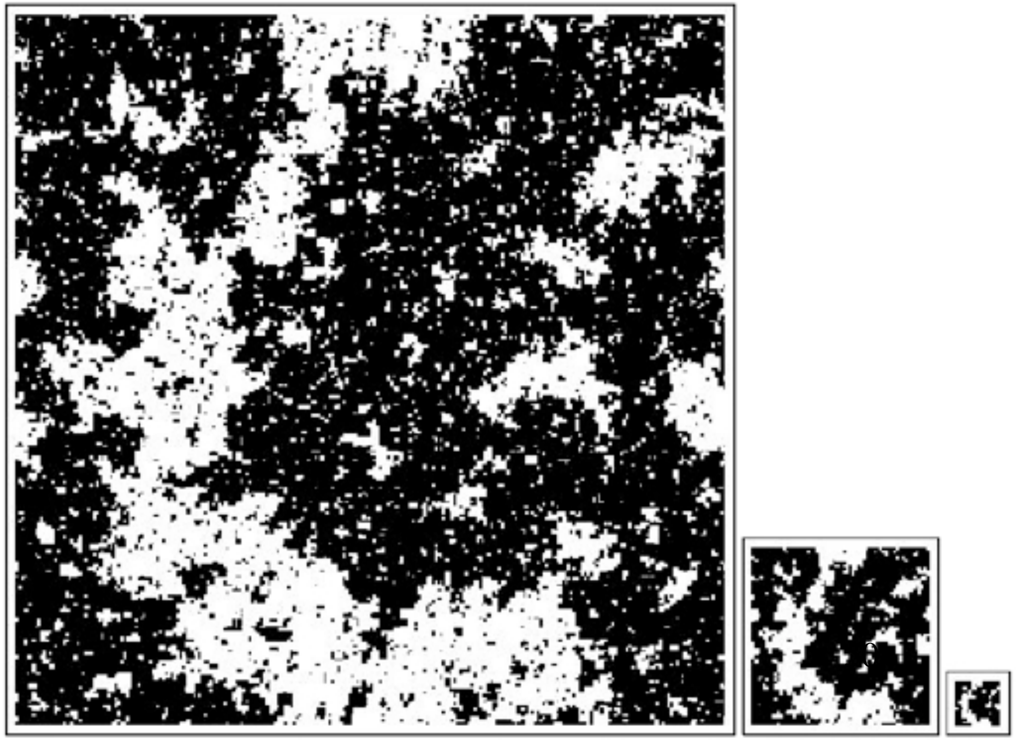


Disorder : K small



Order
K large

Renormalization group:
Organization of the description scale by scale



Critical:
K=critical value

Fundamental reduction theorem

Generically, close to a regime transition, a system bifurcates through the variation of a SINGLE (or a few) effective "control" parameter

Bifurcation: Qualitative change in behavior as parameter is (slowly) varied

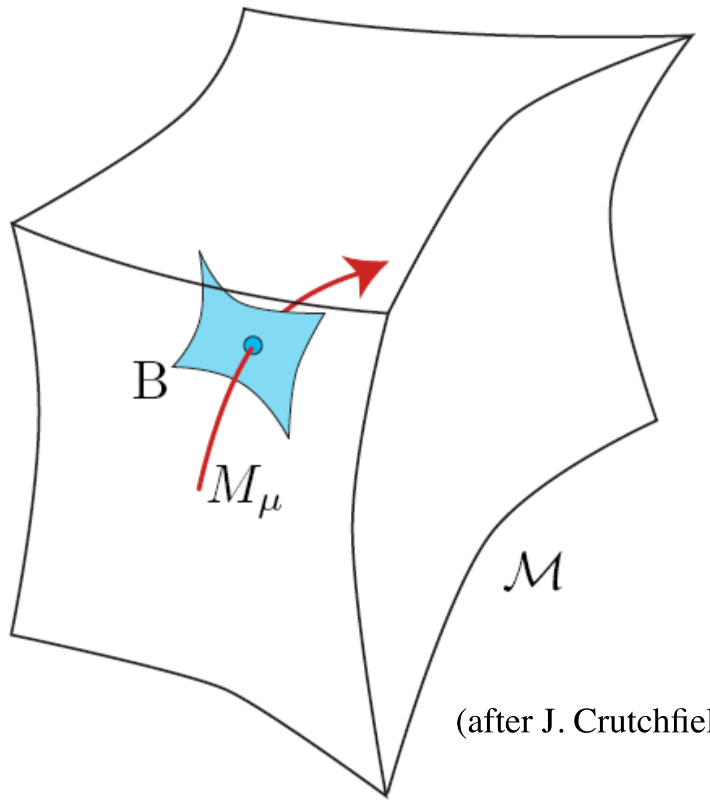
Bifurcation surface: B

Strategy 1: understand from proximity to a reference point as a function of a small parameter

Strategy 2: a few universal "normal forms"

Space of all dynamical systems: $\mathcal{M}$

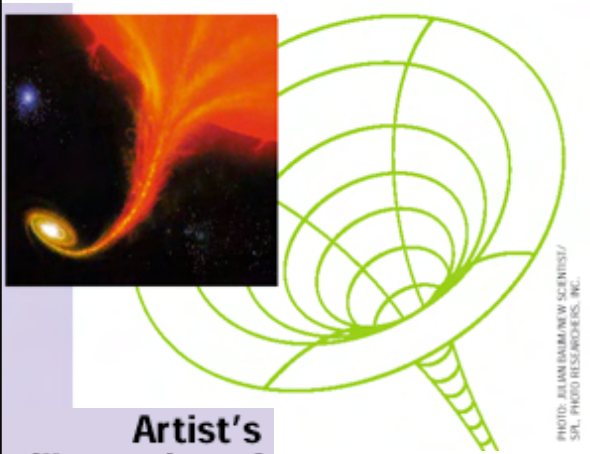
a particular dynamical system: $M \in \mathcal{M}$



(after J. Crutchfield)

Finite-time Singularity

as a result of positive feedbacks

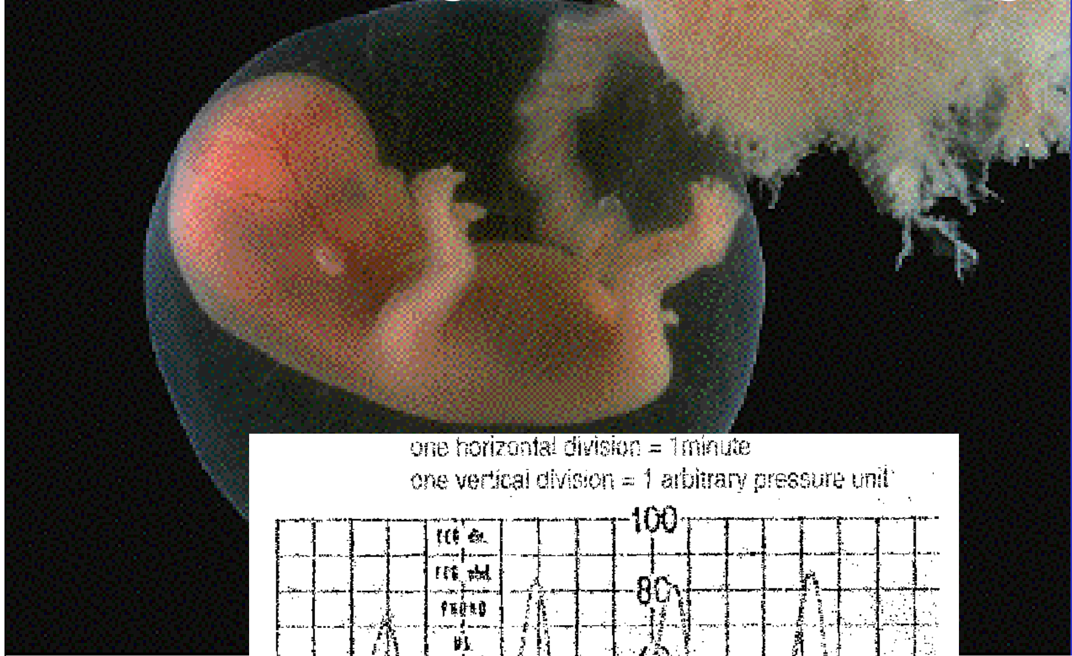


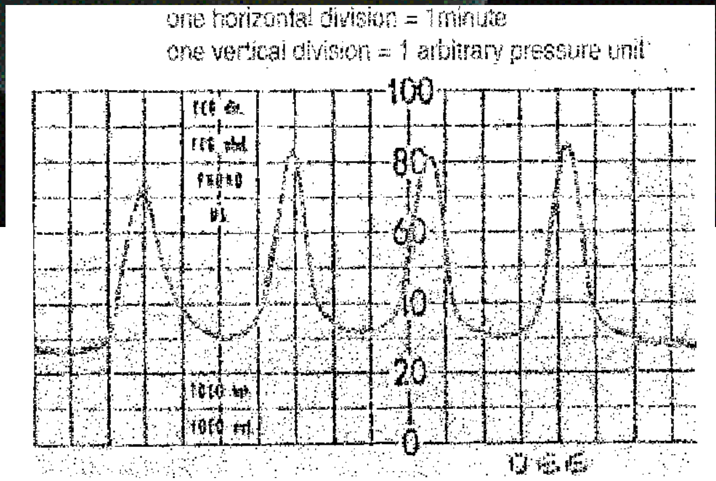
Artist's illustration of matter from a red giant star being pulled toward a black hole.

- Planet formation in solar system by run-away accretion of planetesimals
- PDE's: Euler equations of inviscid fluids and relationship with turbulence
- PDE's of General Relativity coupled to a mass field leading to the formation of black holes
- Zakharov-equation of beam-driven Langmuir turbulence in plasma
- rupture and material failure
- Earthquakes (ex: slip-velocity Ruina-Dieterich friction law and accelerating creep)
- Models of micro-organisms chemotaxis, aggregating to form fruiting bodies
- Surface instability spikes (Mullins-Sekerka), jets from a singular surface, fluid drop snap-off
- Euler's disk (rotating coin)
- Stock market crashes...

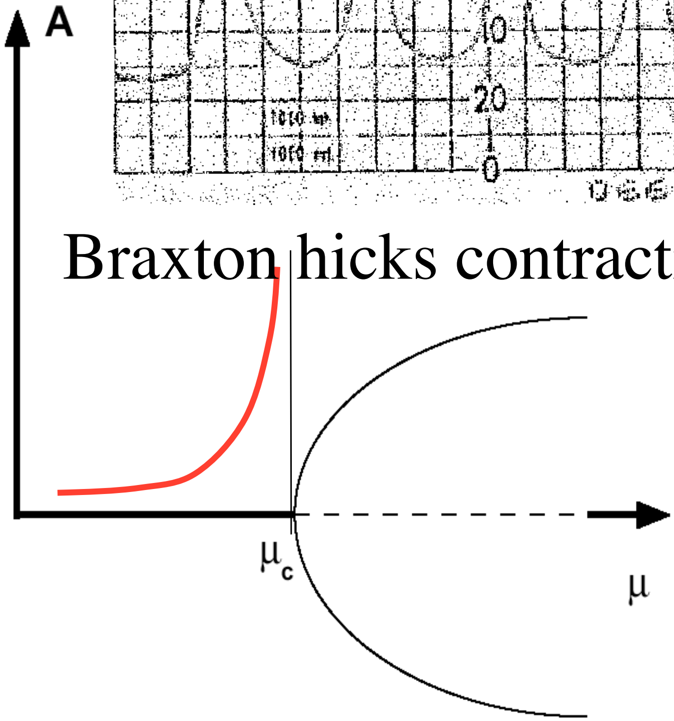
PREDICTABILITY of CRITICAL PARTURITION

Who initiates parturition?





Braxton hicks contractions



Generic Critical Precursors to a Bifurcation

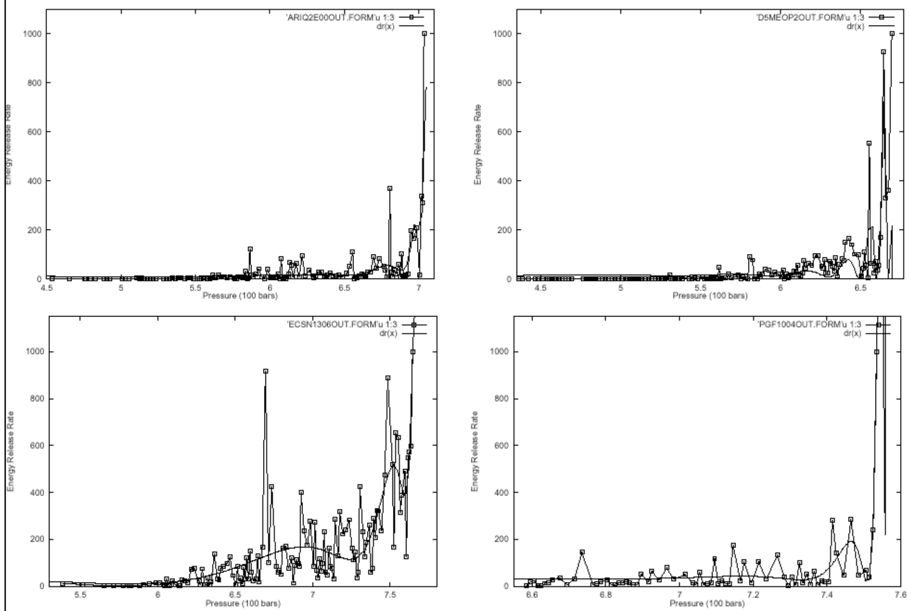
-Amplitude of fluctuations

-Response to external forcing

D. Sornette, F. Ferre and E.Papiernik, Mathematical model of human gestation and parturition : implications for early diagnostic of prematurity and post-maturity", Int. J. Bifurcation and Chaos 4, N°3, 693-699 (1994)

Methodology for predictability of crises

Strategy: look at the forest rather than at the tree



Our prediction system is now used in the industrial phase as the standard testing procedure.

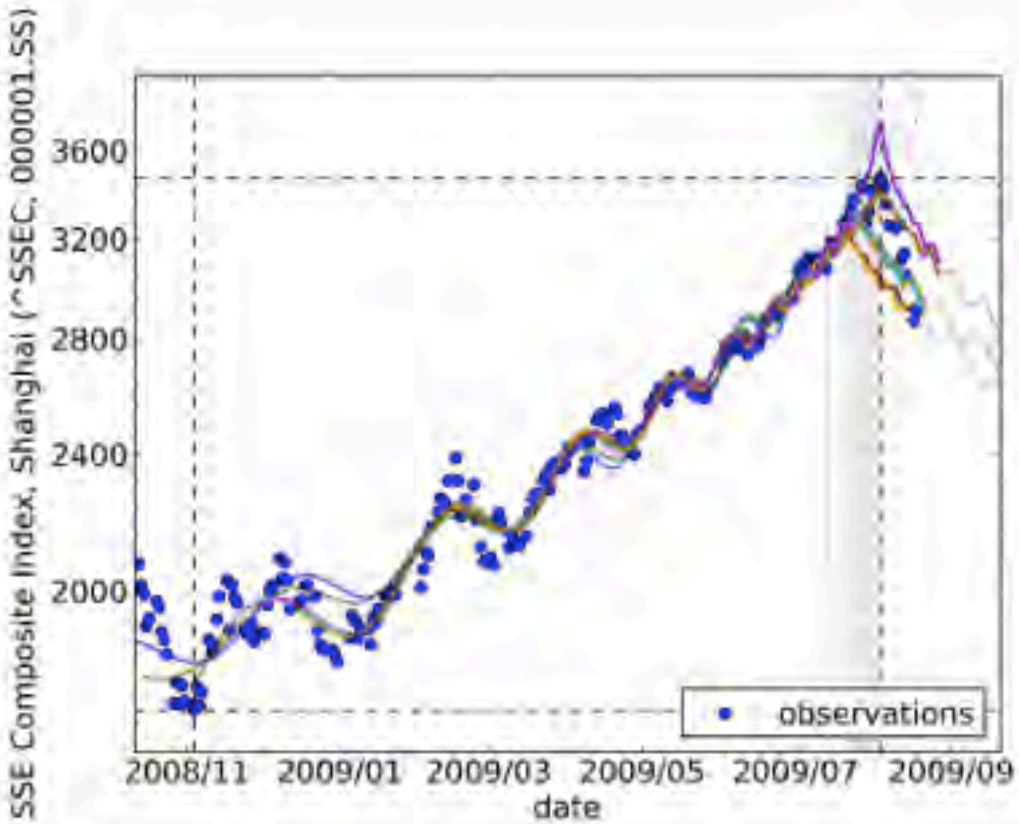
EADS LAUNCH VEHICLES

J.-C. Anifrani, C. Le Floc'h, D. Sornette and B. Souillard
"Universal Log-periodic correction to renormalization group scaling for rupture stress prediction from acoustic emissions", J.Phys.I France 5, n°6, 631-638 (1995)

FCO@ETH: Towards operational science of financial instabilities

Didier Sornette, Maxim Fedorovsky, Stefan Riemann, Hilary Woodard, Ryan Woodard, Wanfeng Yan, Wei-Xing Zhou

- Main mission:
  - Identify bubbles
- Theory:
  - Positive feedback
- Deliverables
  - Weekly global bubble scan
  - Research, papers
  - Public forecasts
  - Digital timestamps



The Financial Bubble Experiment
First Results (2 November 2009 - 3 May 2010)

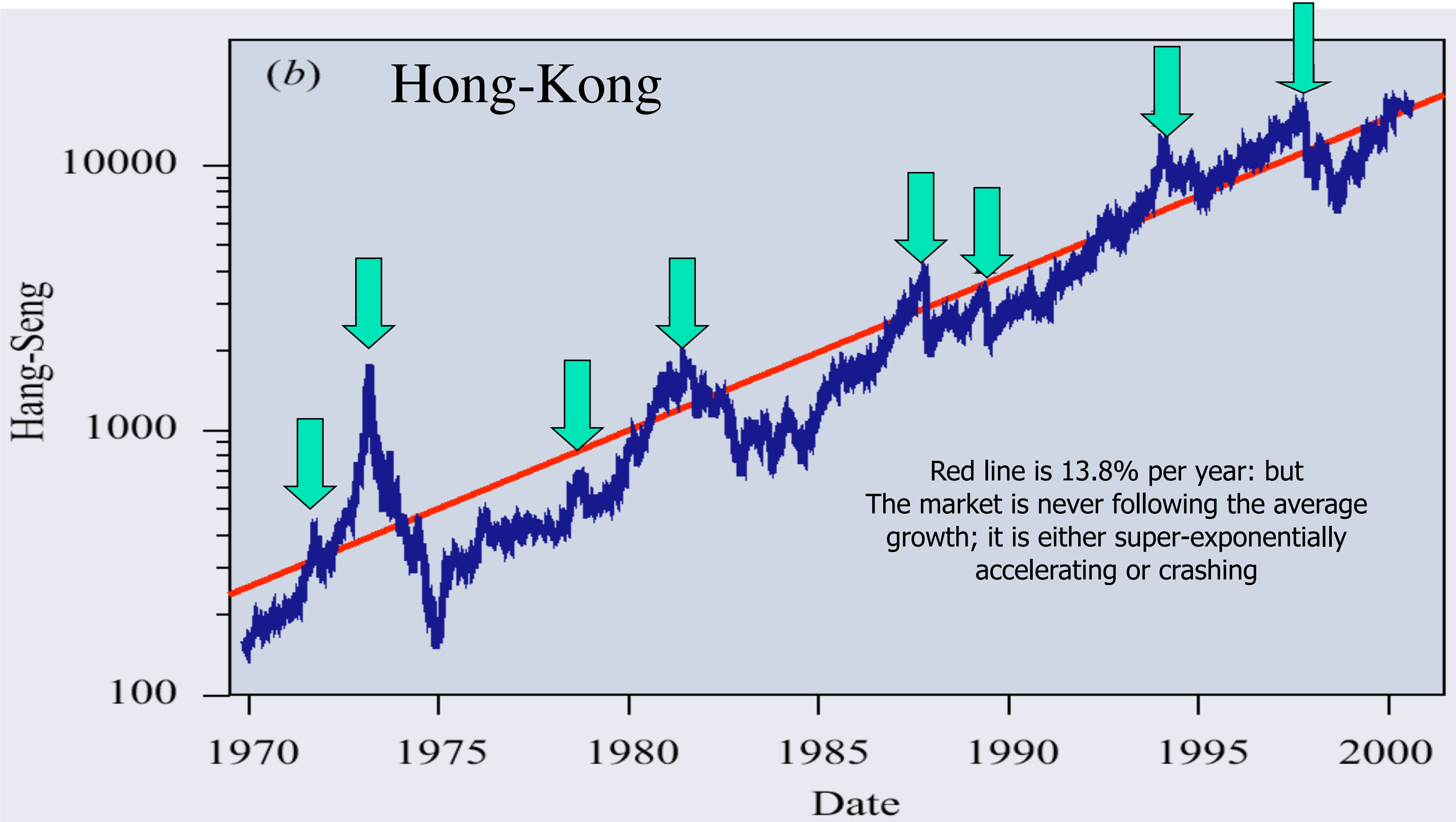
D. Sornette, R. Woodard, M. Fedorovsky, S. Reimann, H. Woodard, W.-X. Zhou

(The Financial Crisis Observatory)

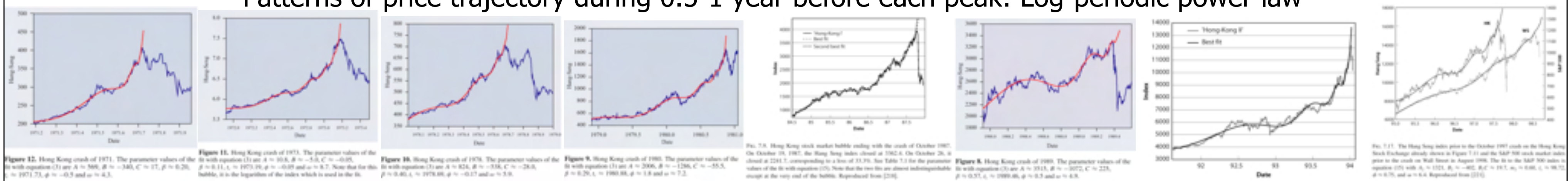
Department of Management, Technology and Economics,

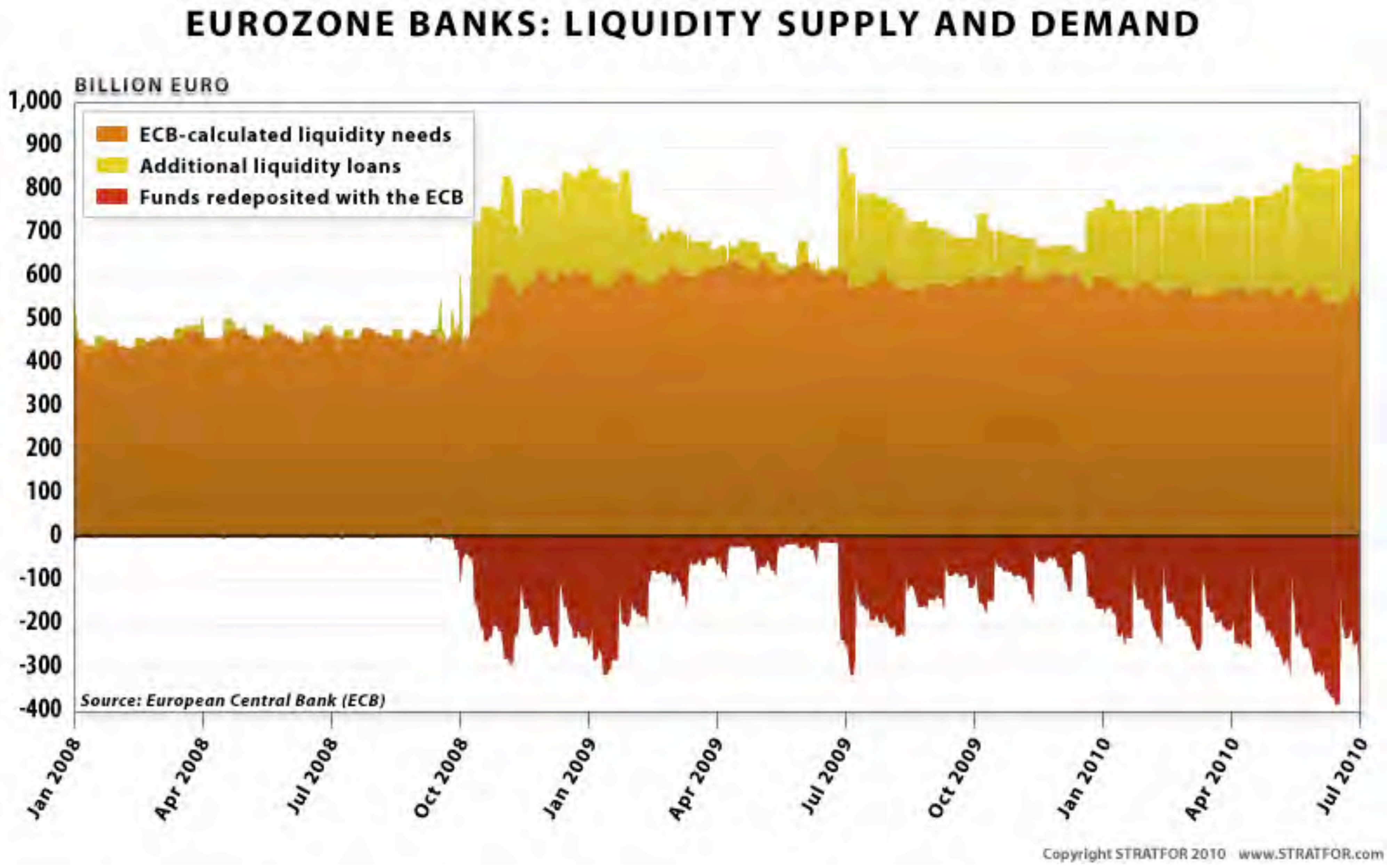
ETH Zurich, Kreuzplatz 5, CH-8032 Zurich, Switzerland

Financial Instability Hypothesis (Minsky)

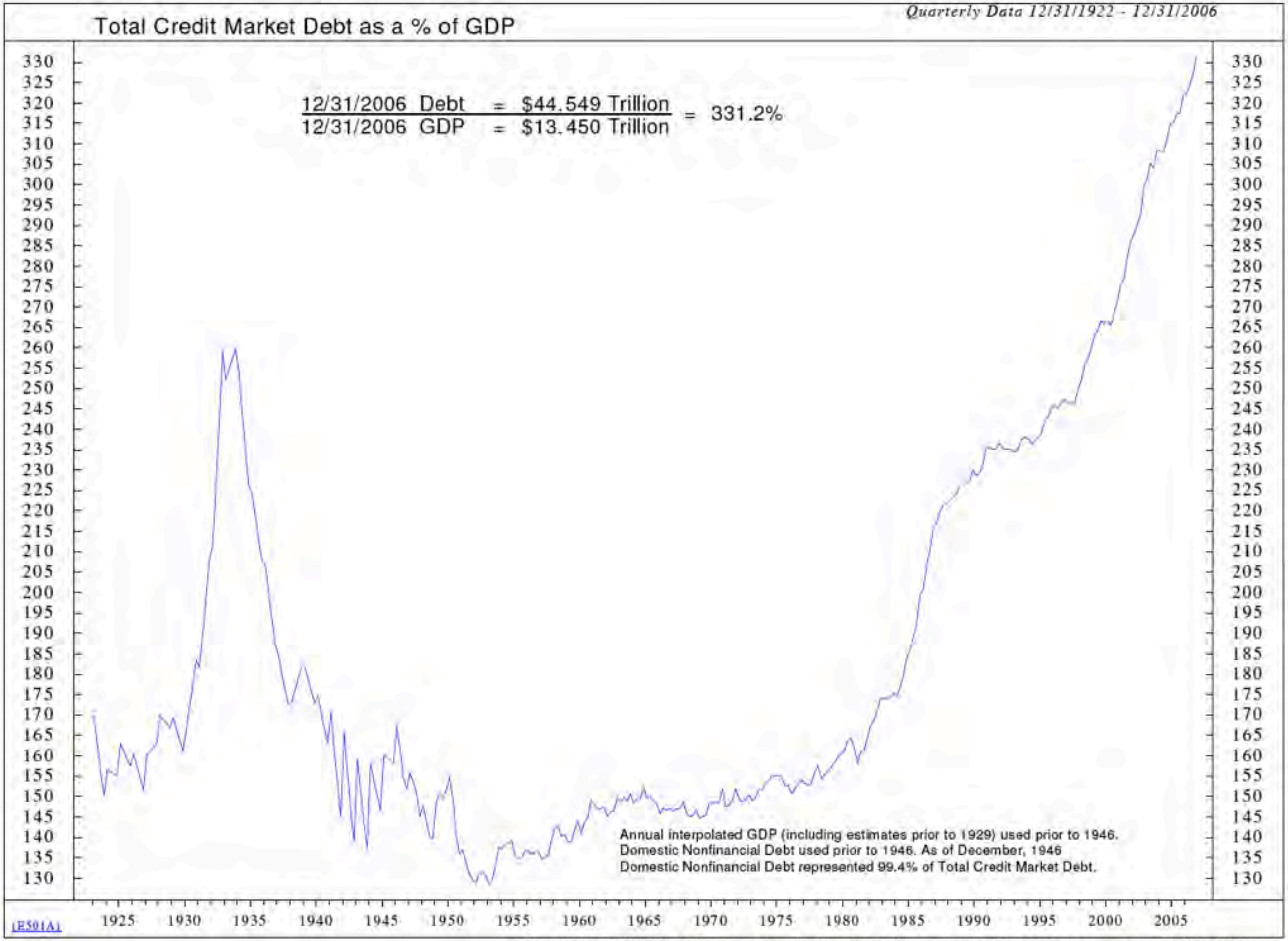


Patterns of price trajectory during 0.5-1 year before each peak: Log-periodic power law



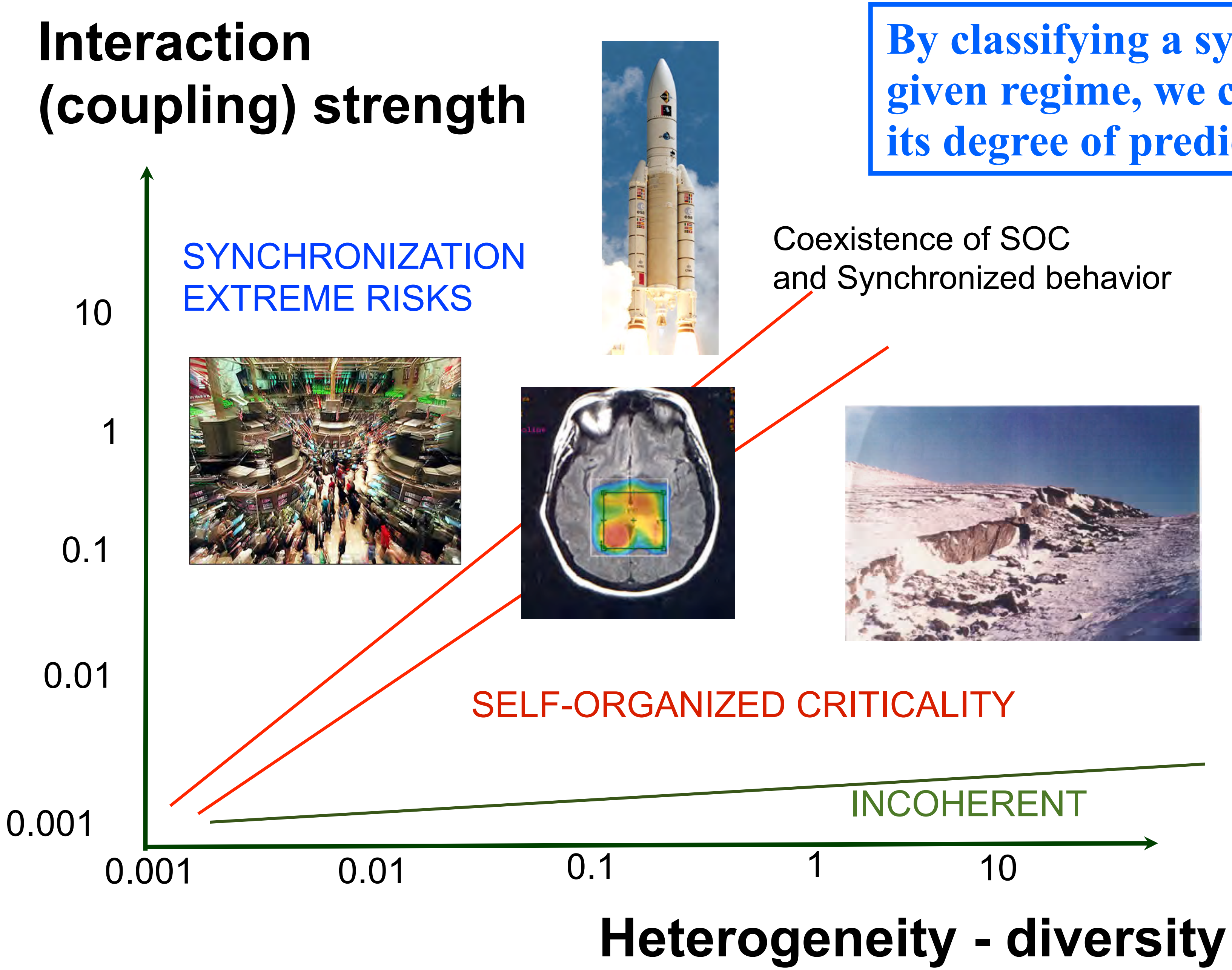


EUROZONE BANKS: LIQUIDITY SUPPLY AND DEMAND
BILLION EURO
ECB-calculated liquidity needs
Additional liquidity loans
Funds redeposited with the ECB
1,000
900
800
700
600
500
400
300
200
100
0
-100
-200
-300
-400
Source: European Central Bank (ECB)
Jan 2008
Apr 2008
Jul 2008
Oct 2008
Jan 2009
Apr 2009
Jul 2009
Oct 2009
Jan 2010
Apr 2010
Jul 2010
Copyright STRATFOR 2010 www.STRATFOR.com


Quarterly Data 12/31/1922 - 12/31/2006
Total Credit Market Debt as a % of GDP
12/31/2006 Debt = $44.549 Trillion
12/31/2006 GDP = $13.450 Trillion
= 331.2%
Annual interpolated GDP (including estimates prior to 1929) used prior to 1946.
Domestic Nonfinancial Debt used prior to 1946. As of December, 1946
Domestic Nonfinancial Debt represented 99.4% of Total Credit Market Debt.
(E501A)

Generic Prediction Phase Diagram

By classifying a system in a given regime, we can assert its degree of predictability.



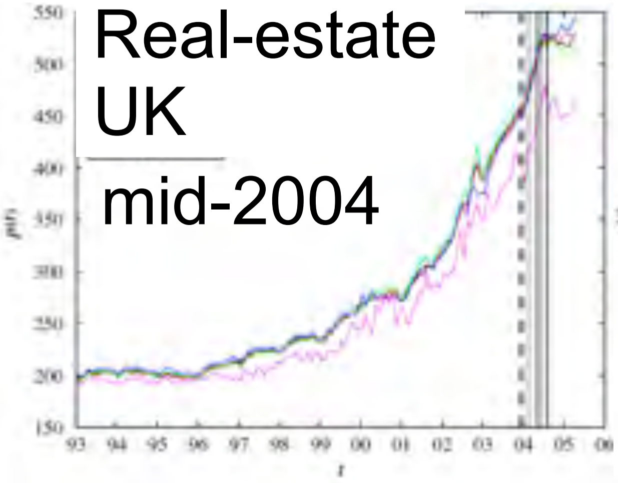
Black Swans, Dragons-Kings and Prediction

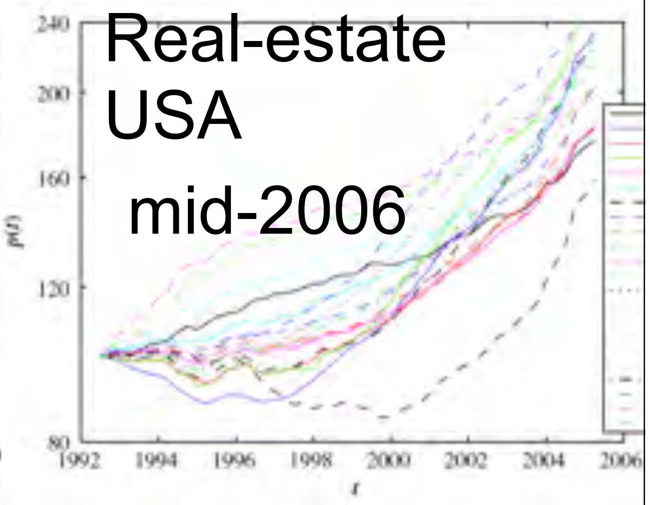
- An illustration of trans-disciplinarity at work
- Out-of-equilibrium view of the world (social systems, economics, geosciences, biology...)
- Dragon-kings as extreme events are the rule rather than the exception. Their study reveal important new mechanisms.
- Crises are (probabilistically) predictable

Predictability of the 2007-XXXX crisis: 15y History of bubbles and Dragon-kings

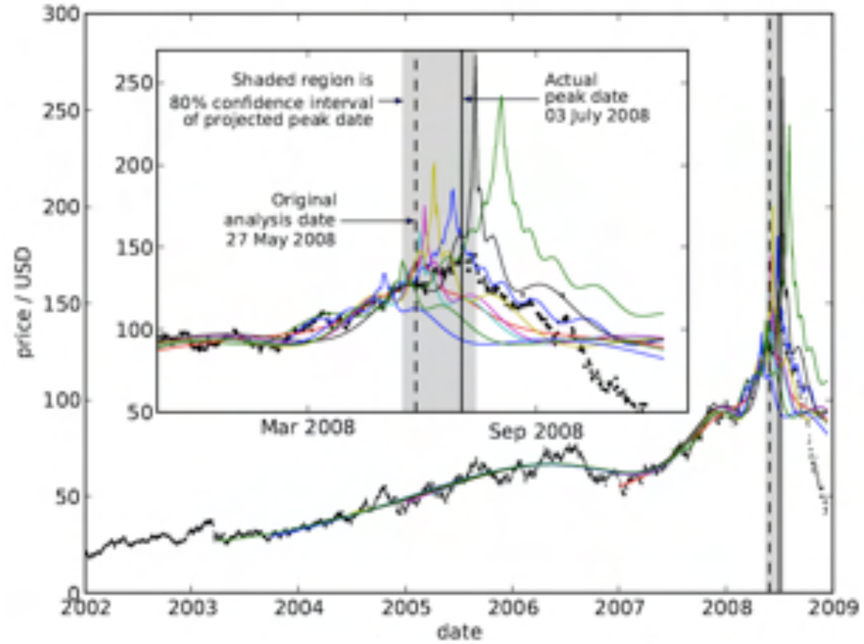
- The ITC “new economy” bubble (1995-2000)
- Slaving of the Fed monetary policy to the stock market descent (2000-2003)
- Real-estate bubbles (2003-2006)
- MBS, CDOs bubble (2004-2007)
- Stock market bubble (2004-2007)
- Commodities and Oil bubbles (2006-2008)

Didier Sornette and Ryan Woodard
Financial Bubbles, Real Estate bubbles, Derivative Bubbles, and the Financial and Economic Crisis (2009)
(http://arxiv.org/abs/0905.0220)

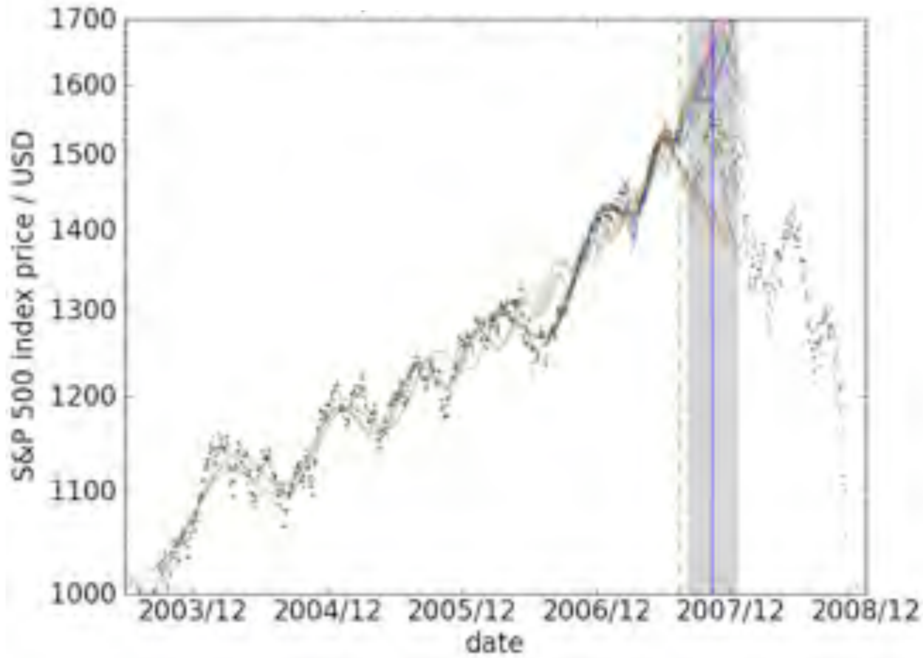




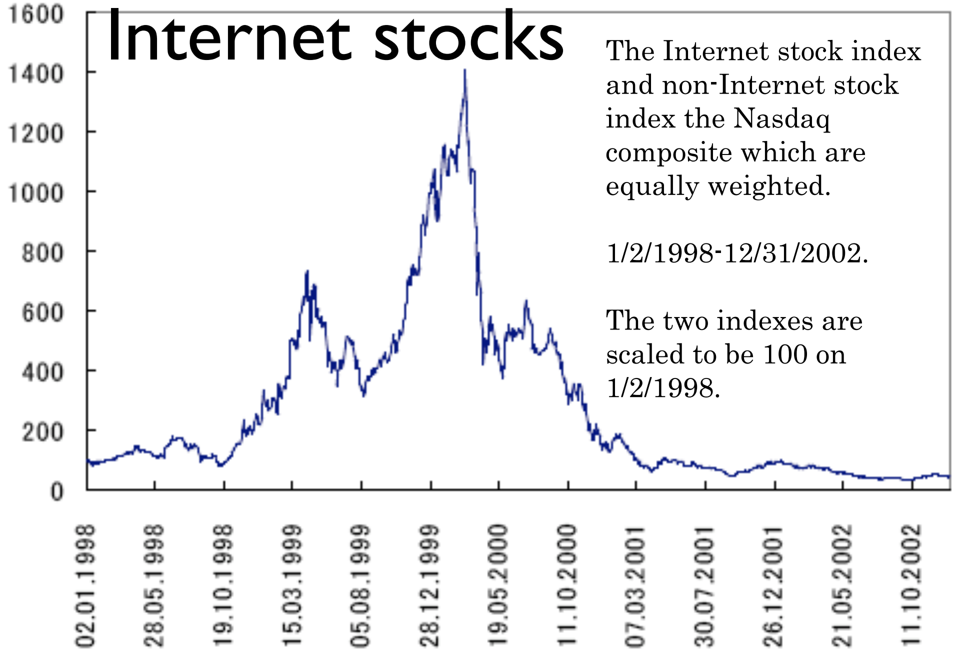
Oil July 2008



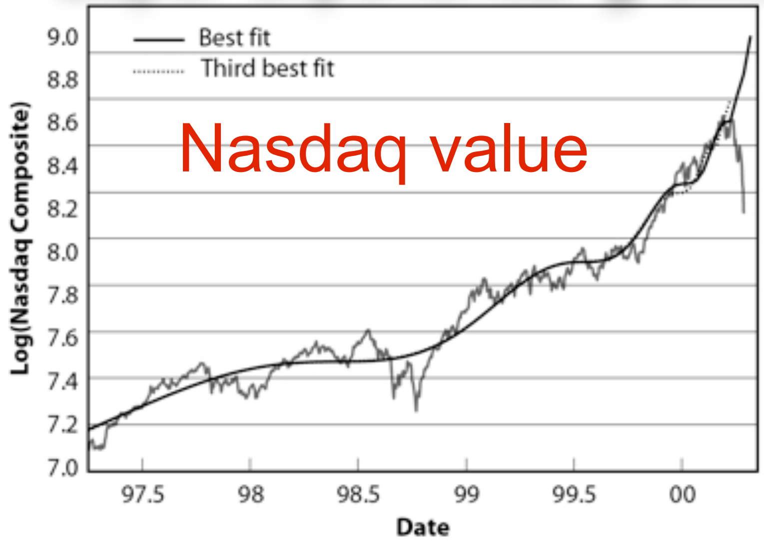
S&P500 USA Oct. 2007



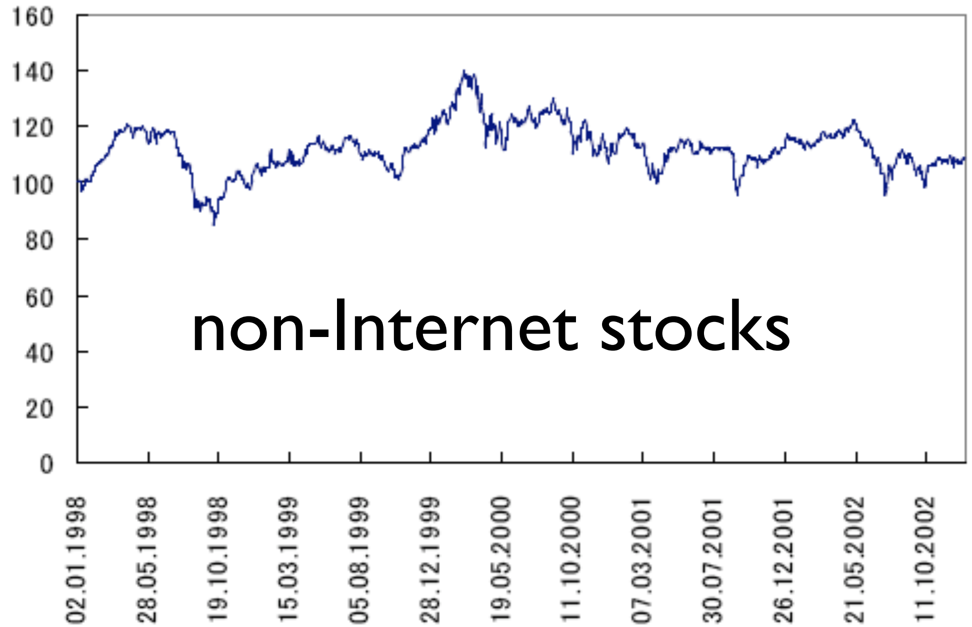
THE NASDAQ CRASH OF APRIL 2000

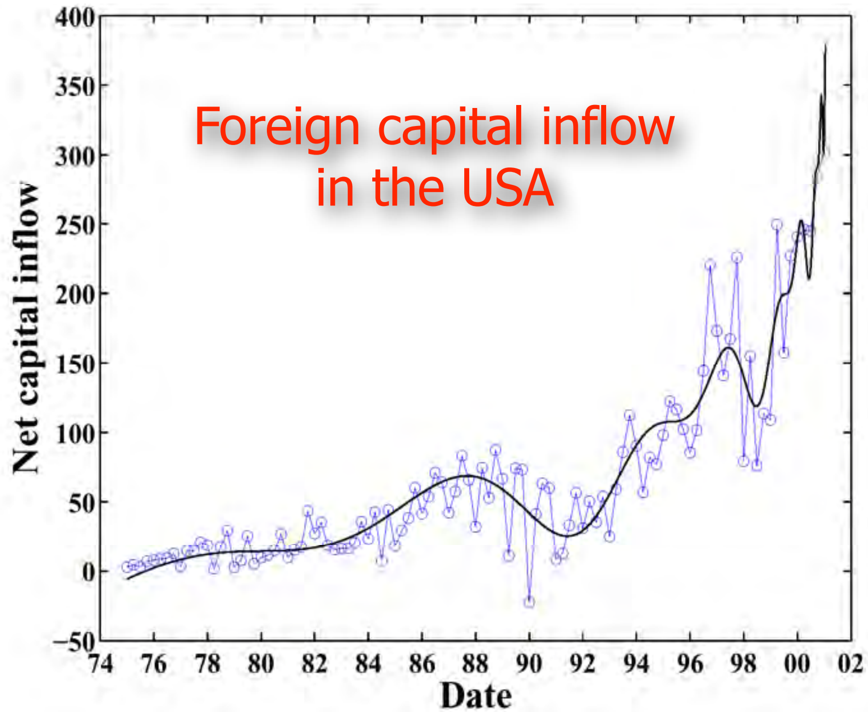


Super-exponential growth



Non-Internet Stock Price Index





Final remarks

1-All proposals will fail if we do not have better science and better metrics to monitor and diagnose (ex: biology, medicine, astronomy, chemistry, physics, evolution, and so on)

2-Leverage as a system variable versus the illusion of control by monetary policy, risk management, and all that

3-Need to make endogenous policy makers and regulators ("creationist" view of government role, illusion of control and law of unintended consequences of regulations)

4-Fundamental interplay between system instability and growth; the positive side of (some) bubbles

5-Time to reassess goals (growth vs sustainability vs happiness). In the end, endogenous co-evolution of culture, society and economy

KEY CHALLENGE: genuine trans-disciplinarity by
TRAINING in 2-3 disciplines + CHANGE OF CULTURE

Further Reading

T. Kaizoji and D. Sornette, Market Bubbles and Crashes, in press in the Encyclopedia of Quantitative Finance (Wiley, 2008)
(preprint at http://arxiv.org/abs/0812.2449)

D. Sornette and R. Woodard Financial Bubbles, Real Estate bubbles, Derivative Bubbles, and the Financial and Economic Crisis
(preprint at http://arxiv.org/abs/0905.0220) will appear in the Proceedings of APFA7 (Applications of Physics in Financial Analysis, http://www.thic-apfa7.com/en/htm/index.html)

Didier Sornette, Why Stock Markets Crash
(Critical Events in Complex Financial Systems)
Princeton University Press, January 2003

Y. Malevergne and D. Sornette, Extreme Financial Risks (From Dependence to Risk Management) (Springer, Heidelberg, 2006).

1. Geosciences of the solid envelop
1.1. Earthquake magnitude.
1.2. Volcanic eruptions.
1.3. Landslides.
1.4. Floods. No protagonist found yet.

2. Meteorological and Climate sciences
2.1. Rains, hurricanes, storms.
2.2. Snow avalanches.

3. Material Sciences and Mechanical Engineering
3.1. Acoustic emissions.
3.2. Hydrodynamic turbulence.

4. Economics : financial drawdowns, distribution of wealth

5. Social sciences: distribution of firm sizes, of city sizes, of social groups...

6. Social sciences : wars, strikes, revolutions, city sizes

7. Medicine: epileptic seizures, epidemics

8. Environmental sciences : extinctions of species, forest fires
8.1. Evolution and extinction of species.
8.2. Forest fires.

Beyond power laws: 7 examples of "Dragons"

Financial economics: Outliers and dragons in the distribution of financial drawdowns.

Population geography: Paris as the dragon-king in the Zipf distribution of French city sizes.

Material science: failure and rupture processes.

Hydrodynamics: Extreme dragon events in the pdf of turbulent velocity fluctuations.

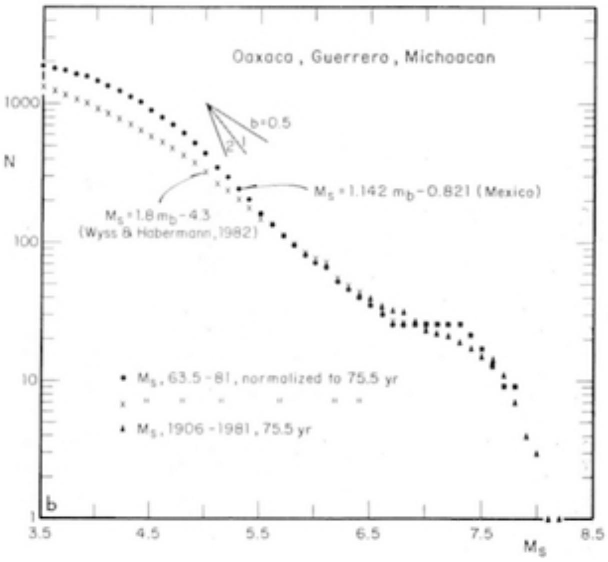
Metastable states in random media: Self-organized critical random directed polymers

Brain medicine: Epileptic seizures

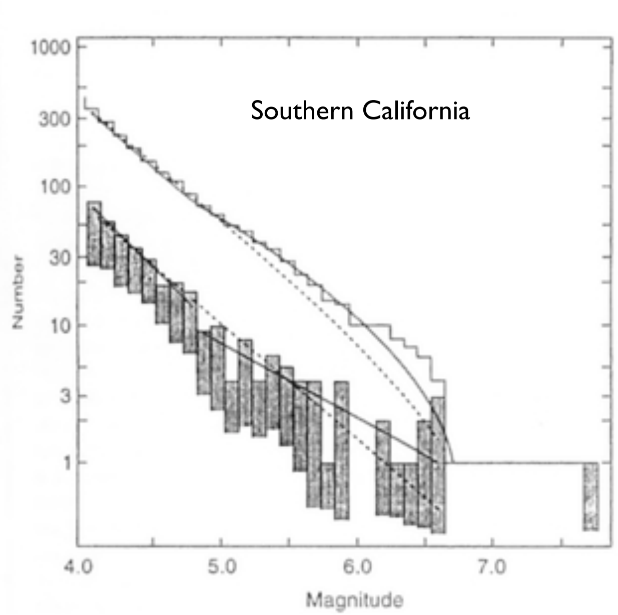
Geophysics: Gutenberg-Richter law and characteristic earthquakes.

Complex magnitude distributions

Characteristic earthquakes?



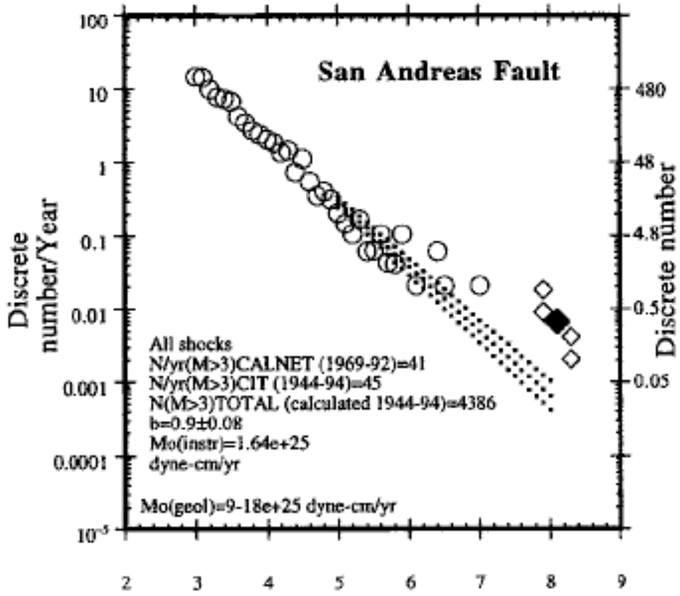
Singh, et. al., 1983, BSSA 73, 1779-1796

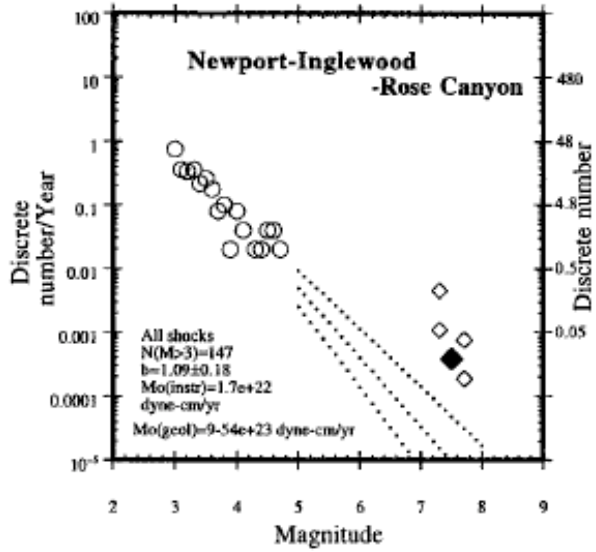


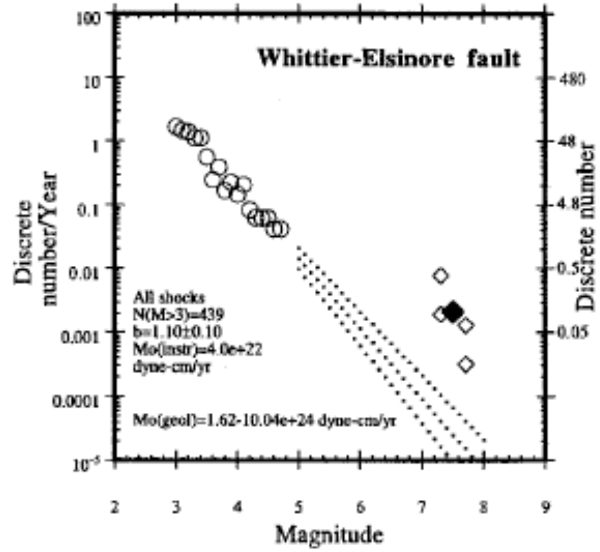
Knopoff, 2000, PNAS 97, 11880-11884

Main, 1995, BSSA 85, 1299-1308

Wesnousky, 1996, BSSA 86, 286-291







Black Swan (*Cygnus atratus*)

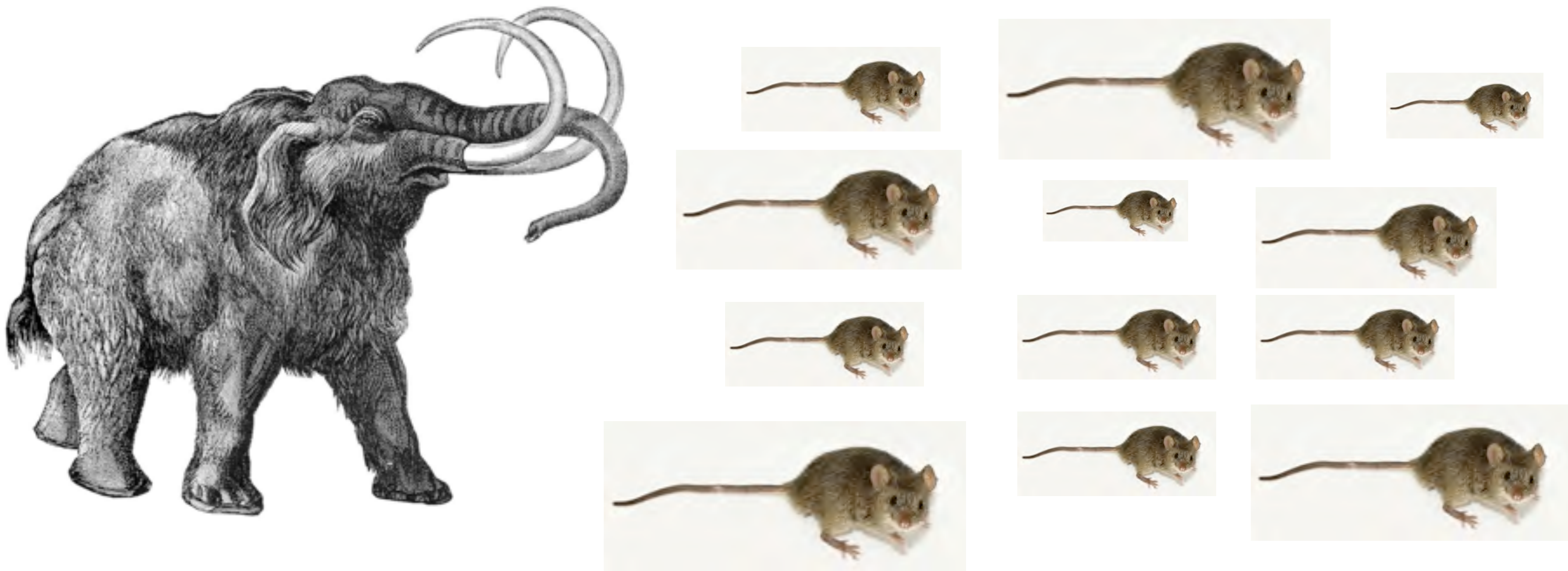
10% daily drop on Nasdaq : 1/1000 probability

1 in 1000 days => 1 day in 4 years

30% drop in three consecutive days?

(1/1000)*(1/1000)*(1/1000) = (1/1000’000’000)

=> one event in 4 millions years!



Mechanisms for positive feedbacks in the stock market

- Technical and rational mechanisms
  1. Option hedging
  2. Insurance portfolio strategies
  3. Trend following investment strategies
  4. Asymmetric information on hedging strategies

- Behavioral mechanisms:
  1. Breakdown of "psychological Galilean invariance"
  2. Imitation(many persons)
     a) It is rational to imitate
     b) It is the highest cognitive task to imitate
     c) We mostly learn by imitation
     d) The concept of "CONVENTION" (Orléan)
  3. "Social Proof" mechanism

Dragon-king story (for finance)

Dragon-king-outlier drawdowns

↓

Require new different mechanism

↓

Follow excesses ("bubbles")

↓

Bubbles are collective endogenous excesses
fueled by positive feedbacks

↓

Most crises are "endogenous"

↓

Possible diagnostic and predictions
via "coarse-grained" metrics (forest versus trees)