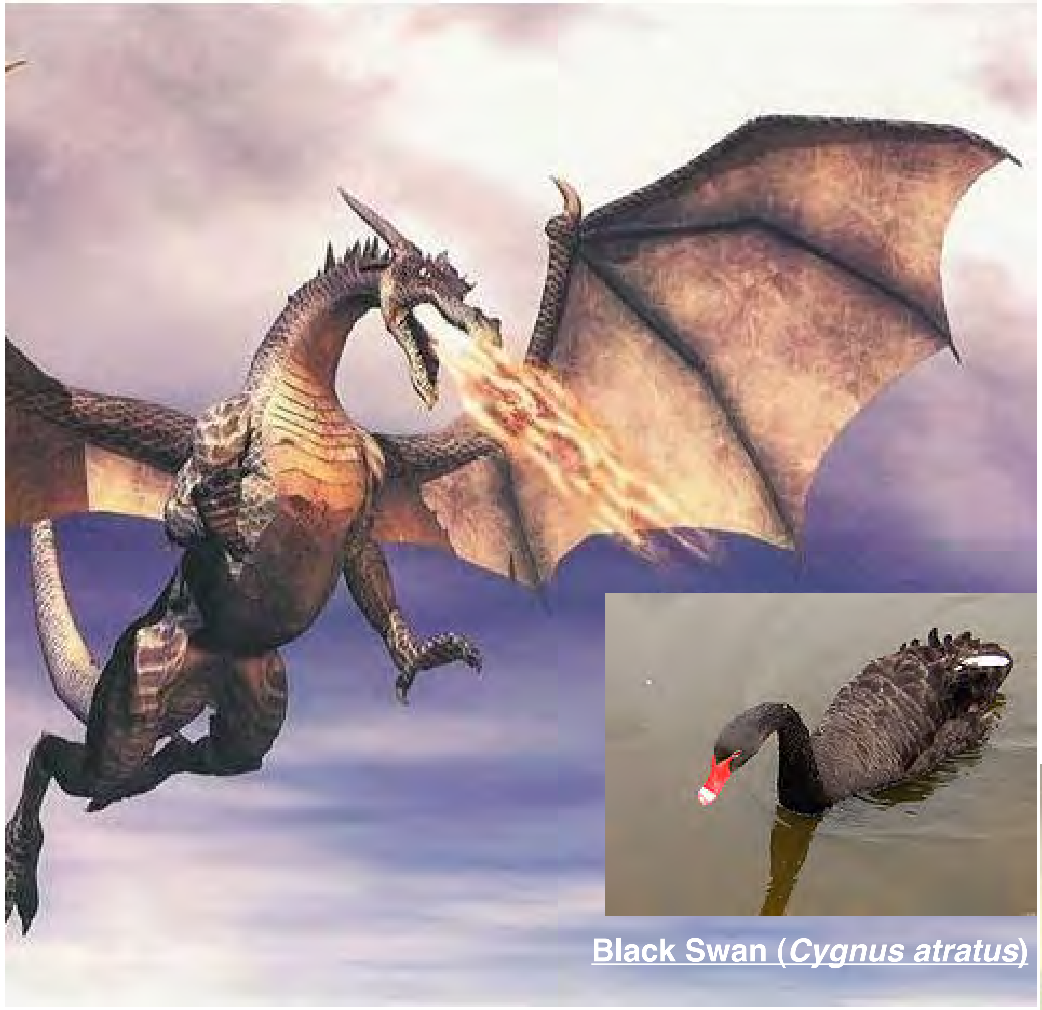
Black Swans, Dragons-Kings and PREDICTION



Black Swan (*Cygnus atratus*)

Didier SORNETTE

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Member of the Swiss Finance Institute

co-founder of the Competence Center for Coping with Crises in Socio-Economic Systems, ETH Zurich (http://www.ccss.ethz.ch/)

Professor of Physics associated with the Department of Physics (D-PHYS), ETH Zurich

Professor of Geophysics associated with the Department of Earth Sciences (D-ERWD), ETH Zurich

If you are a good economist, a virtuous economist, you are reborn as a physicist. But if you are an evil, wicked economist, you are reborn as a sociologist. -- An Indian economist, quoted by Paul Krugman (Econ Nobel 2008)

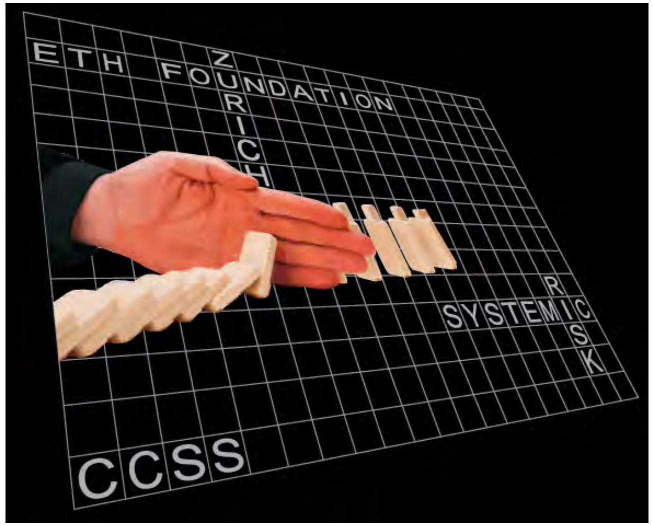
ETH Competence Center for "Coping with Crises in Socio-Economic Systems"

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Kay Axhausen

Dirk Helbing (Chairman)

Frank Schweitzer



Hans J. Herrmann

Didier Sornette

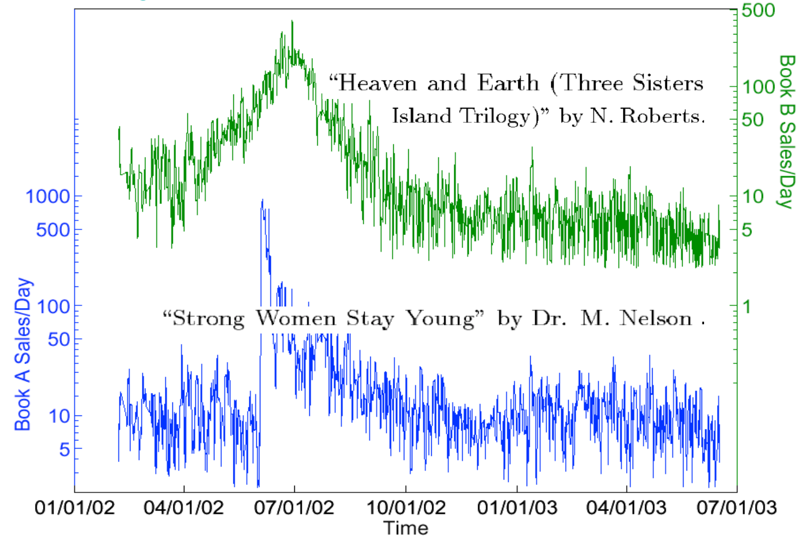
Lars-Erik Cederman

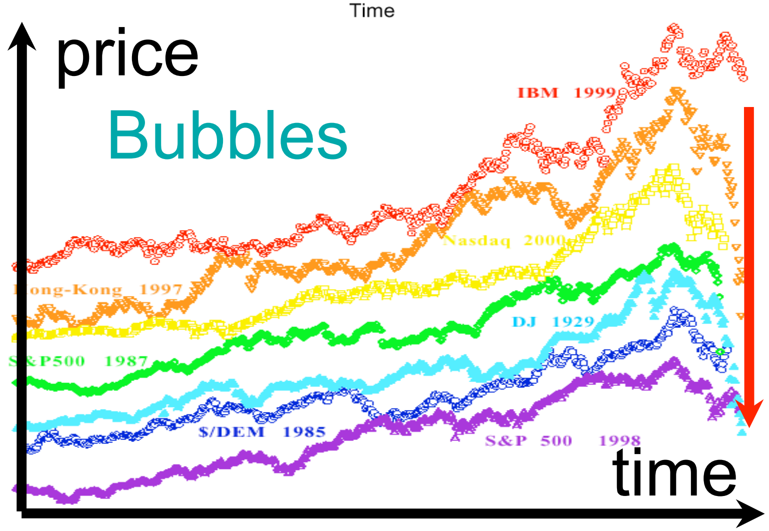
- Crises in financial markets
- Crises in societal infrastructures
- Crises involving political violence

www.ccss.ethz.ch/

- Collective dynamics and organization of social agents (Commercial sales,YouTube, Open source softwares, Cyber risks)
- Agent-based models of bubbles and crashes, credit risks, systemic risks
- Prediction of complex systems, stock markets, social systems
- Asset pricing, hedge-funds, risk factors…
- Human cooperation for sustainability
- Natural and biological hazards (earthquakes, landslides, epidemics, critical illnesses…)

Dynamics of success





(3 guest-professors, 5 foreign associate professors, 3 post-docs, 2 senior researcher, 10 PhD students, 6-8 Master students)

Crises are not 

but

"Dragon-kings" 

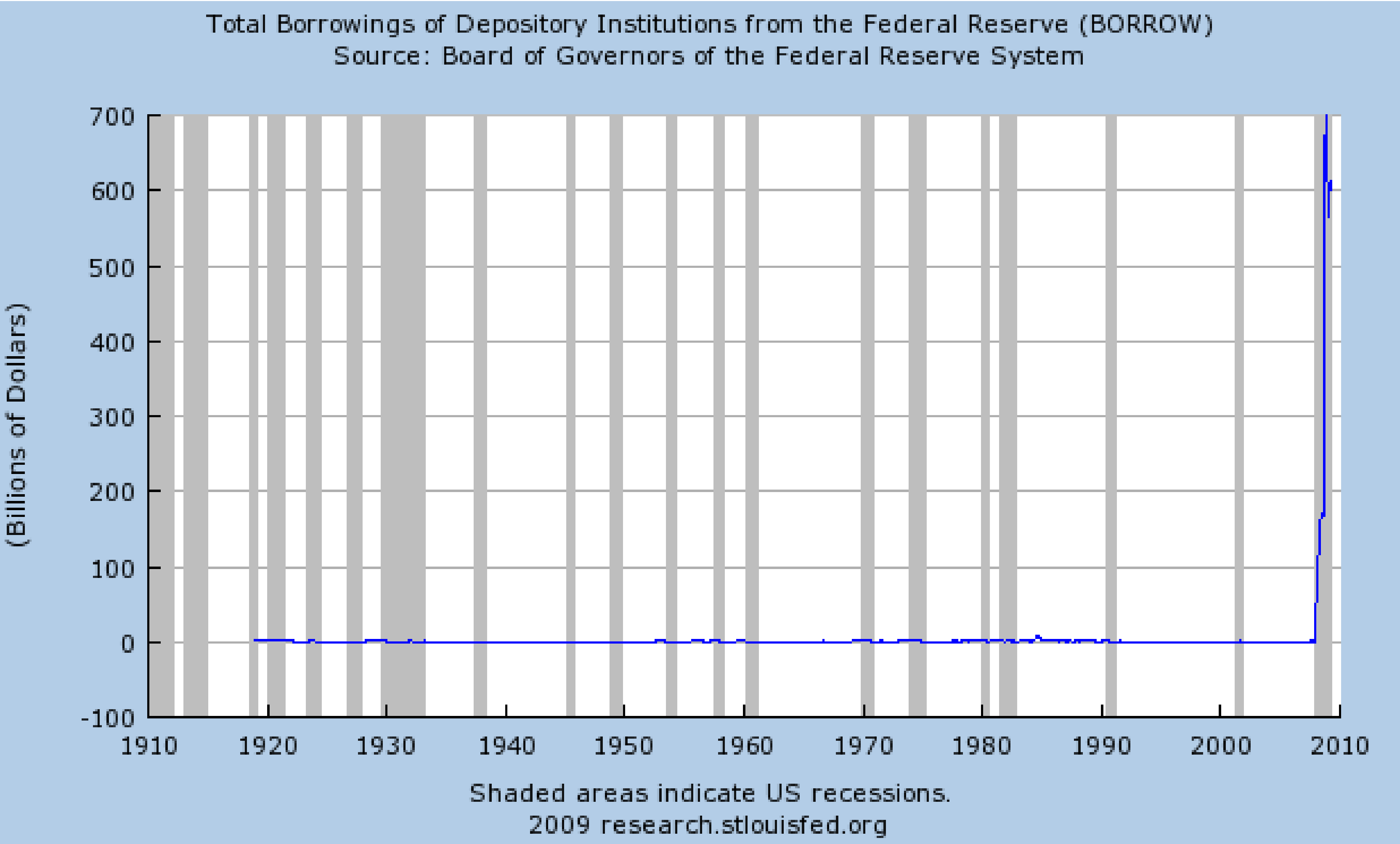
Black Swan (*Cygnus atratus*)

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.

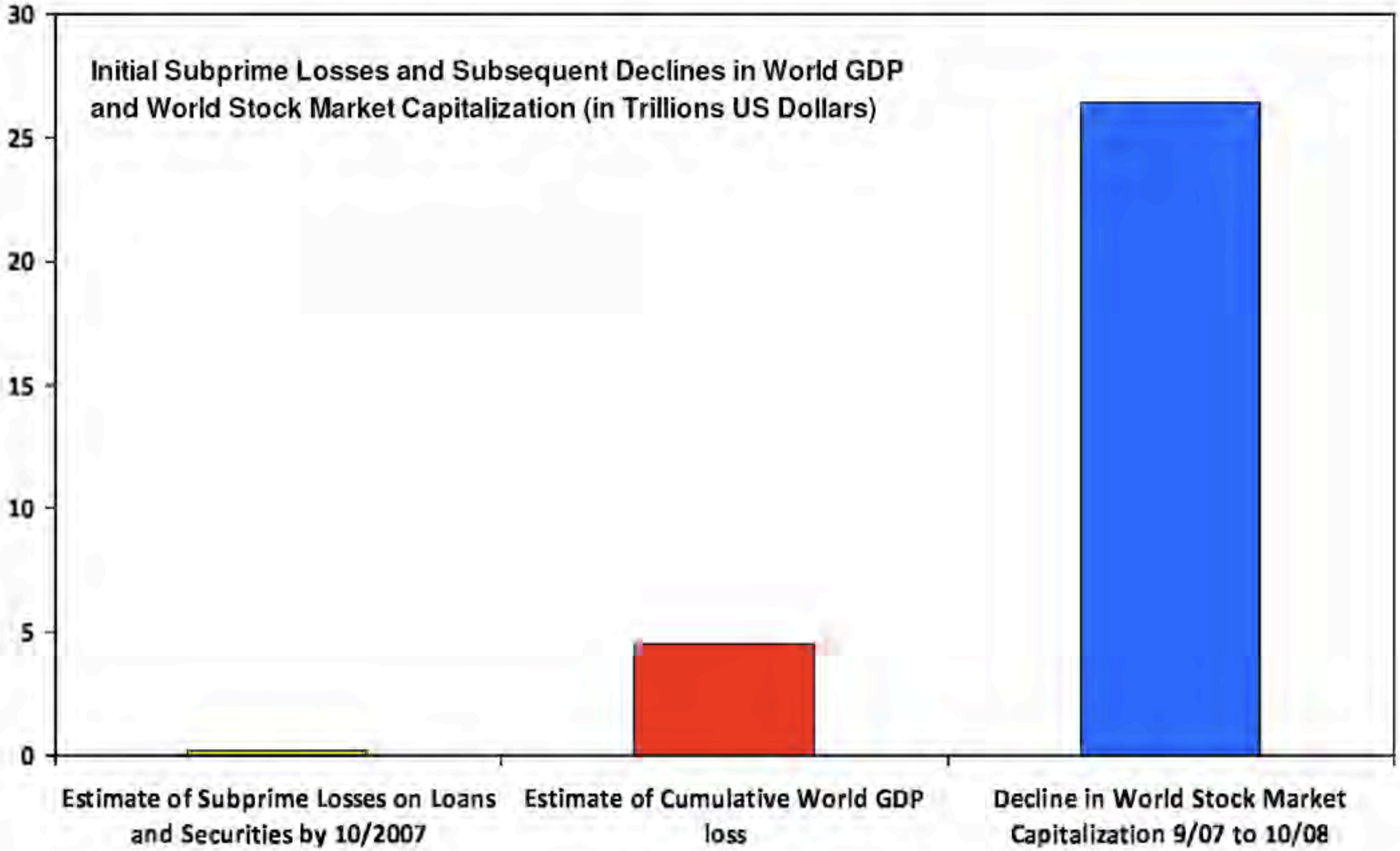
2008 FINANCIAL CRISIS



March 2009

The Paradox of the 2007-20XX Crisis

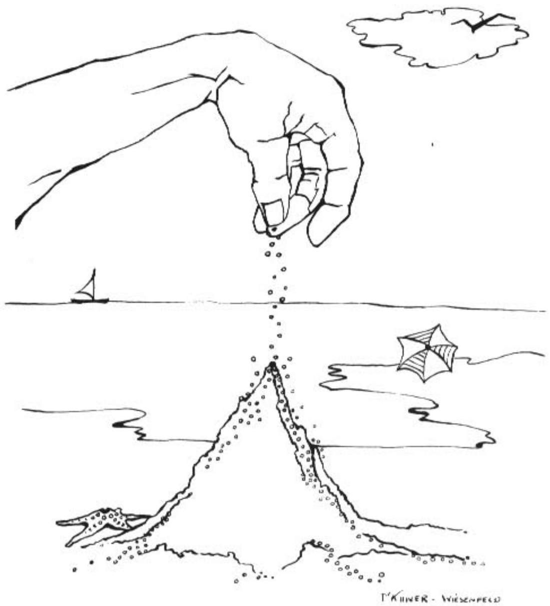
(trillions of US$)



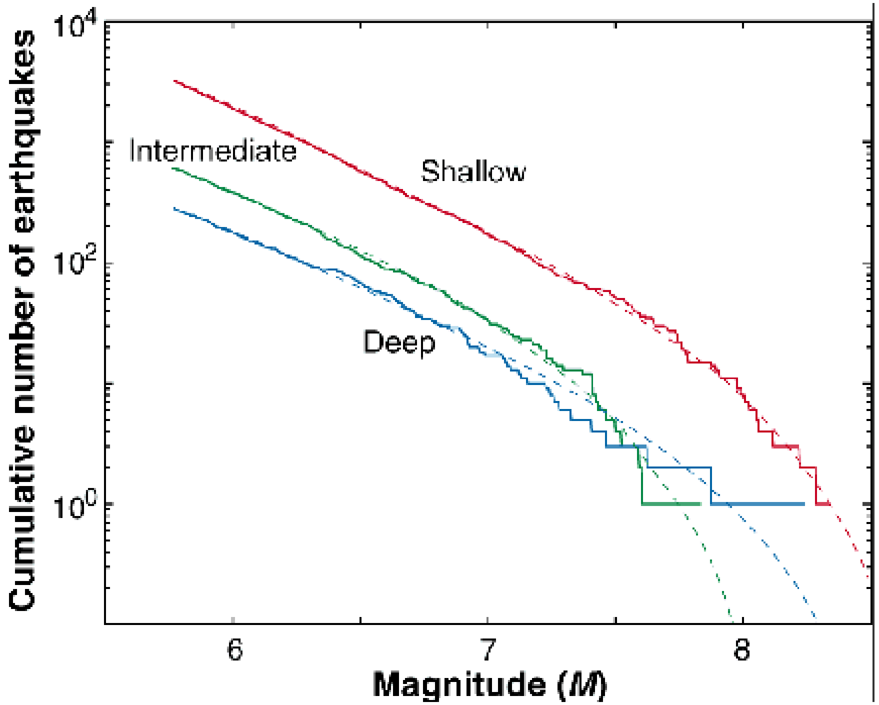
Source: IMF Global Financial Stability Report; World Economic Outlook November update and estimates; World Federation of Exchanges.

“fat-tail event” ?

Self-organized criticality

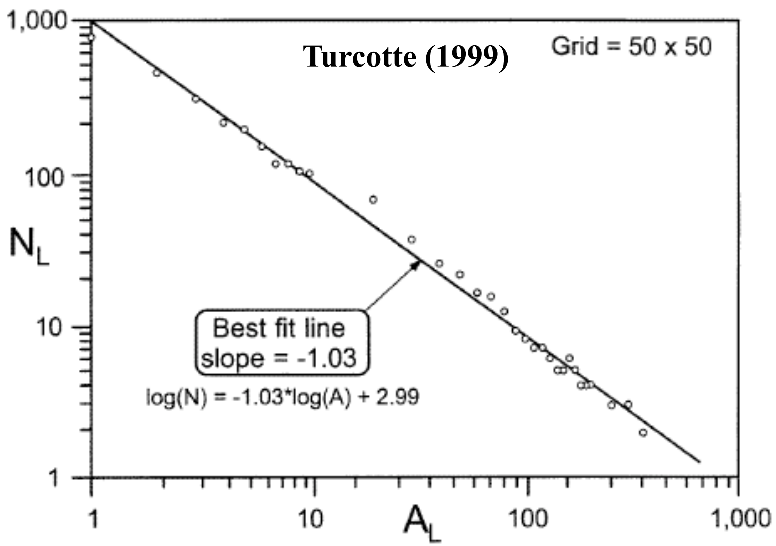


(Bak, Tang, Wiesenfeld, 1987)

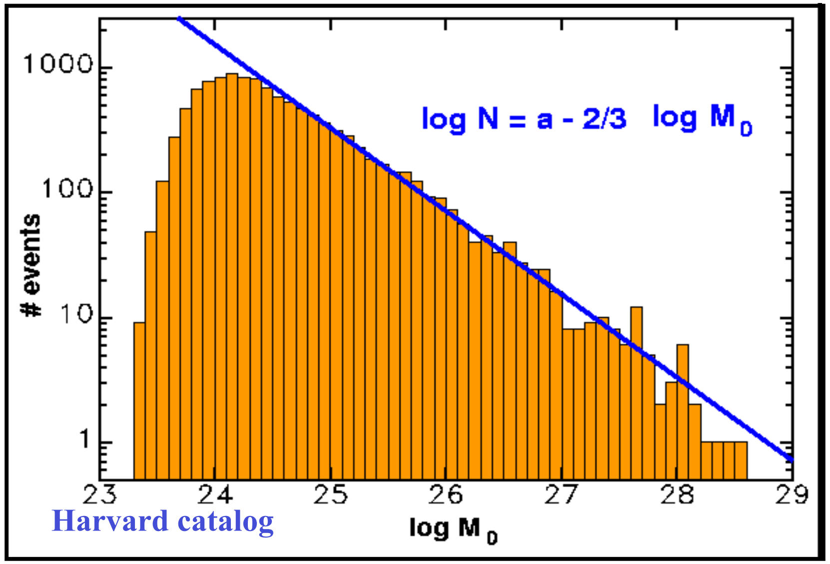


Earthquakes Cannot Be Predicted

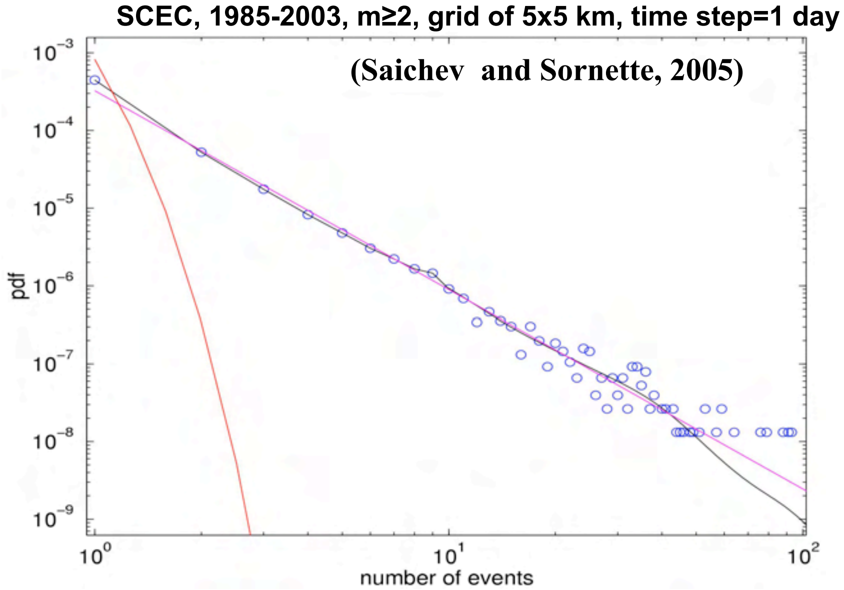
Robert J. Geller, David D. Jackson, Yan Y. Kagan, Francesco Mulargia
Science 275, 1616-1617 (1997)



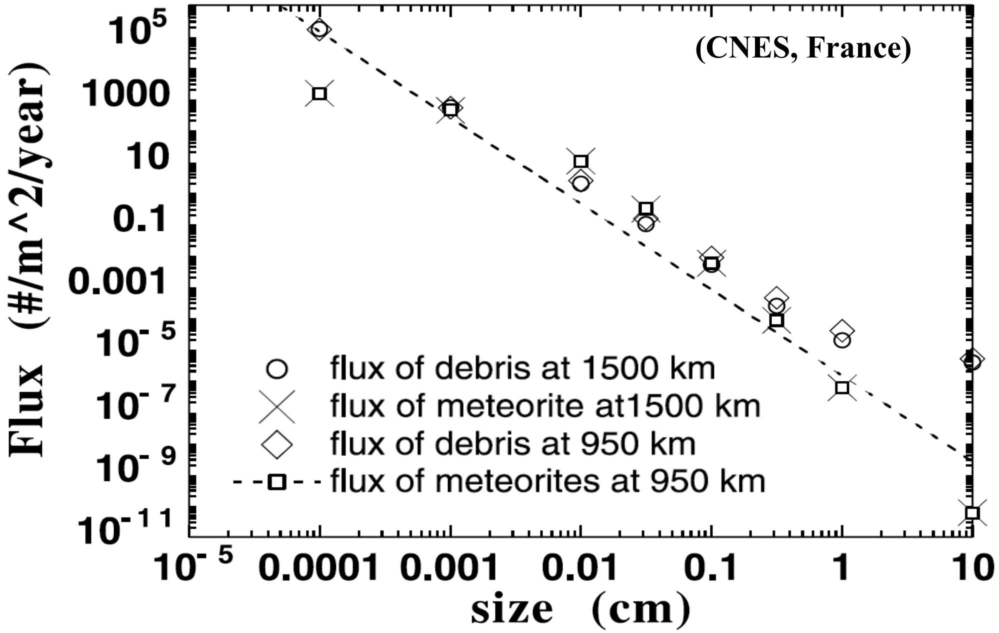
Heavy tails in pdf of earthquakes



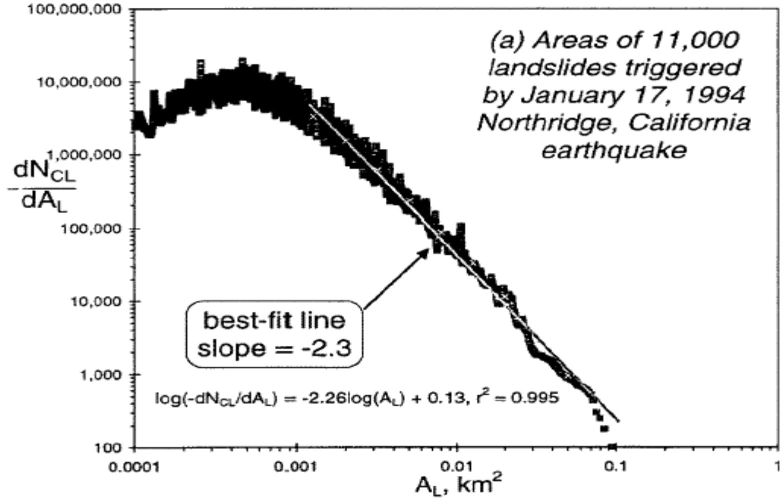
Heavy tails in pdf of seismic rates



Heavy tails in ruptures



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



Turcotte (1999)

Heavy tails in pdf of forest fires

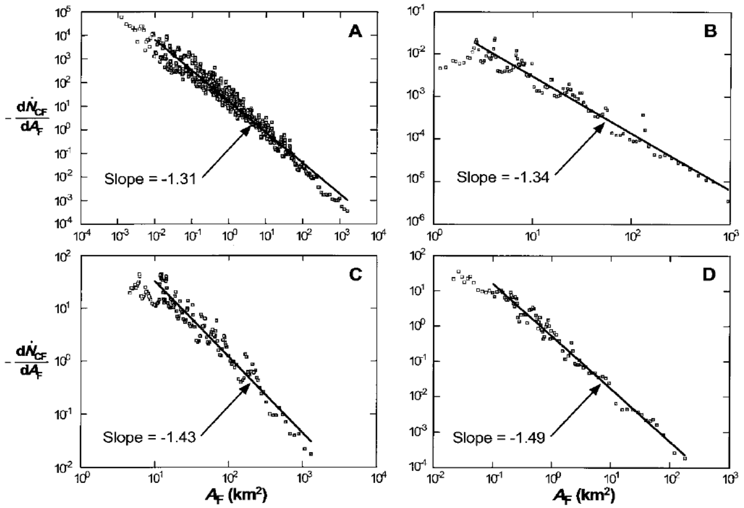
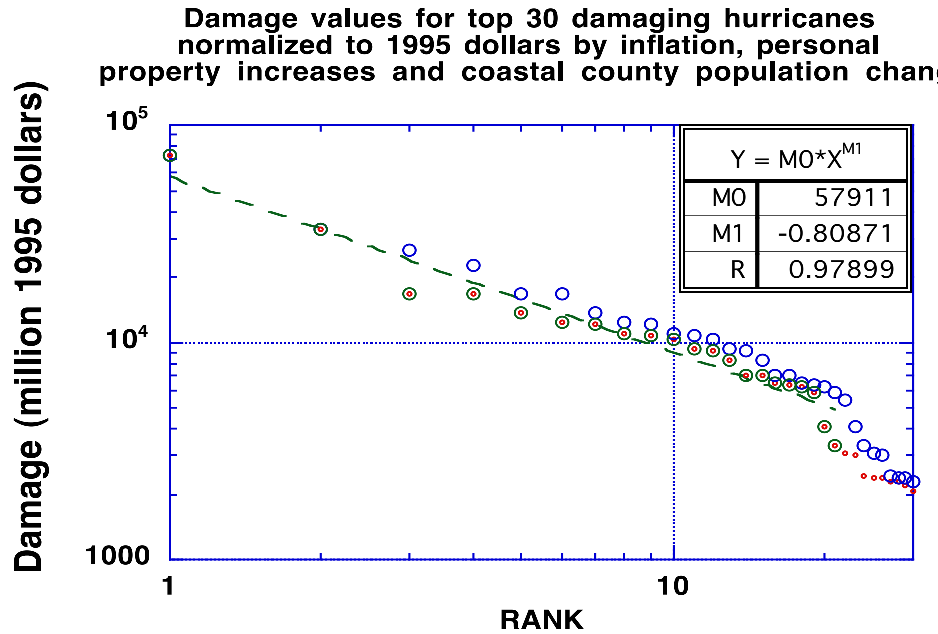


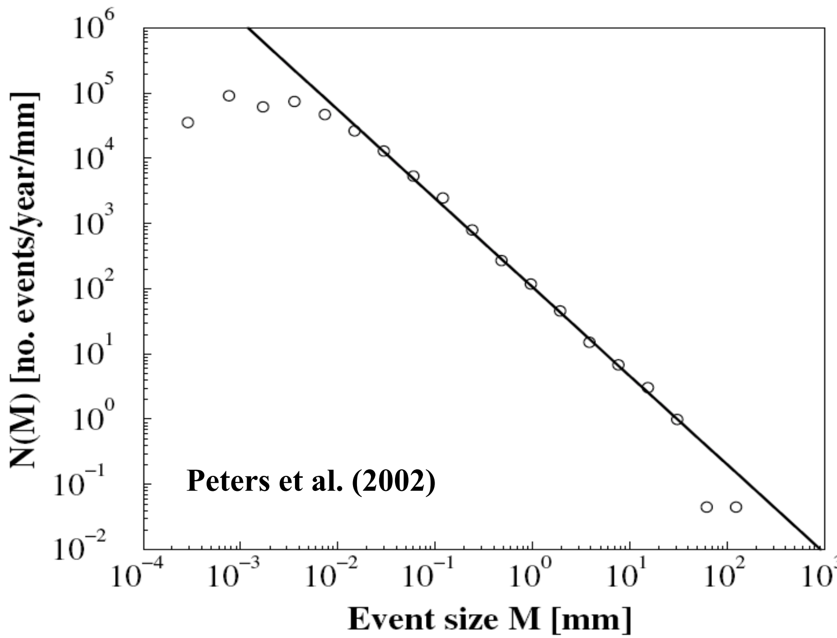
Fig. 2. Noncumulative frequency-area distributions for actual forest fires and wildfires in the United States and Australia: (**A**) 4284 fires on U.S. Fish and Wildlife Service lands (1986–1995) (*9*), (**B**) 120 fires in the western United States (1150–1960) (*10*), (**C**) 164 fires in Alaskan boreal 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)

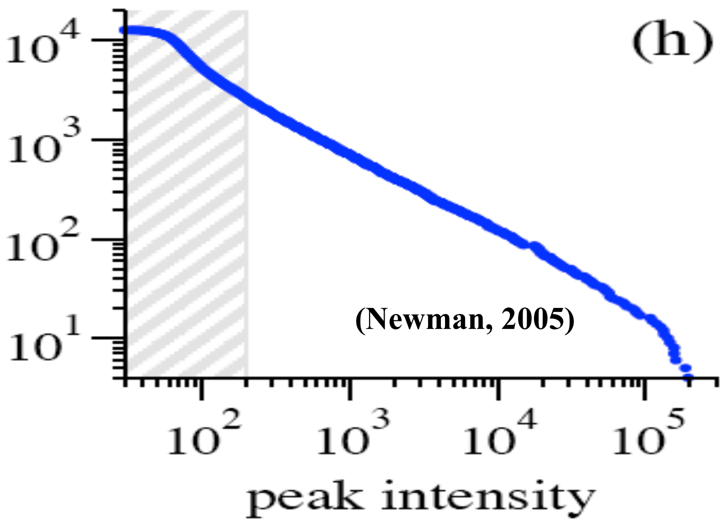
Heavy tails in pdf of Hurricane losses



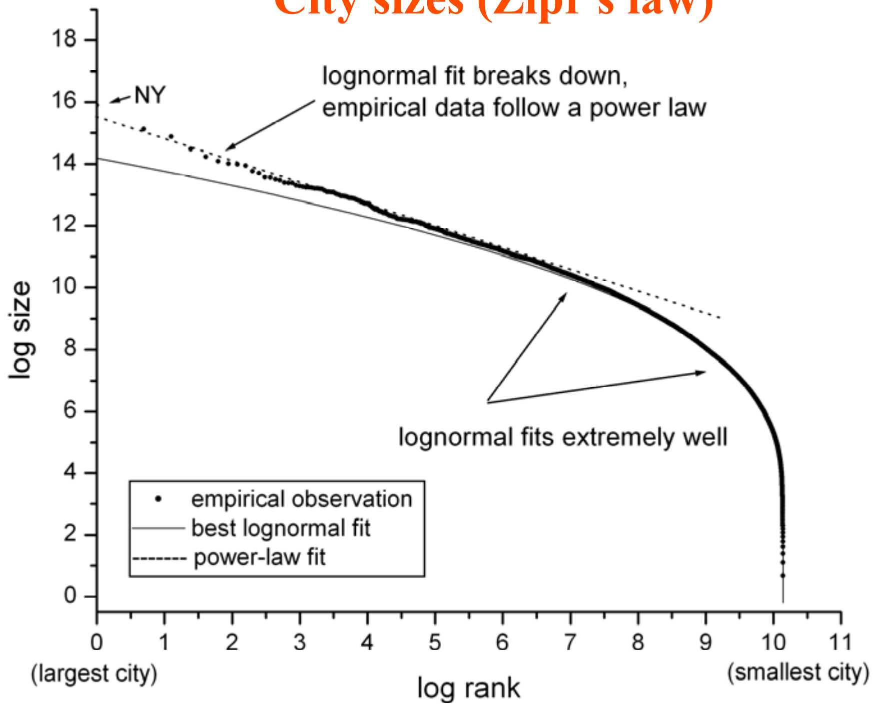
Heavy tails in pdf of rain events

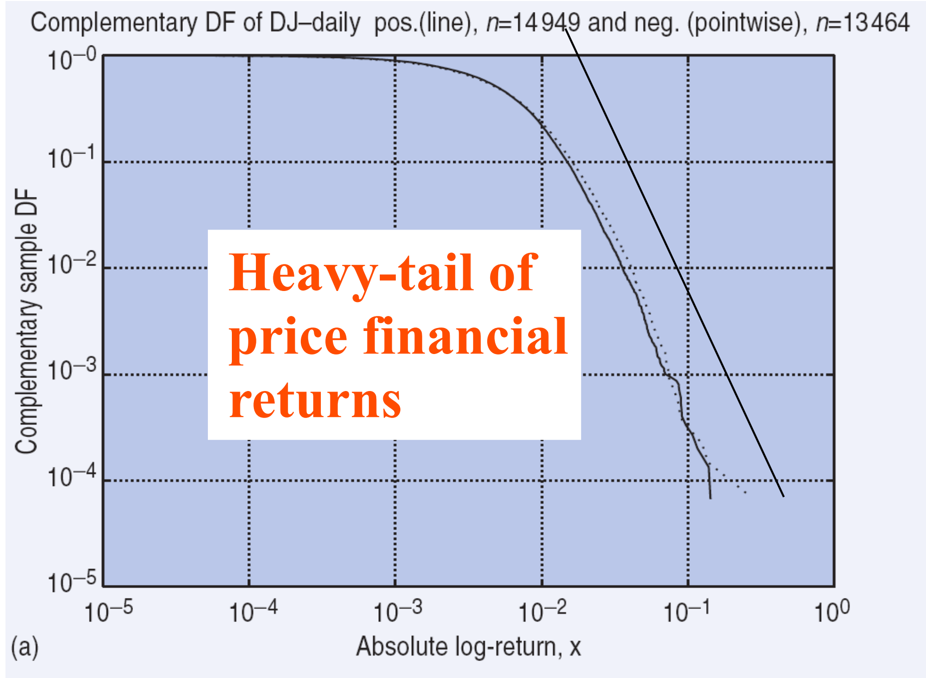


Heavy tails in pdf of Solar flares



City sizes (Zipf's law)





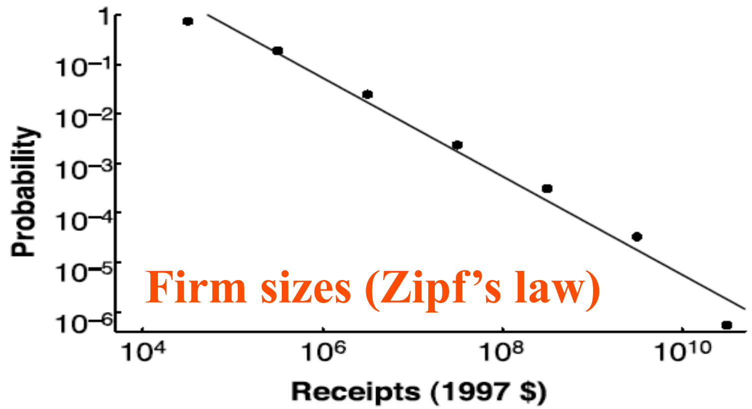
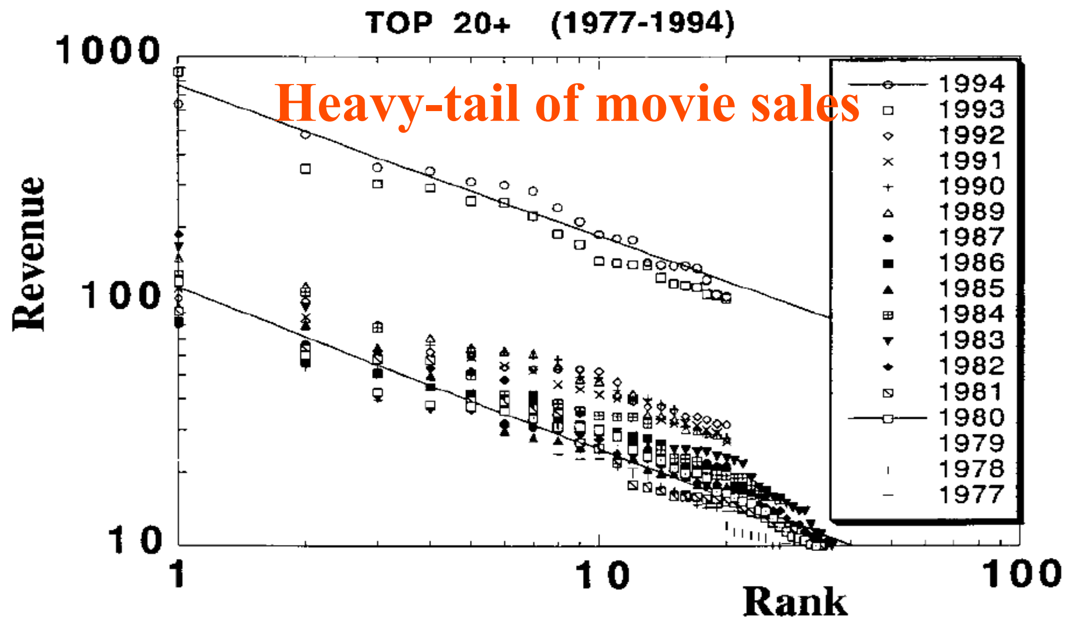
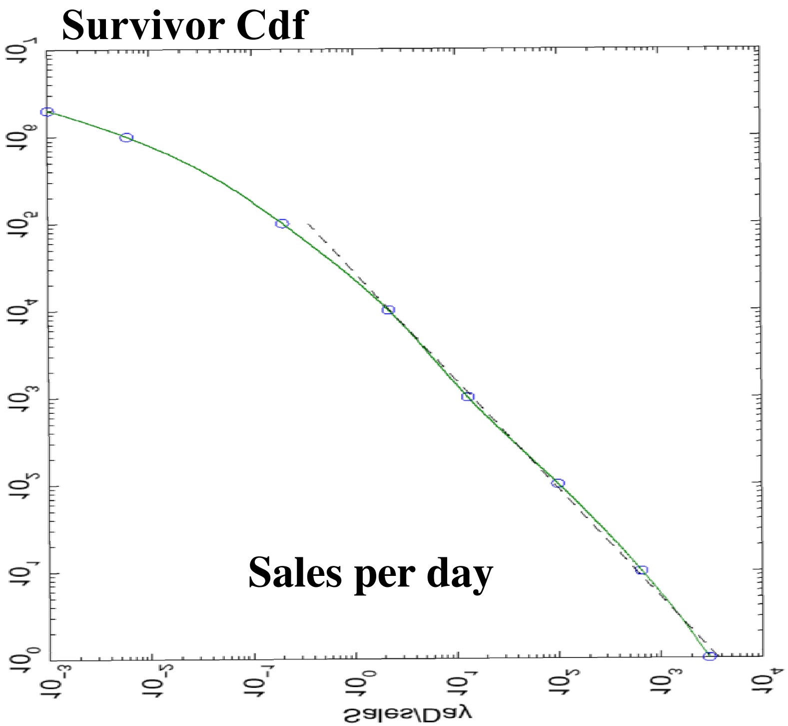


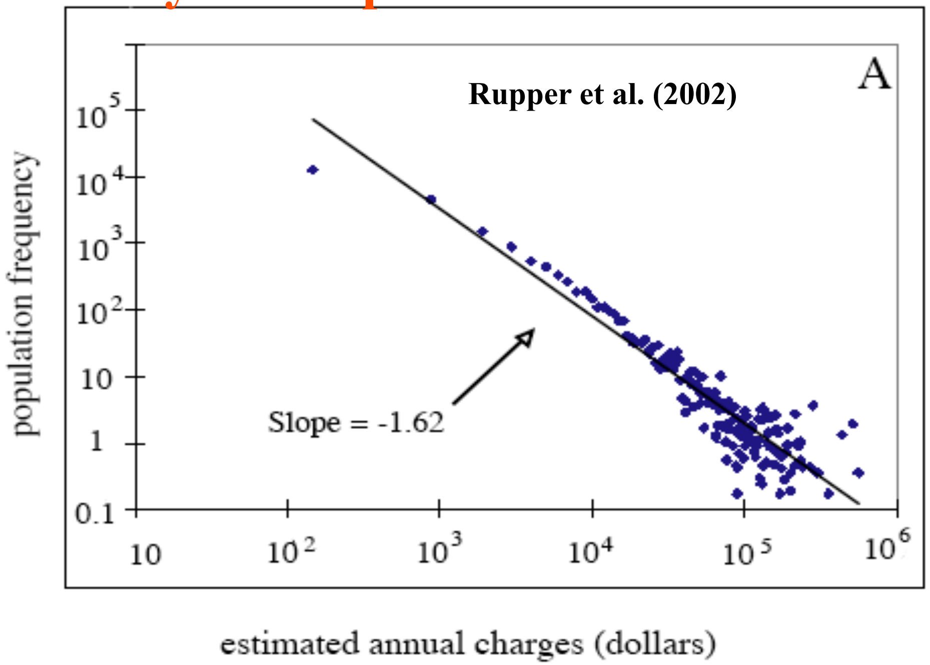
Fig. 2. Tail cumulative distribution function of U.S. firm sizes, by receipts in dollars. Data are for 1997 from the U.S. Census Bureau, tabulated in bins whose width increases in powers of 10. The solid line is the OLS regression line through the data and has slope of 0.994 (SE = 0.064; adjusted $R^2 = 0.976$).



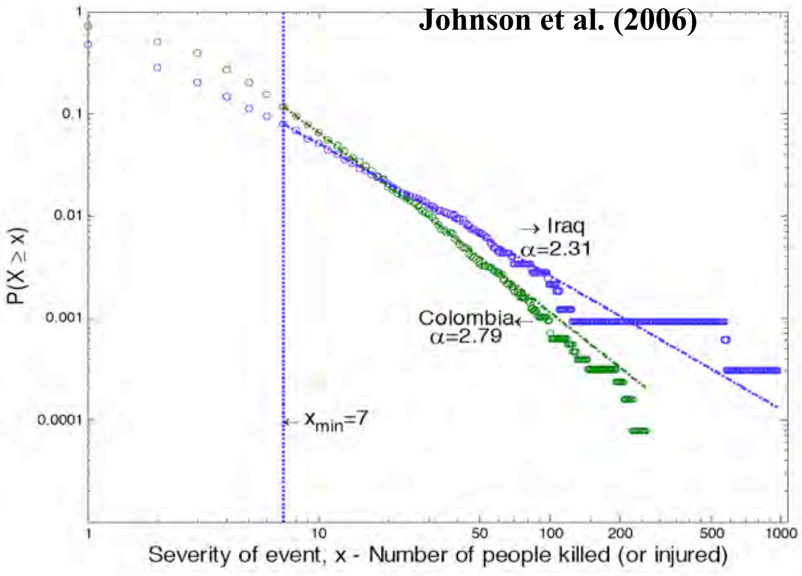
Heavy-tail of pdf of book sales



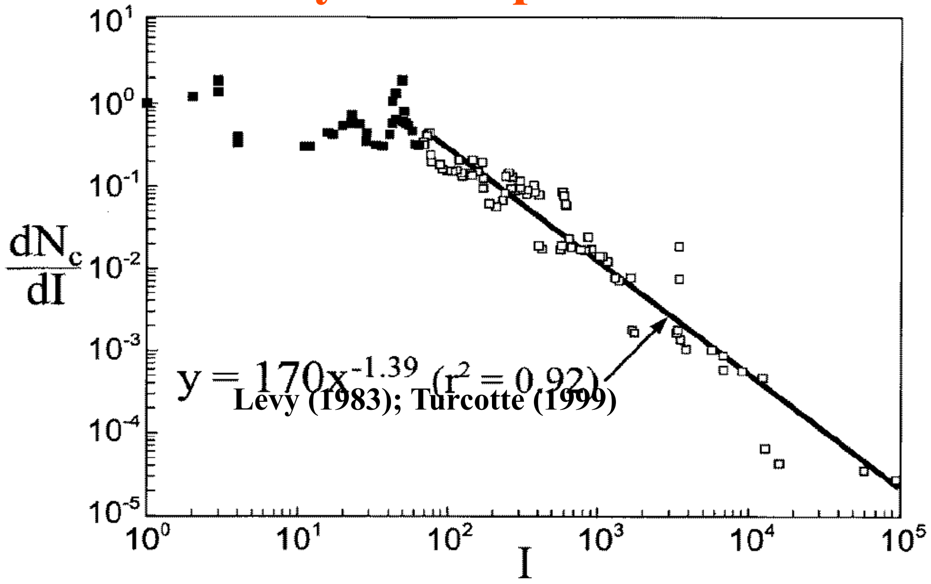
Heavy-tail of pdf of health care costs



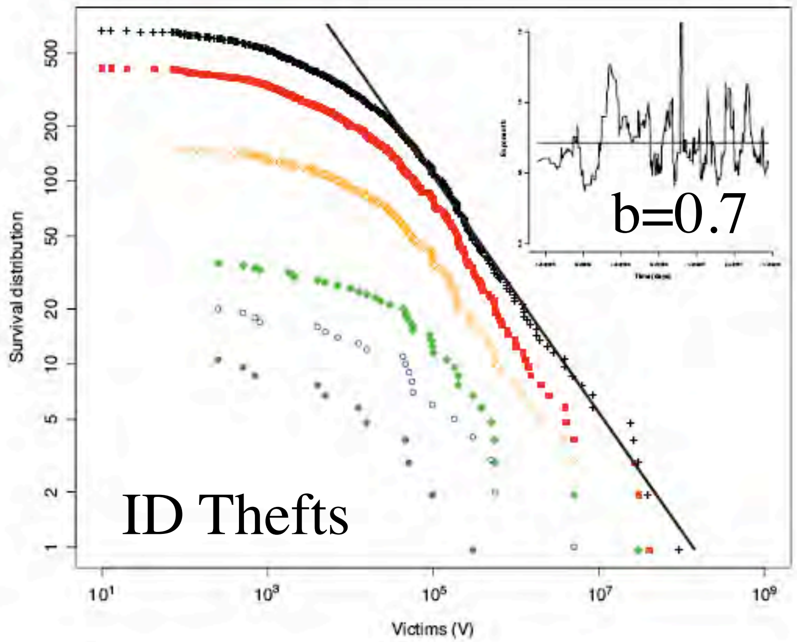
Heavy-tail of pdf of terrorist intensity



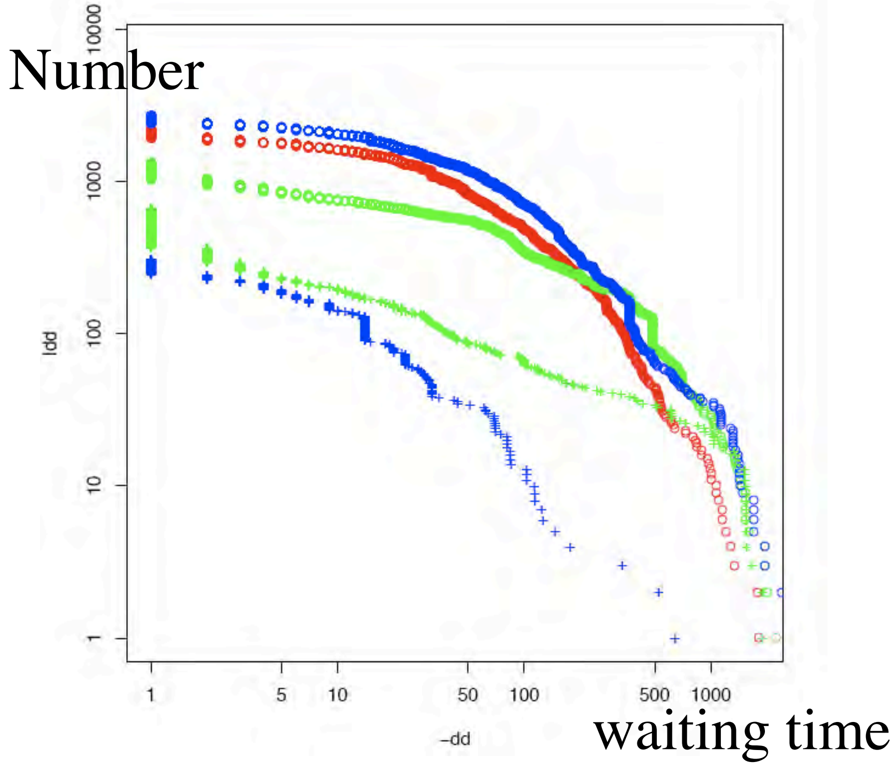
Heavy-tail of pdf of war sizes



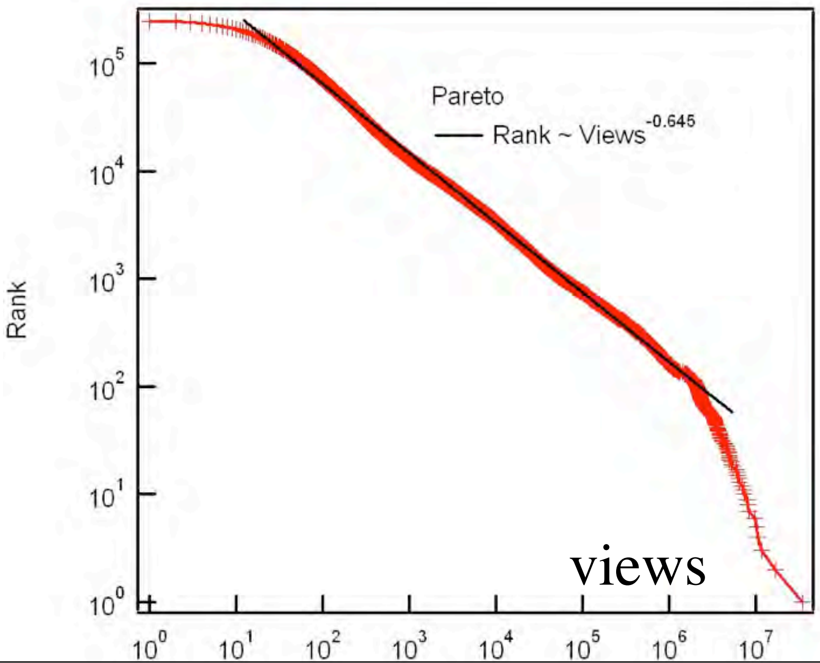
Heavy-tail of cdf of cyber risks

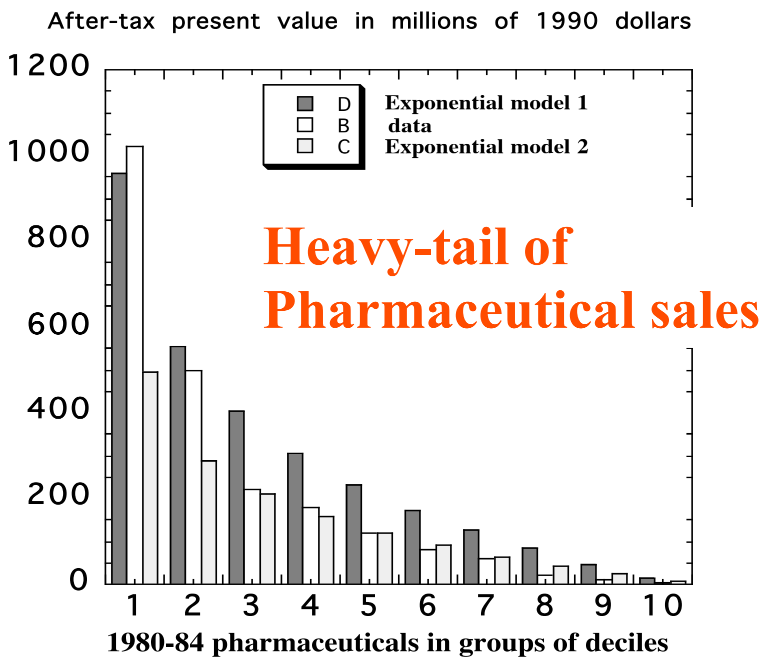


Software vulnerabilities



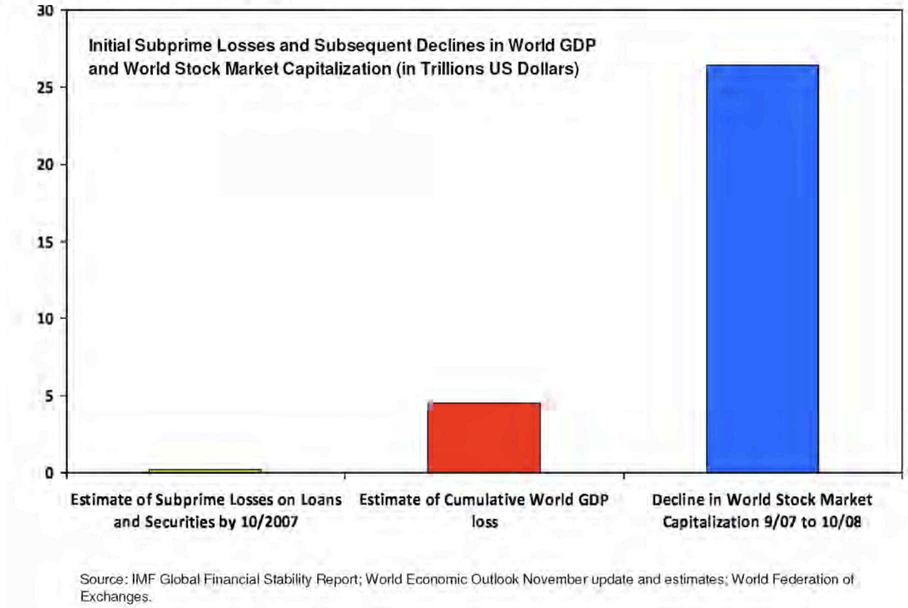
Heavy-tail of YouTube view counts





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 and insurance



Causes of the 2007-XXXX crisis?

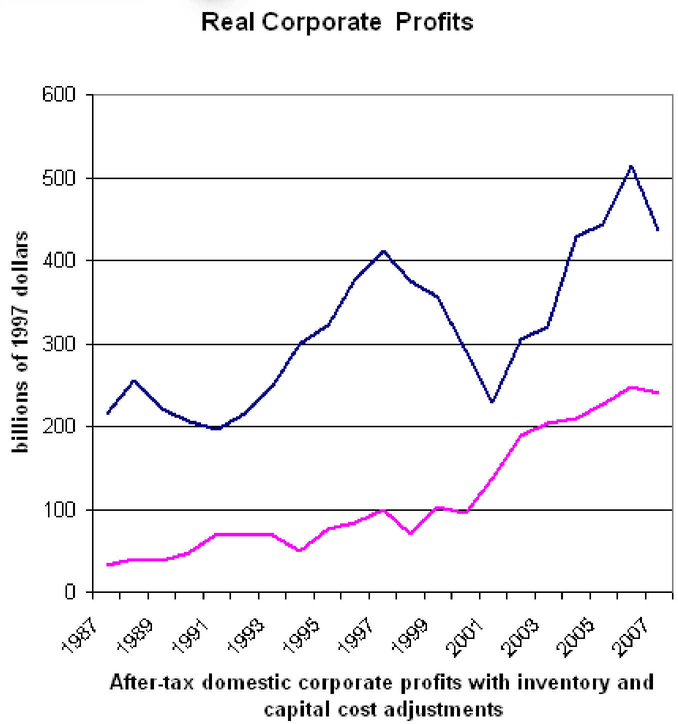
- Real-estate loans and MBS as fraction of bank assets
- Managers greed and poor corporate governance problem
- Deregulation and lack of oversight
- Bad quantitative risk models in banks (Basel II)
- Lowering of lending standards
- Securitization of finance
- Leverage
- Rating agency failures
- Under-estimating aggregate risks
- Growth of over-capacity

+ facilitating factors (Freddy Mac and Fanny Mae, social politics ...)

Dragons and PREDICTION

Dragon-king story

- 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

Dragon-king story

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)

Beyond power laws: 7 examples of "Dragons"

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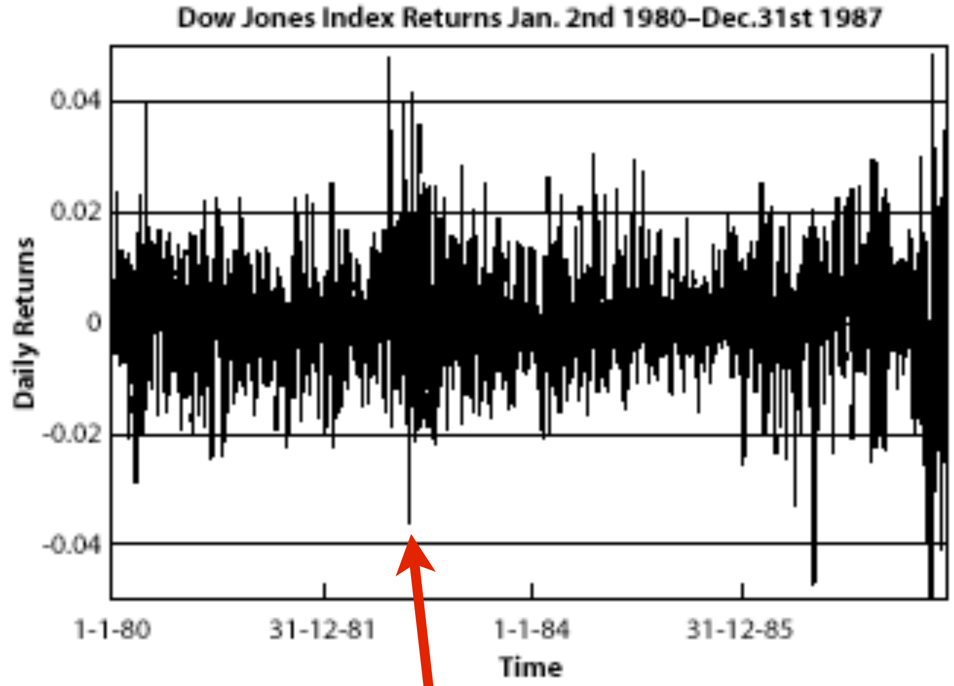
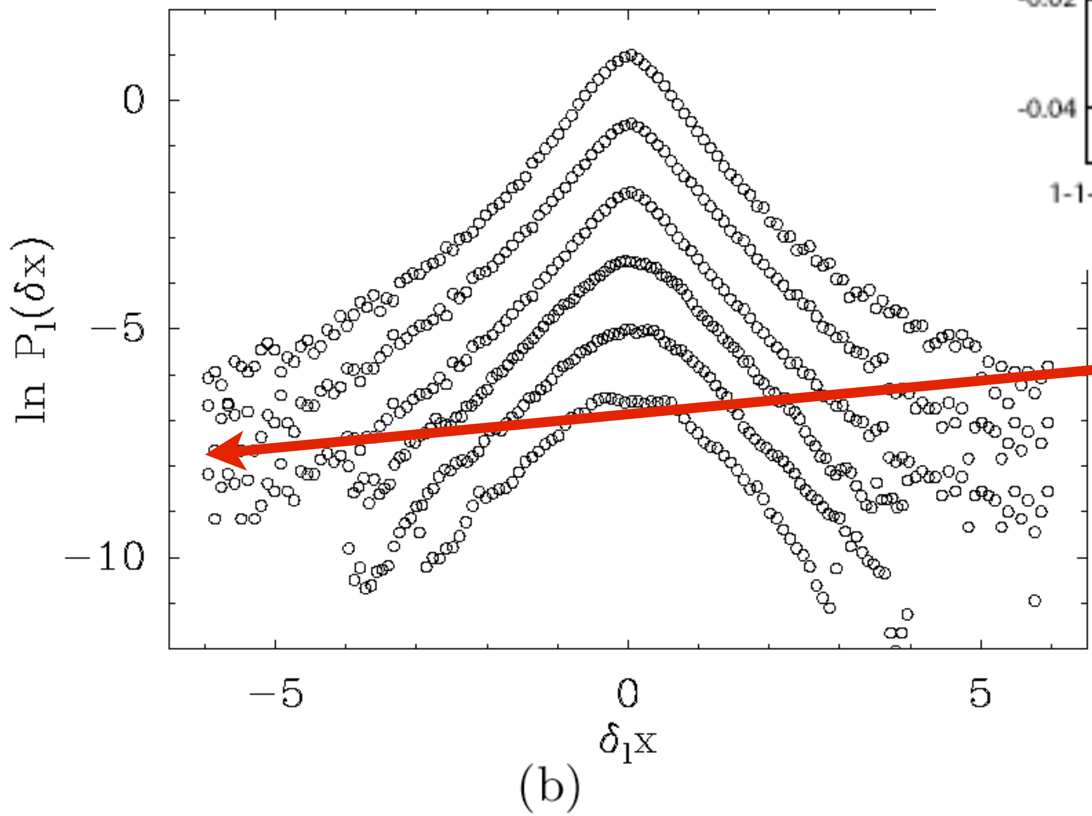
Crashes as "Black swans"?

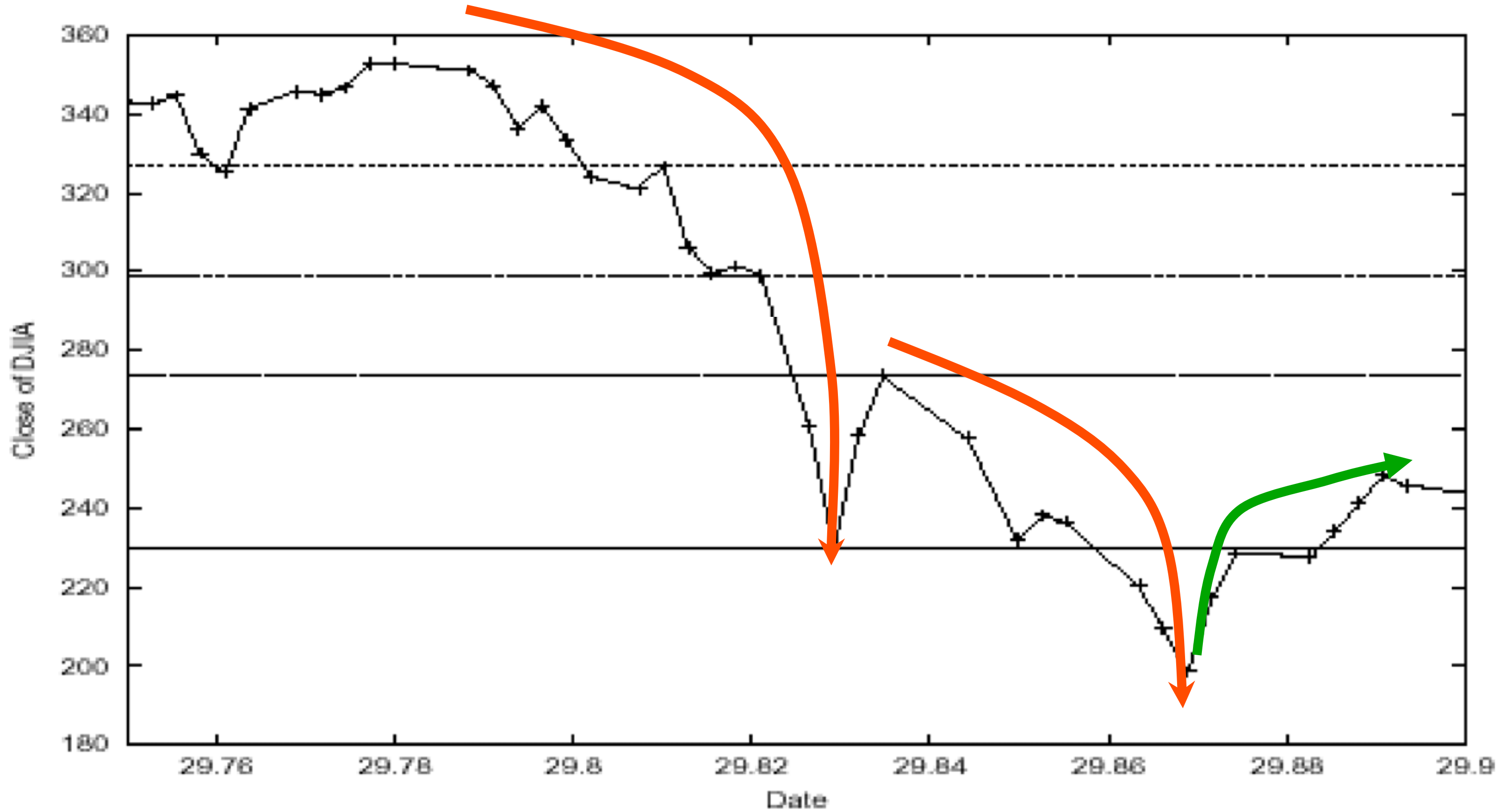
Traditional emphasis on Daily returns do not reveal any anomalous events



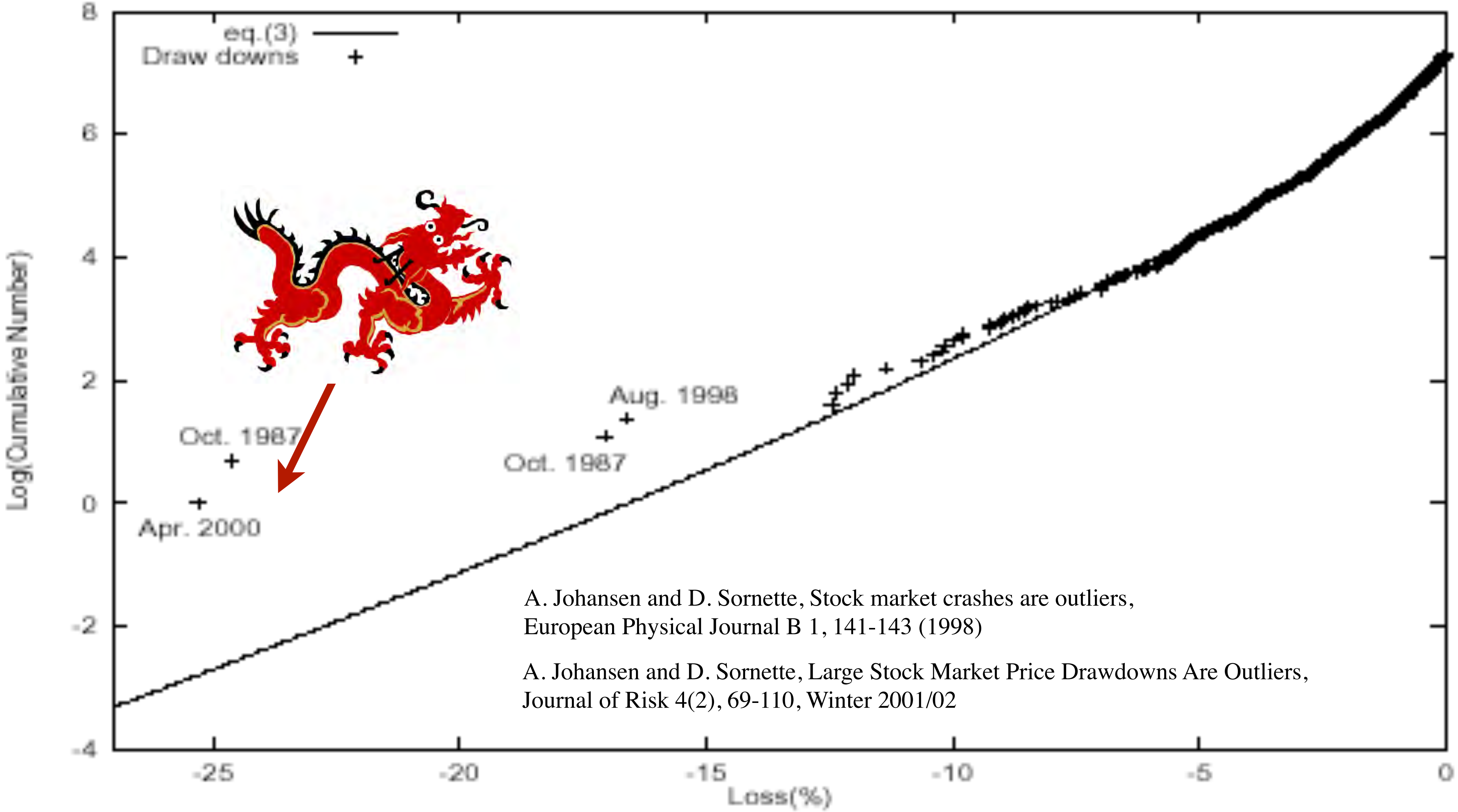


"Black swans"

Better risk measure: drawdowns



“Dragons” of financial risks



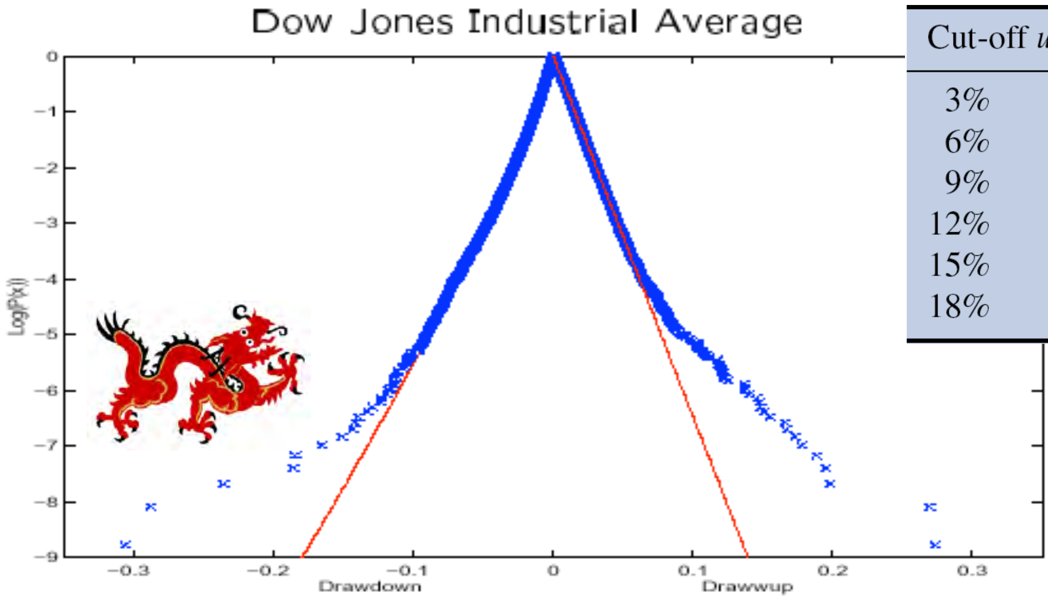
A. Johansen and D. Sornette, Stock market crashes are outliers, European Physical Journal B 1, 141-143 (1998)

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

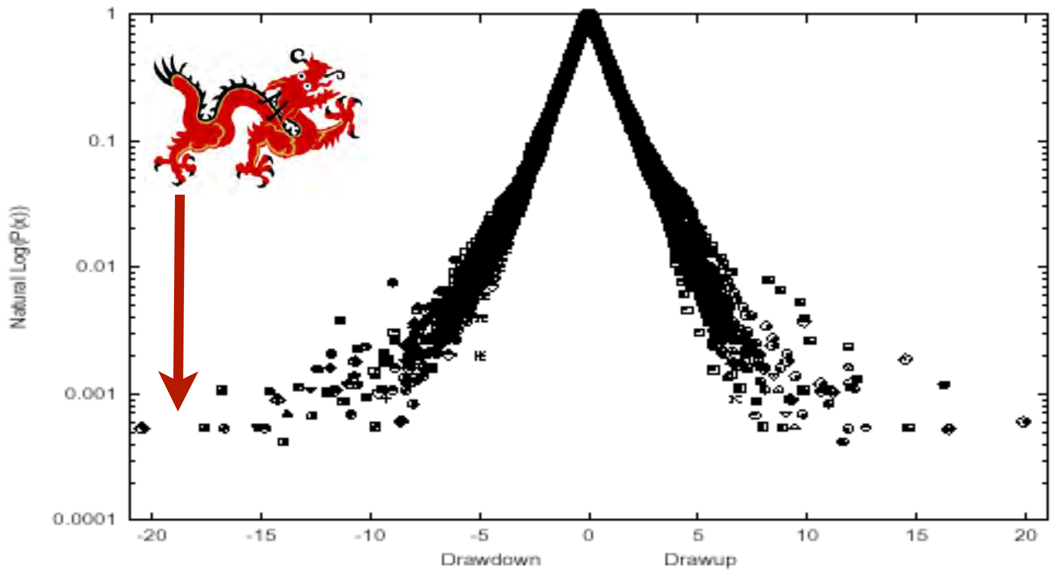
$$N(DD) = A \exp\left(-\left(|DD|/\chi\right)^z\right).$$

"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%



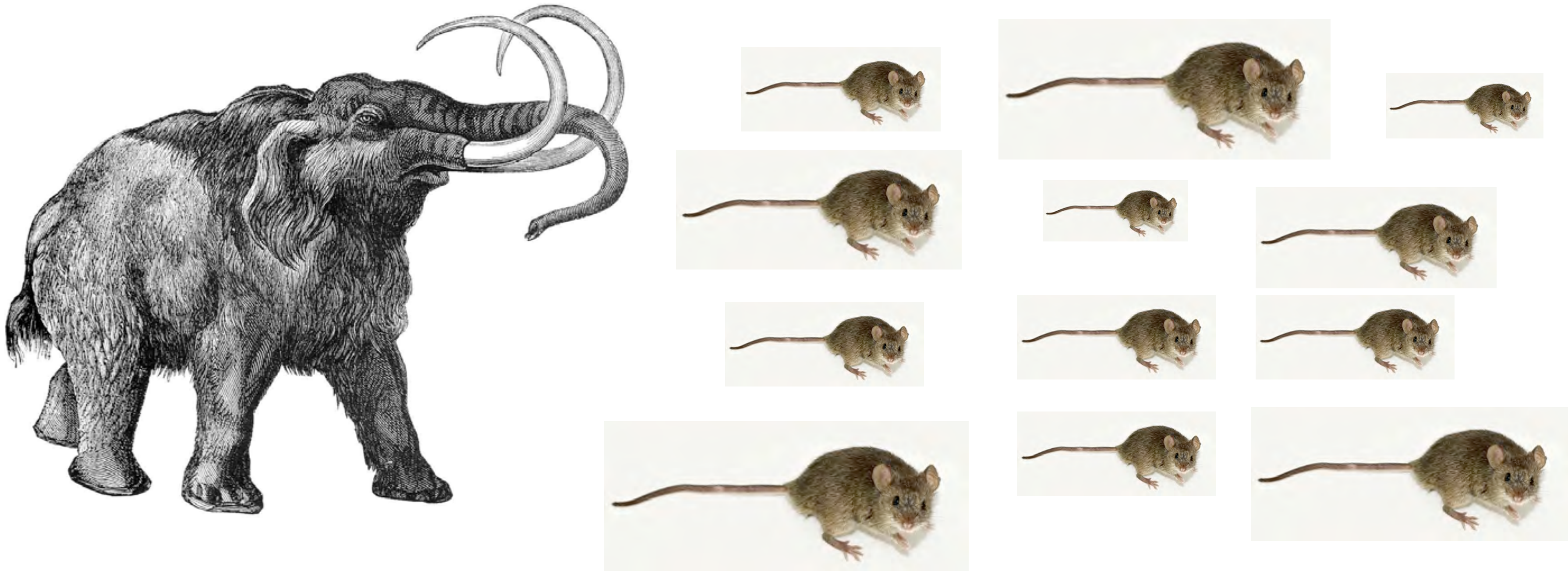
10% daily drop on Nasdaq : 1/1000 probability

1 in 1000 days => 1 day in 4 years

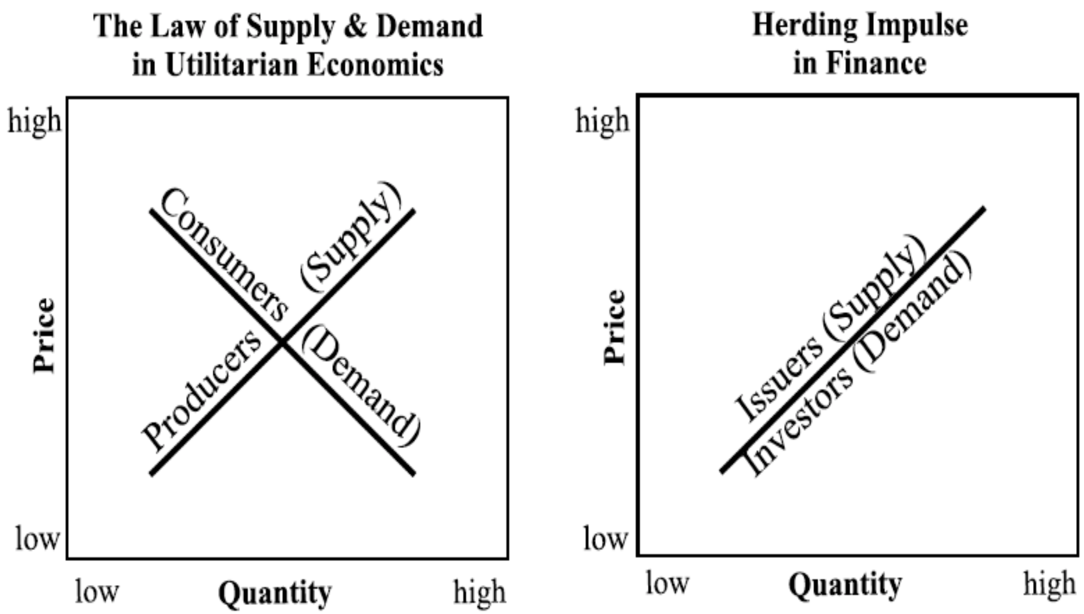
30% drop in three consecutive days?

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

=> one event in 4 millions years!



Positive feedbacks



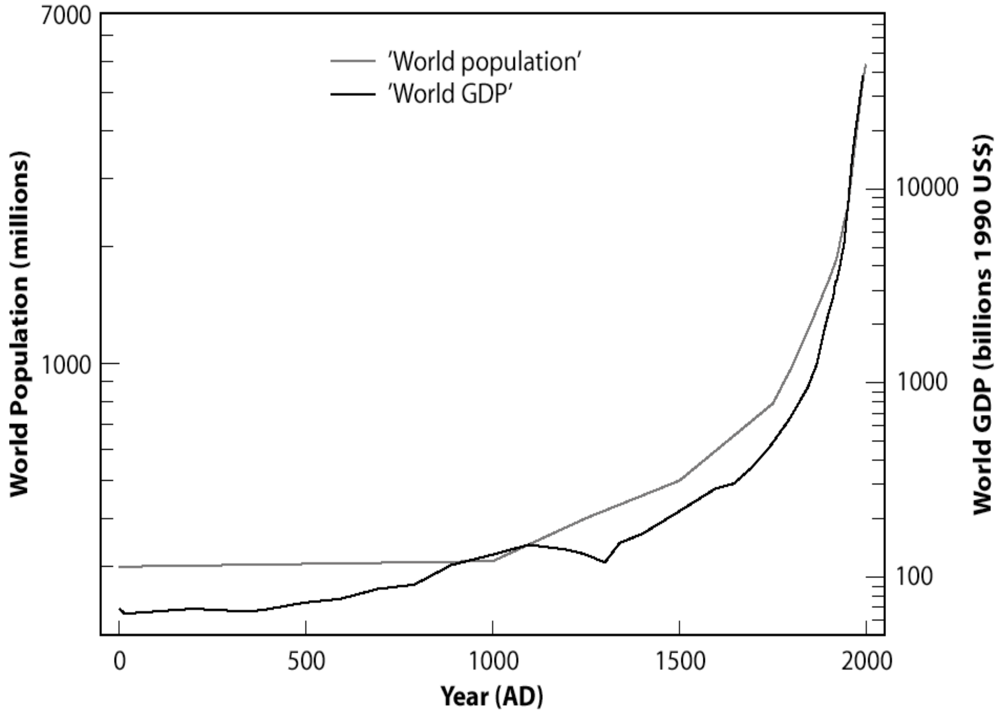
© 2003 Robert R. Prechter, The Socionomics Institute

-bubble phase
-crash phase

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

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

$$m = 1/(d-1) > 0 \text{ and } t_c = t_0 + m p_0^{1-d}/c.$$



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

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)

Imitation

-Imitation is considered an efficient mechanism of social learning.

- Experiments in developmental psychology suggest that infants use imitation to get to know persons, possibly applying a ‘like-me’ test (‘persons which I can imitate and which imitate me’).

- Imitation is among the most complex forms of learning. It is found in highly socially living species which show, from a human observer point of view, ‘intelligent’ behavior and signs for the evolution of traditions and culture (humans and chimpanzees, whales and dolphins, parrots).

- In non-natural agents as robots, tool for easing the programming of complex tasks or endowing groups of robots with the ability to share skills without the intervention of a programmer. Imitation plays an important role in the more general context of interaction and collaboration between software agents and human users.

Thy Neighbor's Portfolio: Word-of-Mouth Effects in the Holdings and Trades of Money Managers

THE JOURNAL OF FINANCE • VOL. LX, NO. 6 • DECEMBER 2005

HARRISON HONG, JEFFREY D. KUBIK, and JEREMY C. STEIN*

A mutual fund manager is more likely to buy (or sell) a particular stock in any quarter if other managers in the same city are buying (or selling) that same stock. This pattern shows up even when the fund manager and the stock in question are located far apart, so it is distinct from anything having to do with local preference. The evidence can be interpreted in terms of an epidemic model in which investors spread information about stocks to one another by word of mouth.

A fundamental observation about human society is that people who communicate regularly with one another think similarly. There is at any place and in any time a *Zeitgeist*, a spirit of the times.... Word-of-mouth transmission of ideas appears to be an important contributor to day-to-day or hour-to-hour stock market fluctuations. (pp. 148, 155)

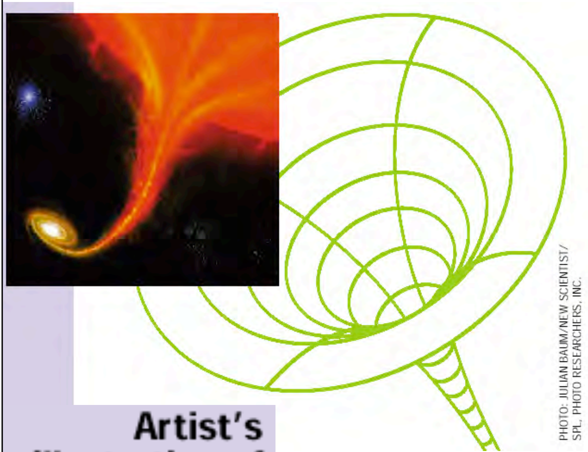
Shiller (2000)

Humans Appear Hardwired To Learn By 'Over-Imitation'

ScienceDaily (Dec. 6, 2007) — Children learn by imitating adults--so much so that they will rethink how an object works if they observe an adult taking unnecessary steps when using that object, according to a new Yale study.

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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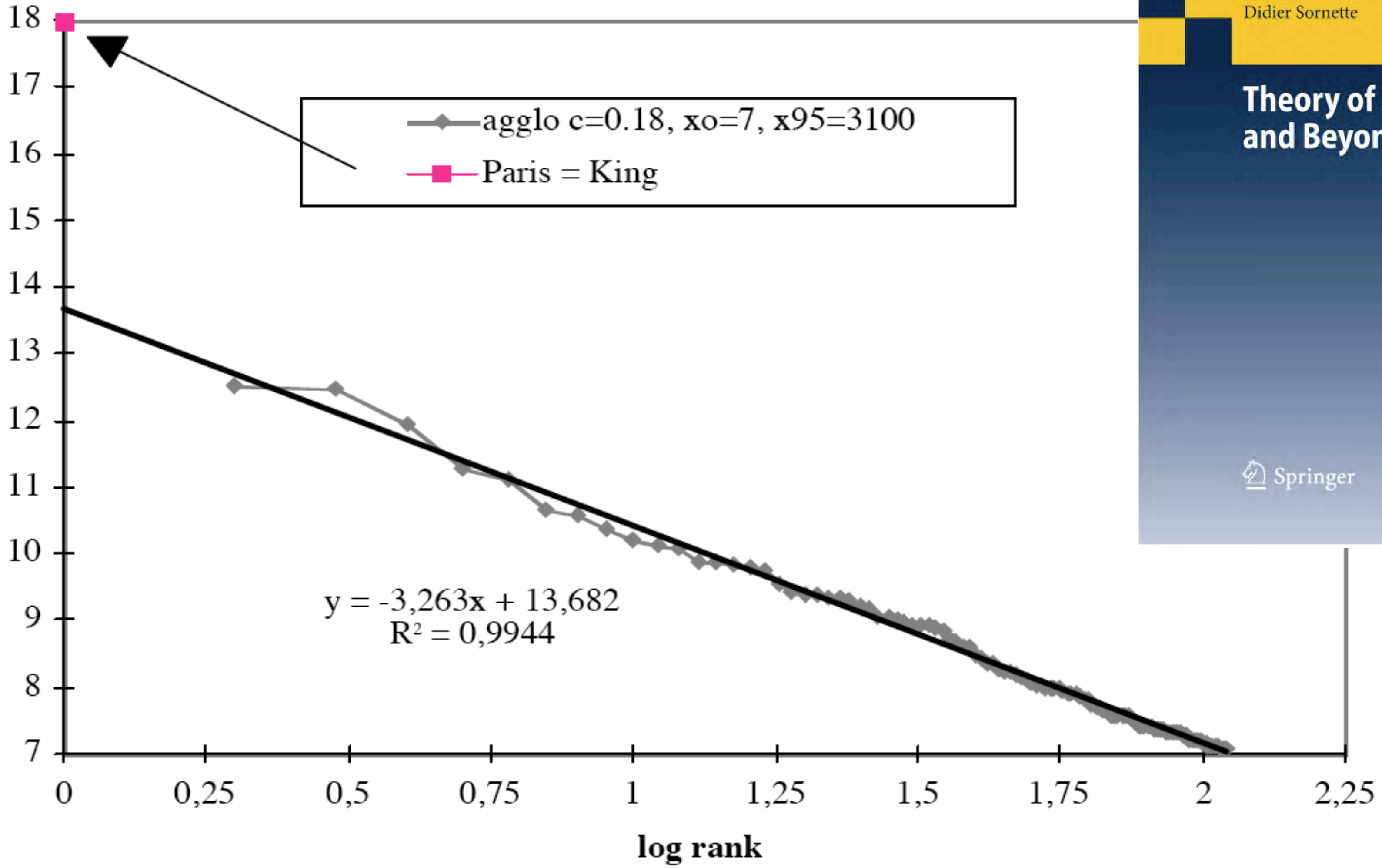
Paris as a king-dragon



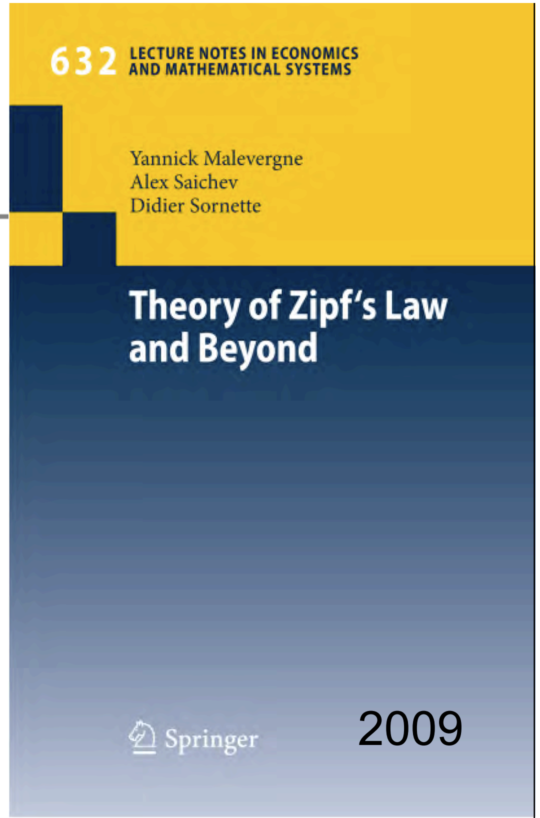


Fig. 7. French agglomerations: stretched exponential and "King effect".

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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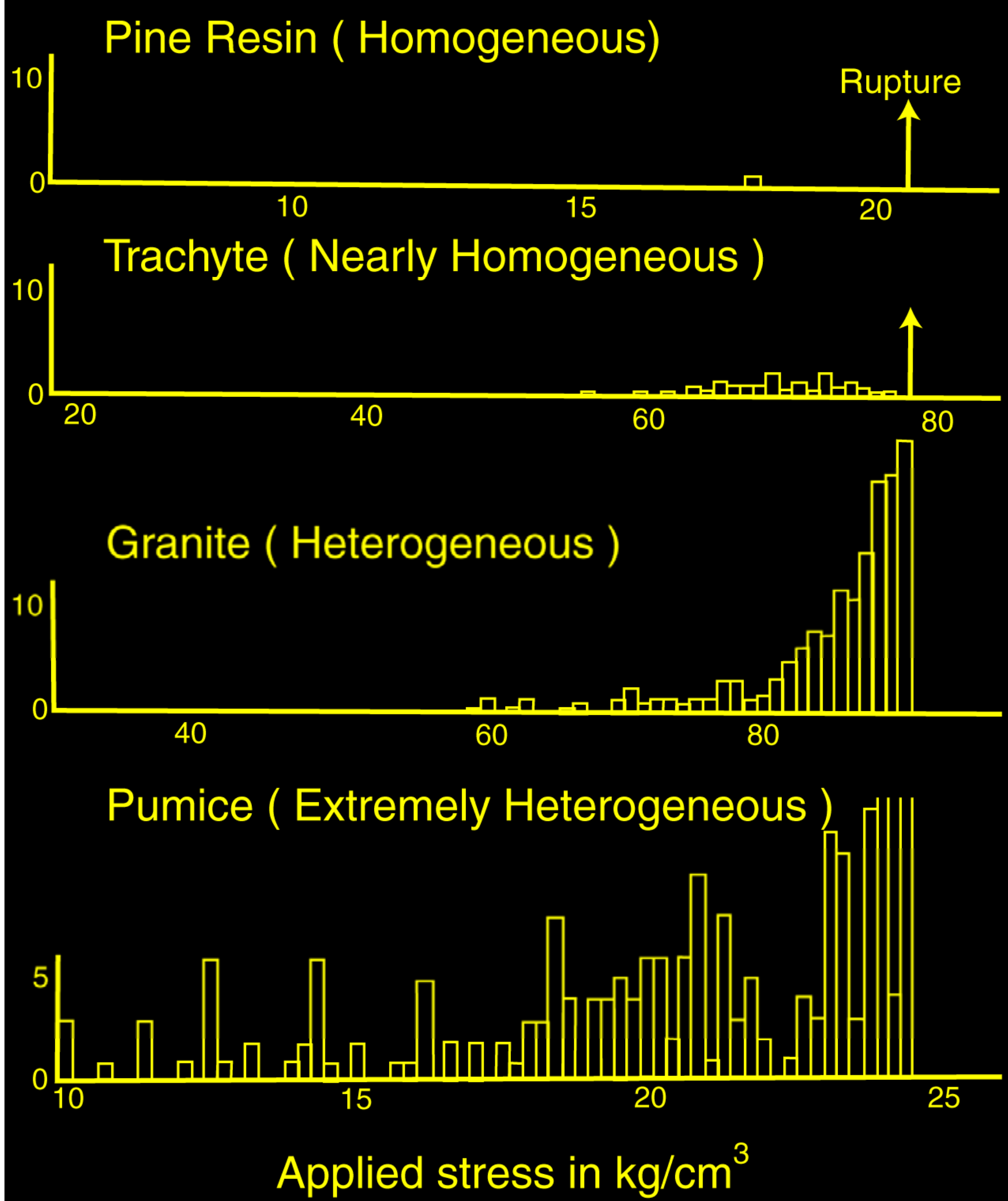


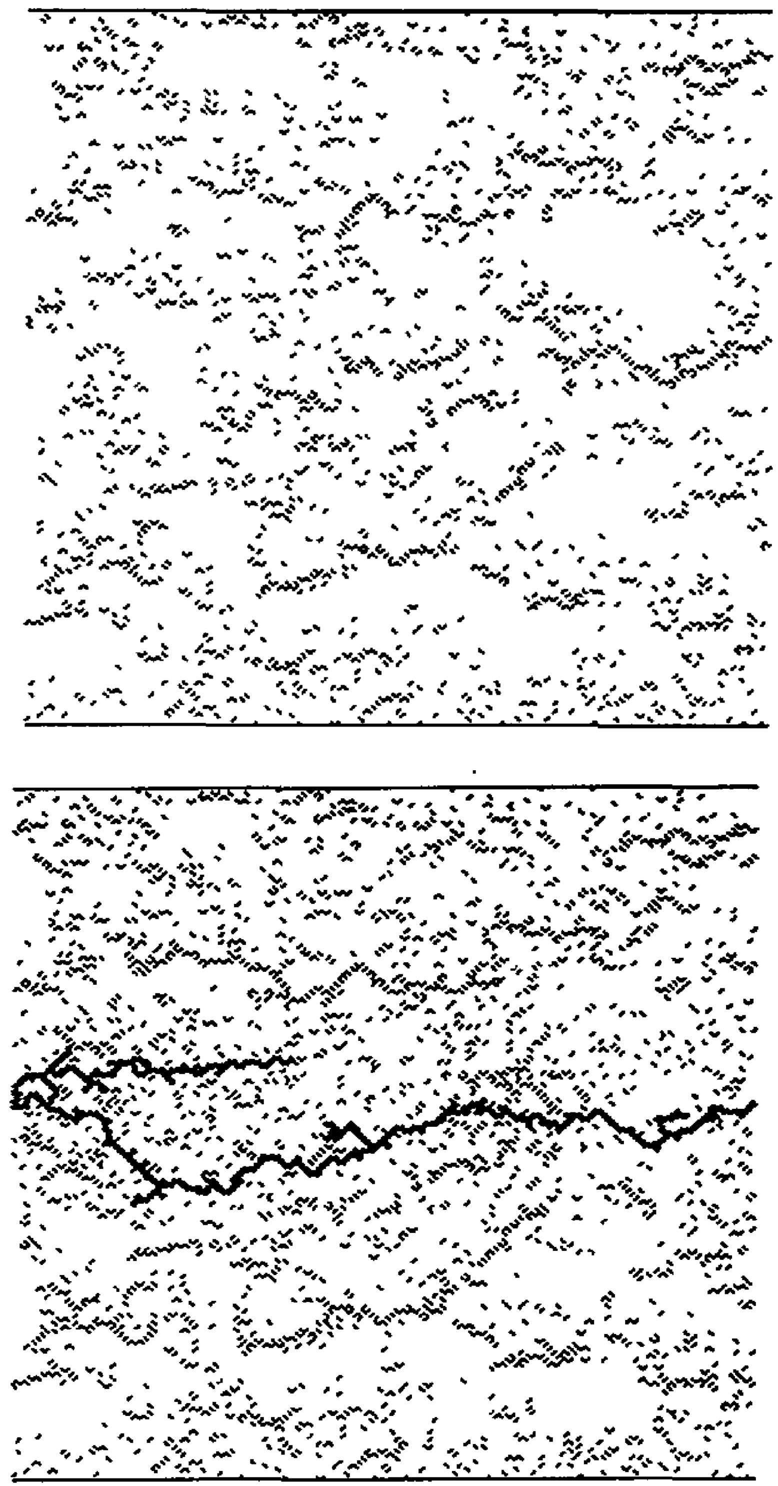
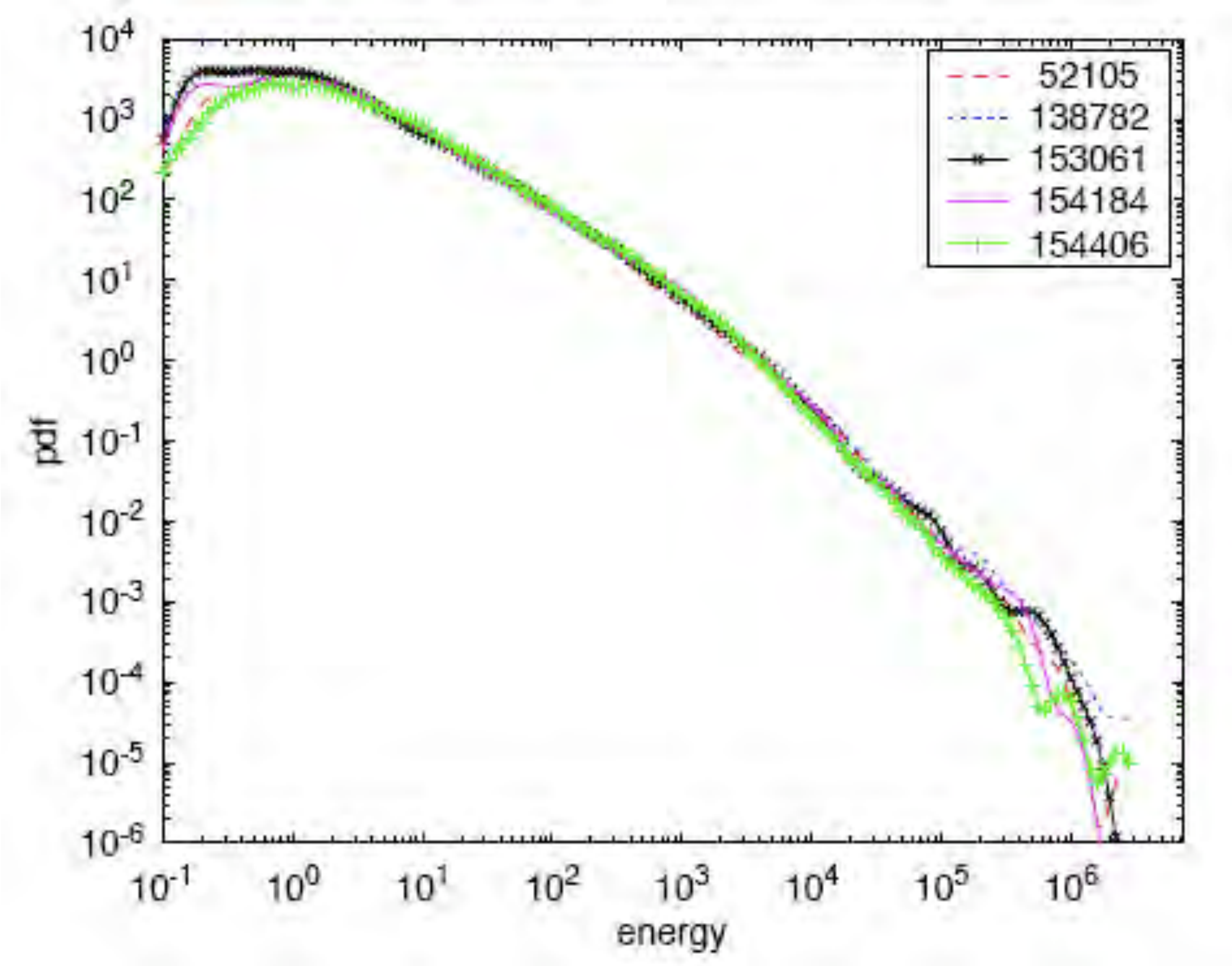


Fig. 4. Frequency of elastic shocks under increasing stresses in materials with different heterogeneity. From Mogi [1962]



...

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.

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)

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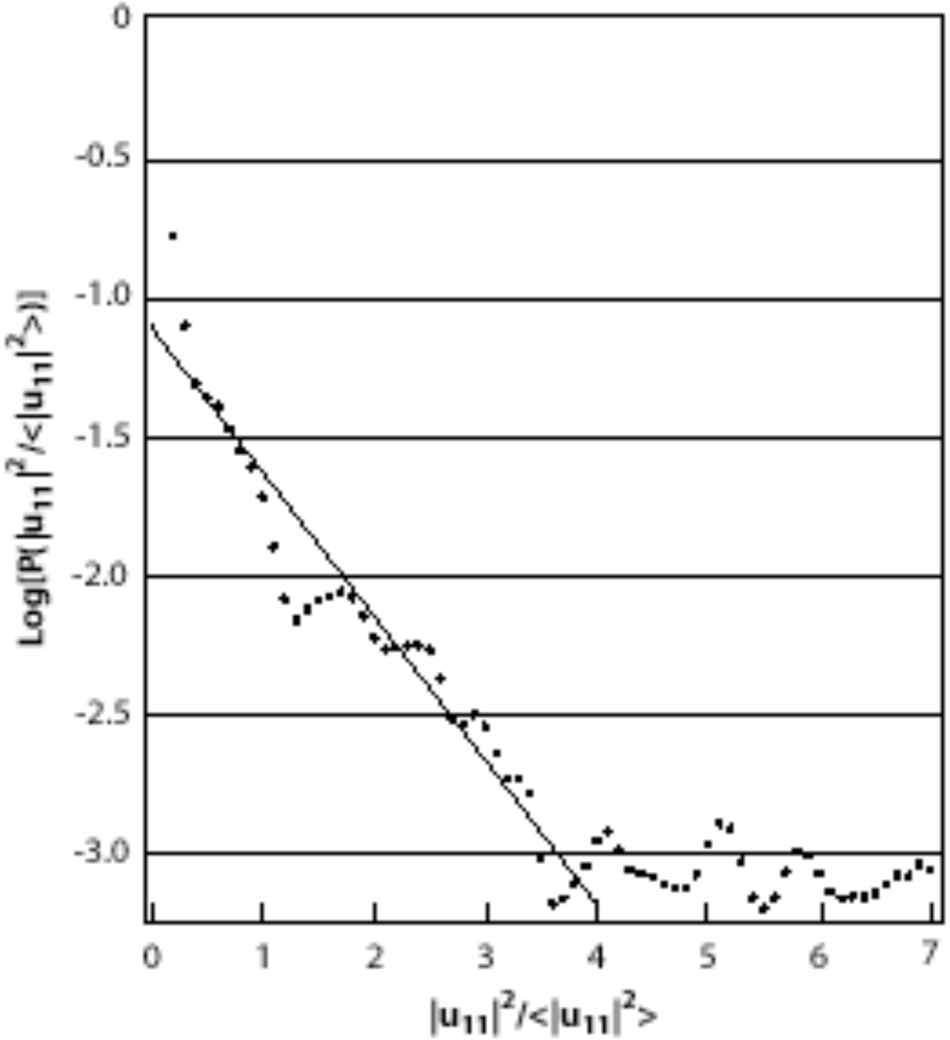
Brain medicine: Epileptic seizures

Geophysics: Gutenberg-Richter law and characteristic earthquakes.

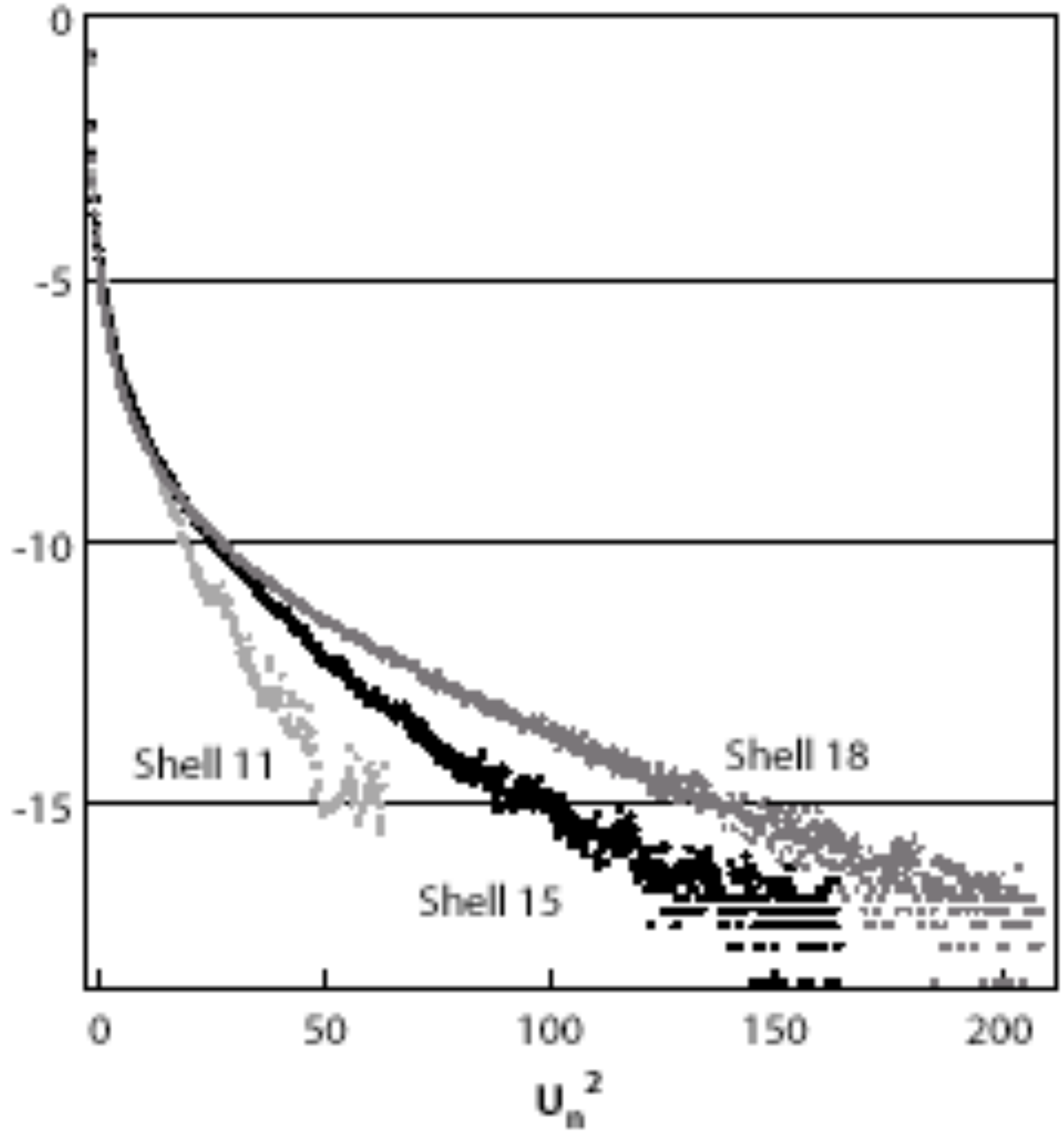
Mathematical Geophysics Conference **Extreme Earth Events**

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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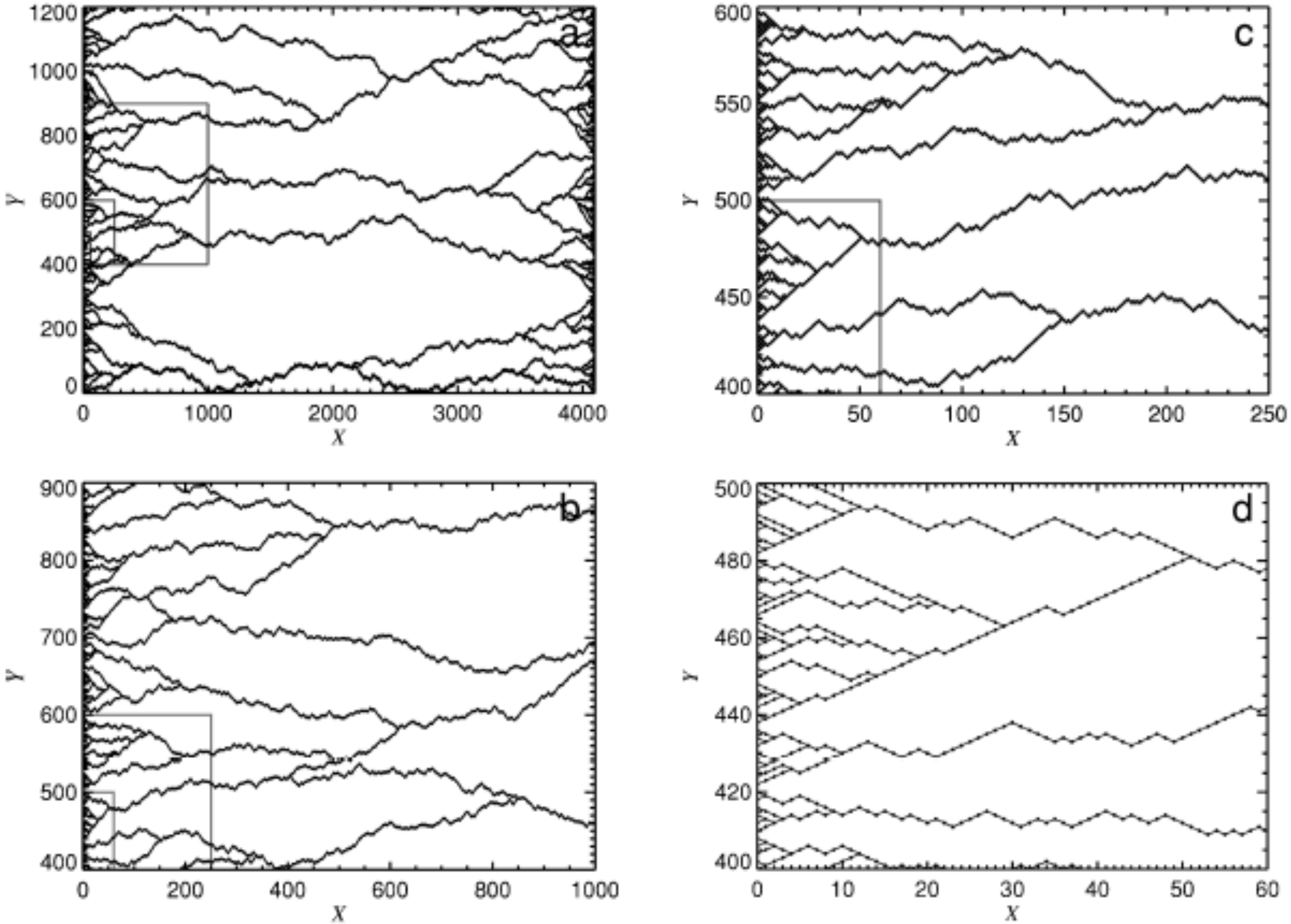
Metastable states in random media

Self-organized critical random directed polymers



Per Jogi, Didier Sornette and Michael Blank, Fine structure and complex exponents in power law distributions from random maps, Phys. Rev. E 57 120-134 (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”

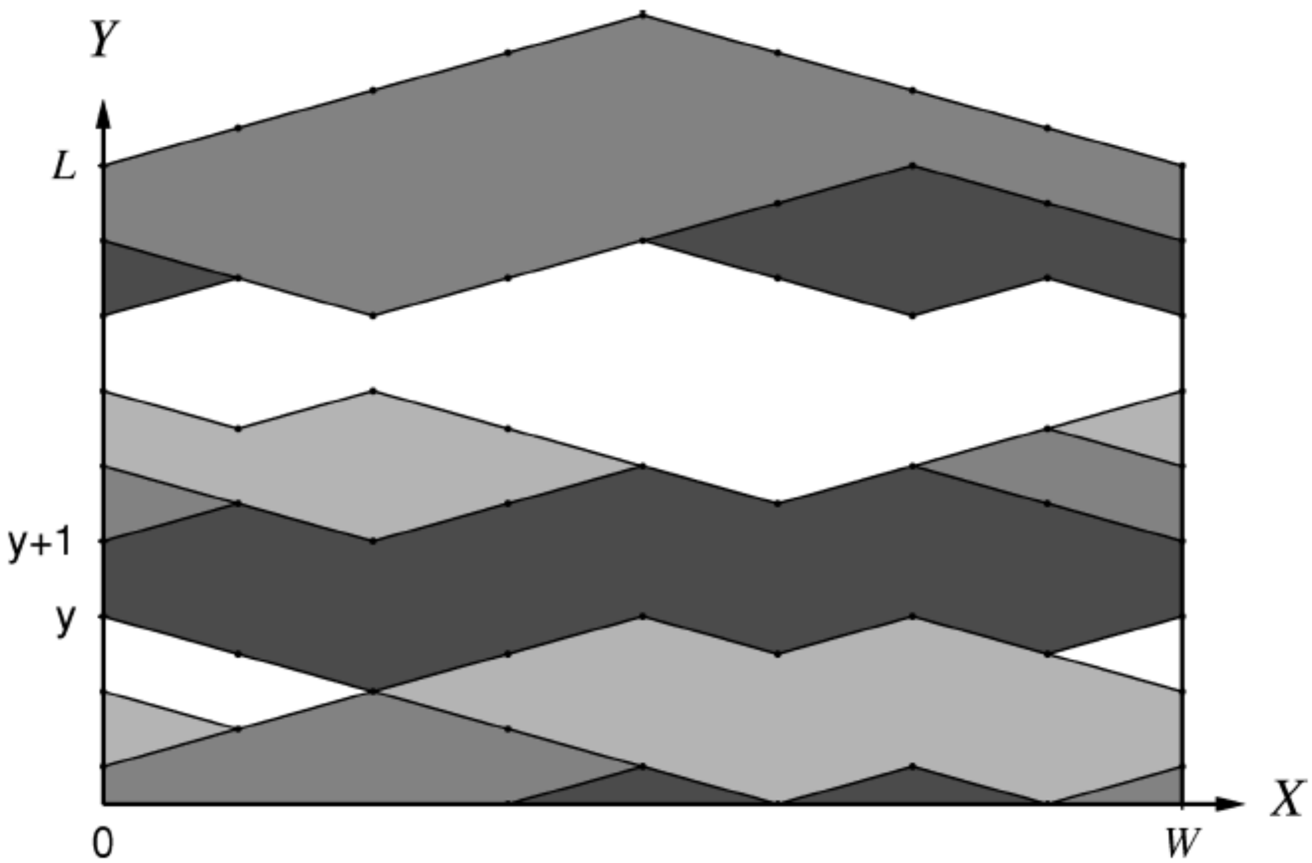


FIG. 2. Schematic representation of optimal RDPs fixed at their two end points. An avalanche is defined by the area S spanned by the transition from the optimal configuration at y to $y+1$, i.e., S is the area interior to the perimeter formed by the union of the two optimal RDP configurations at y and $y+1$ 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

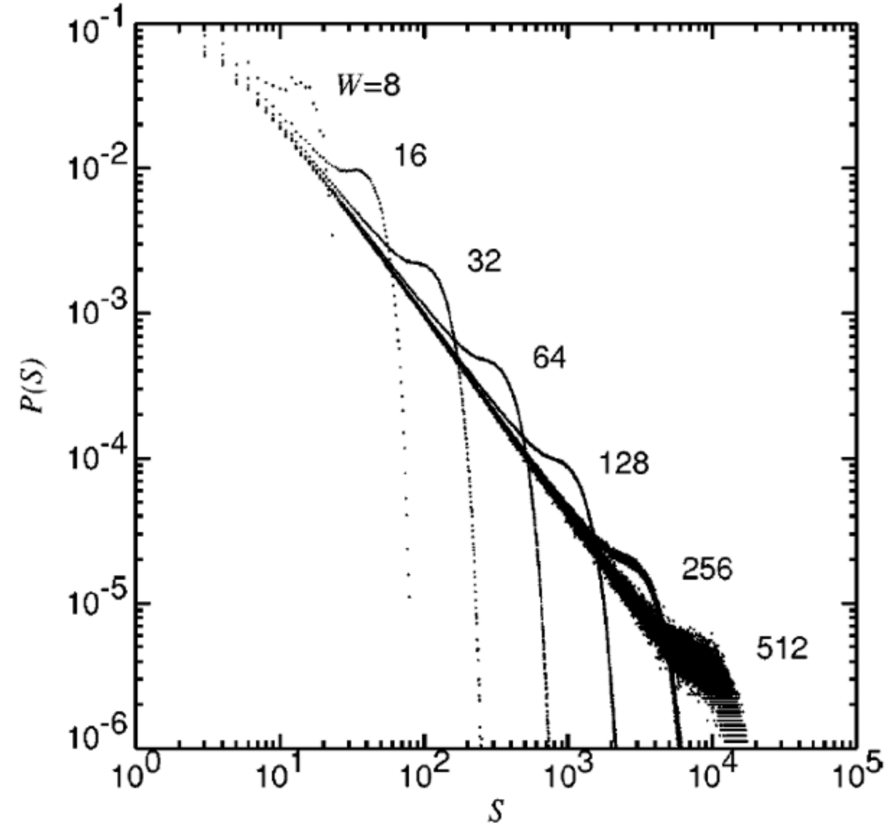


FIG. 3. Distribution $P(S)$ of RDP avalanche sizes obtained numerically for system widths from $W=8$ to 512 on a log-log plot. Here the system lengths L are 2×10^7 (for $W=8$), $3\times10^6(W=16)$, $2\times10^7(W=32)$, $10^8(W=64)$, $2\times10^8(W=128)$, $5\times10^7(W=256)$, and $9\times10^6(W=512)$.

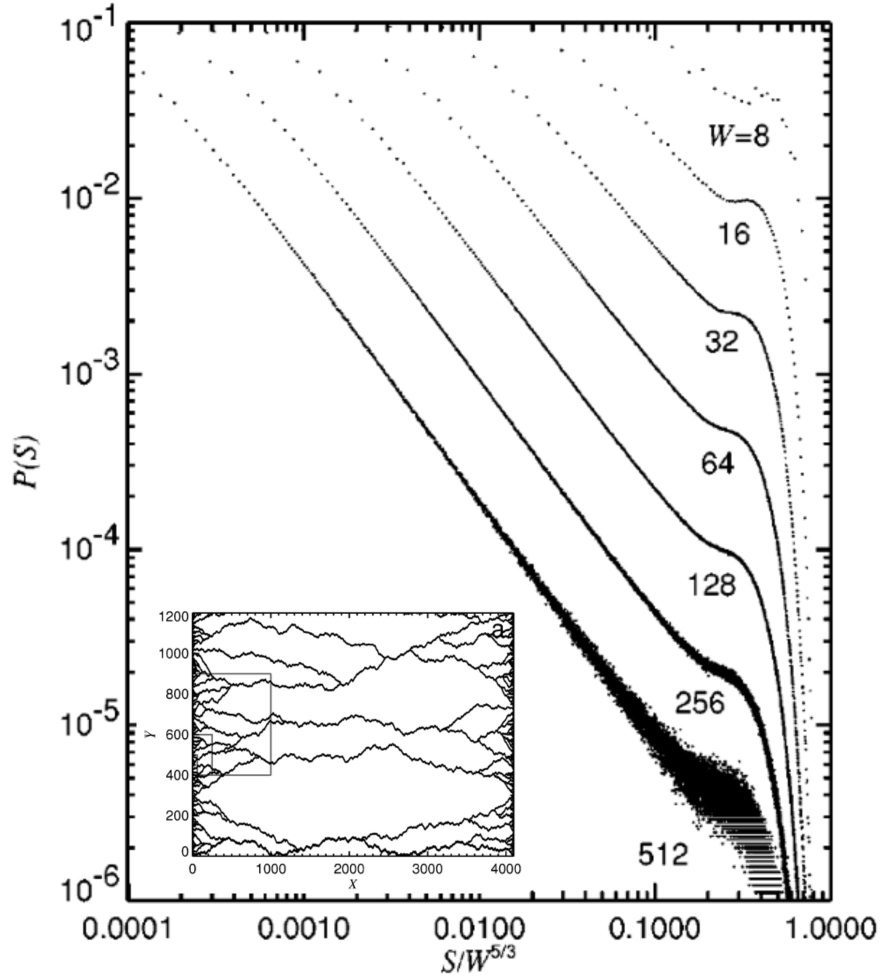


FIG. 4. $P(S)$ as a function of the rescaled variable $S/W^{5/3}$ for $W=8-512$ on a log-log plot.

Two characteristic scales and their scaling laws

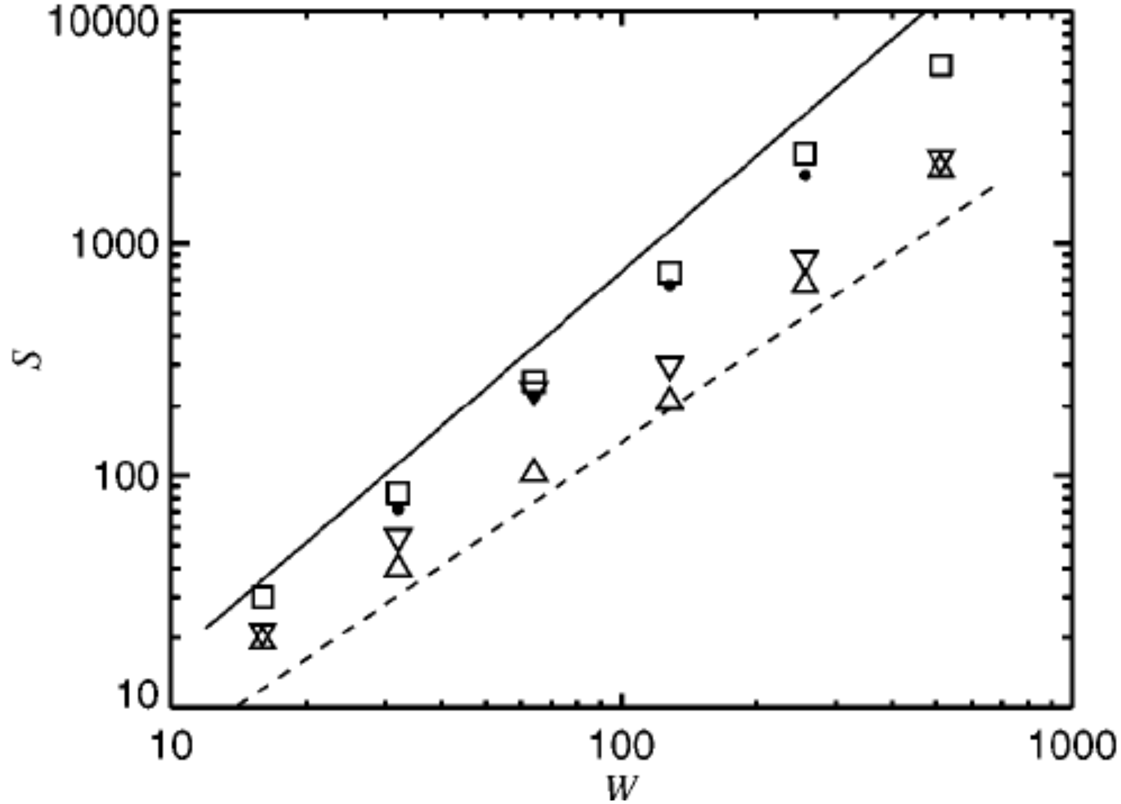
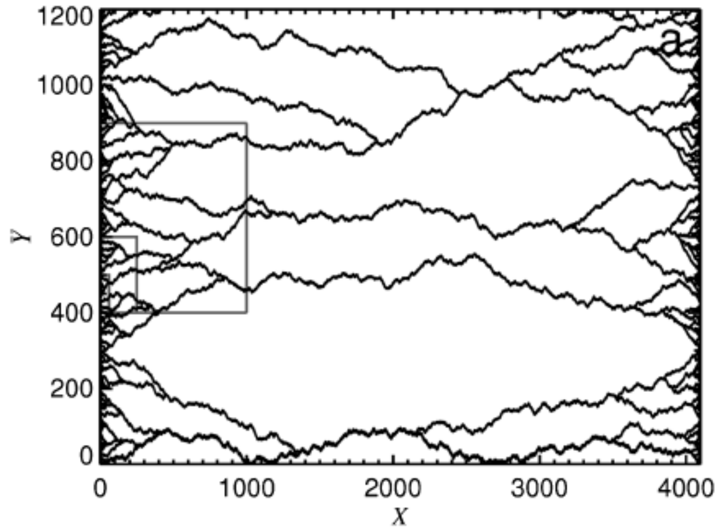


FIG. 7. Estimated W dependence of the three characteristic avalanche sizes. S_{up}, the upper limit for which $P(S)$ seems well approximated by a power law, is judged from Fig. 4 to have high and low values marked by $\bigtriangledown$ and $\bigtriangleup$, respectively (values taken at the midpoint of the triangle's horizontal side). S_{bump} ($\square$) tracks the location of the bump of $P(S)$ and is here chosen as the position of the inflection point of the different distributions displayed in Fig. 3. S_{tail}, ($\bullet$) represents the lower limit of the linear domain of the curves in Fig. 6. The solid line (proportional to $W^{5/3}$) and the dashed line (proportional to $W^{4/3}$) are included as guides.



Per Jogi, Didier Sornette and Michael Blank, Fine structure and complex exponents in power law distributions from random maps, Phys. Rev. E 57 120-134 (1998)

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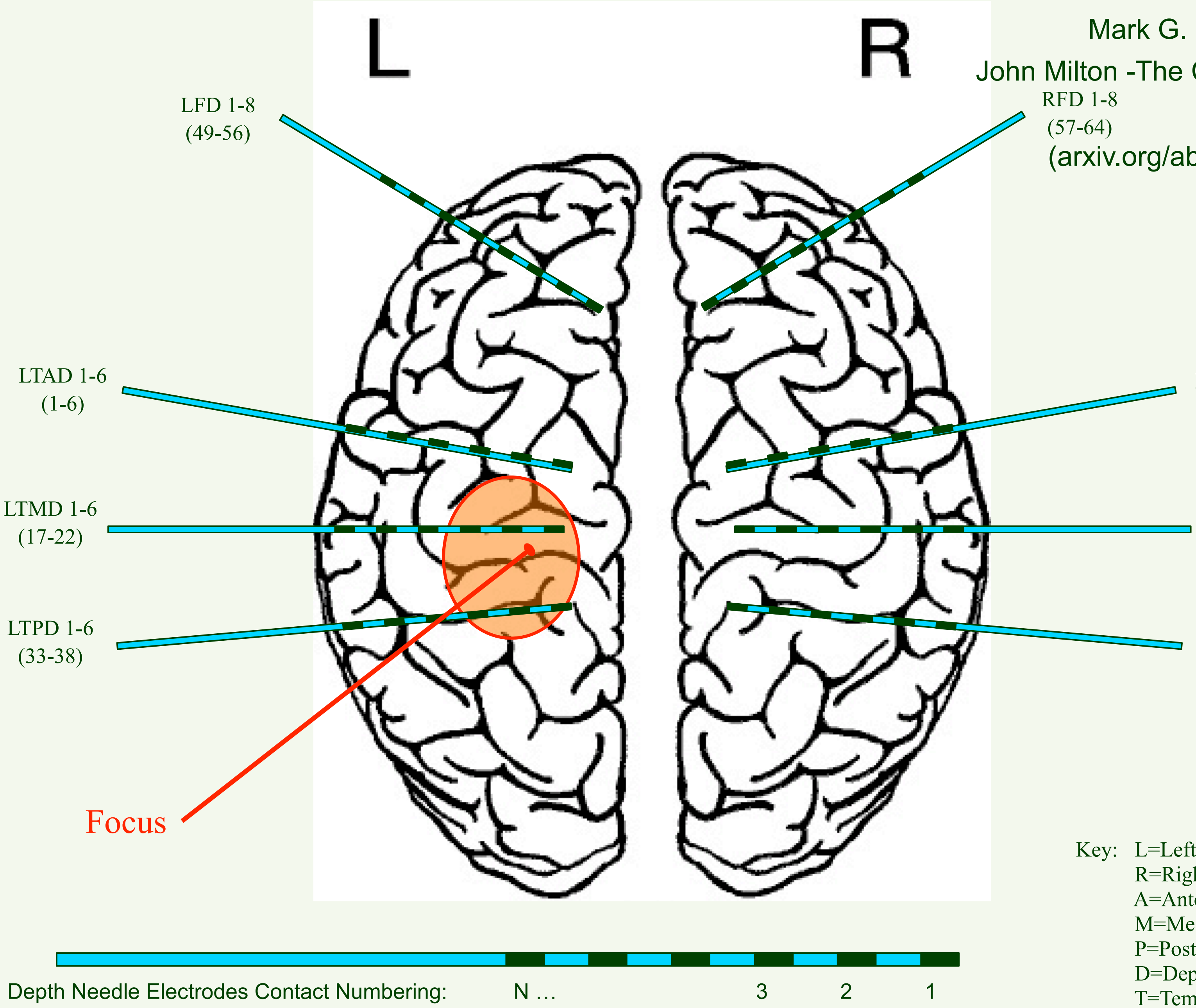
Epileptic Seizures – Quakes of the Brain?

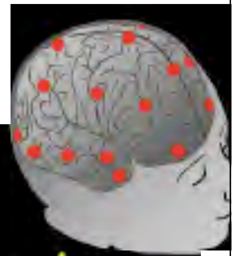
with Ivan Osorio – KUMC & FHS
Mark G. Frei - FHS
John Milton -The Claremont Colleges

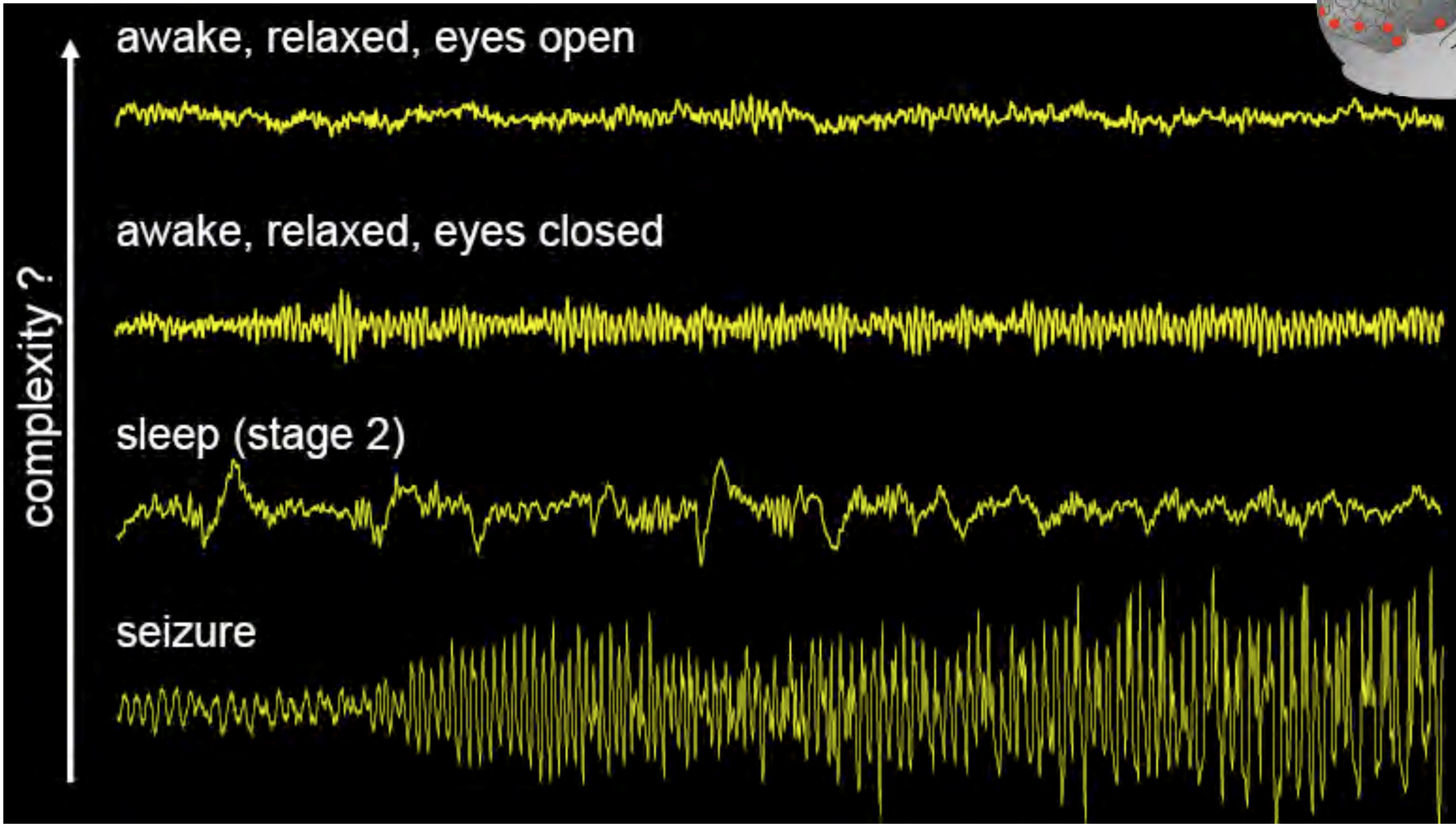
(arxiv.org/abs/0712.3929)

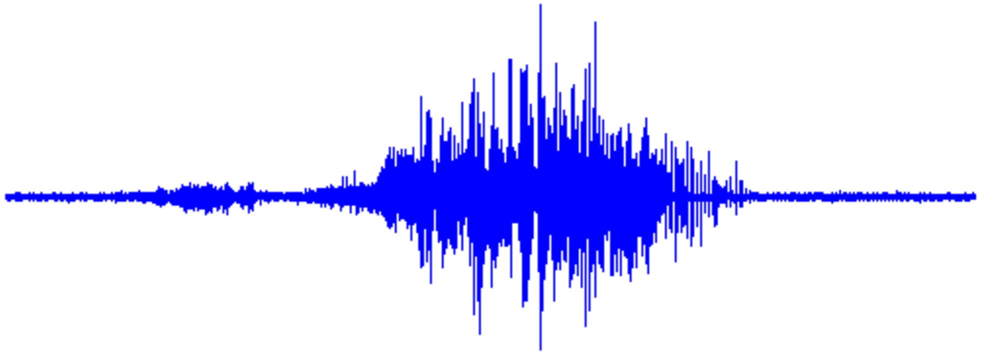


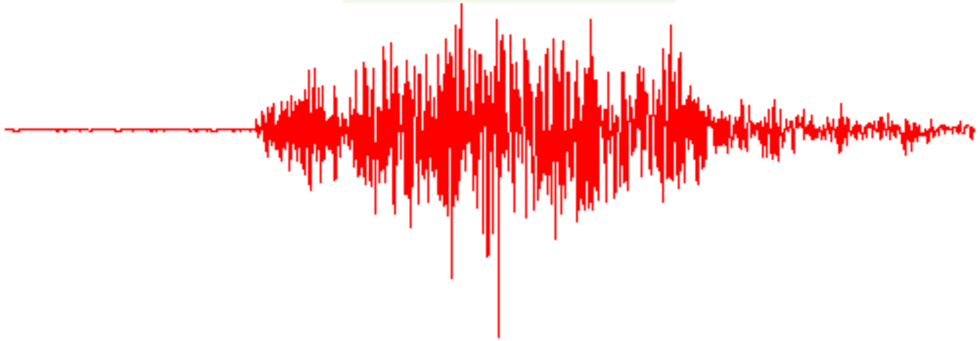
Key: L=Left
R=Right
A=Anterior
M=Mesial
P=Posterior
D=Depth
T=Temporal
F=Frontal

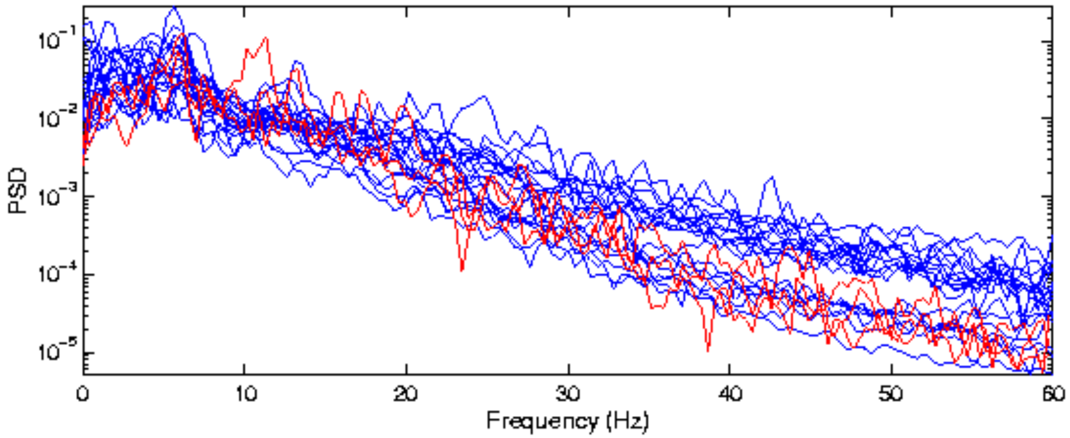
Bursts and Seizures

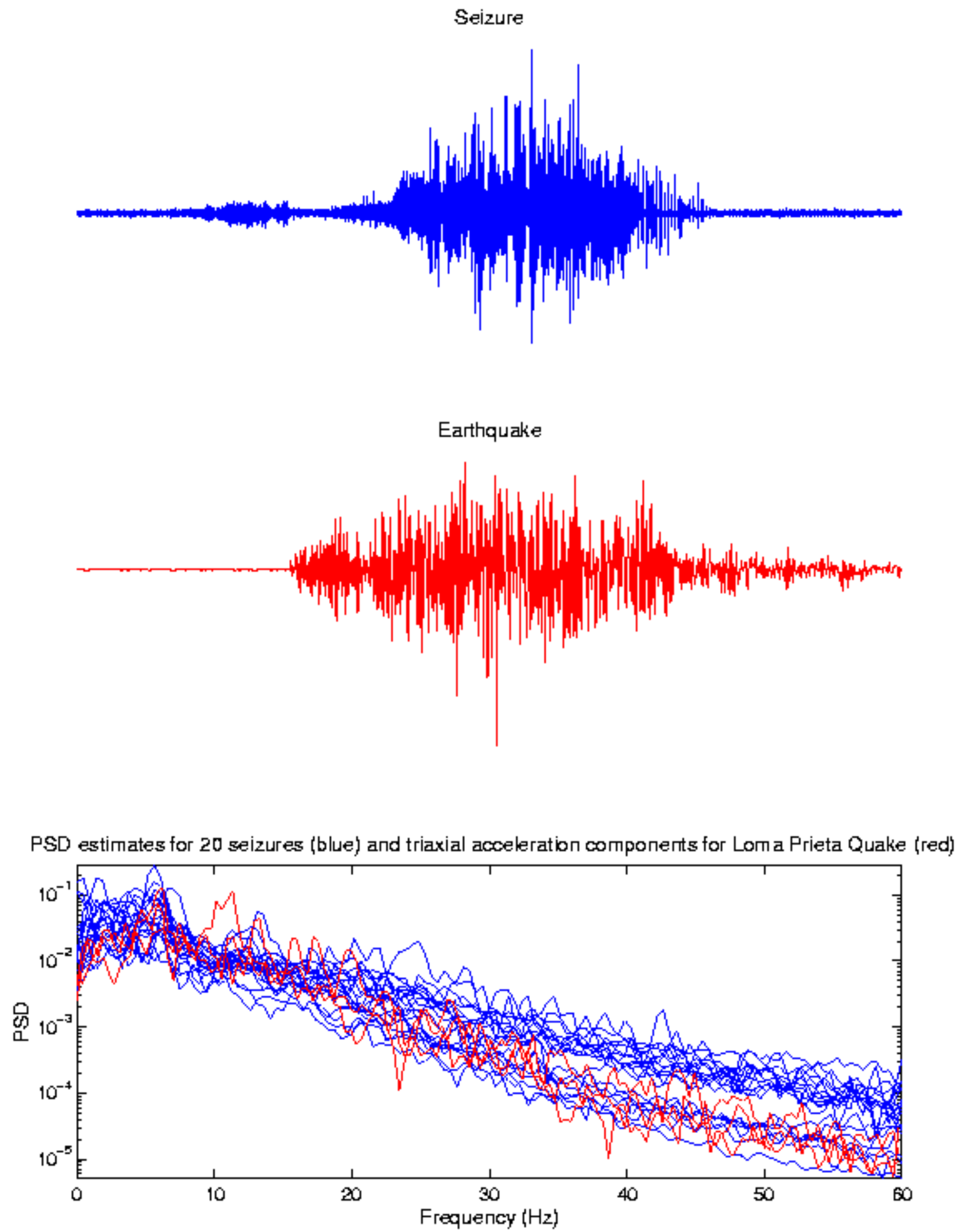




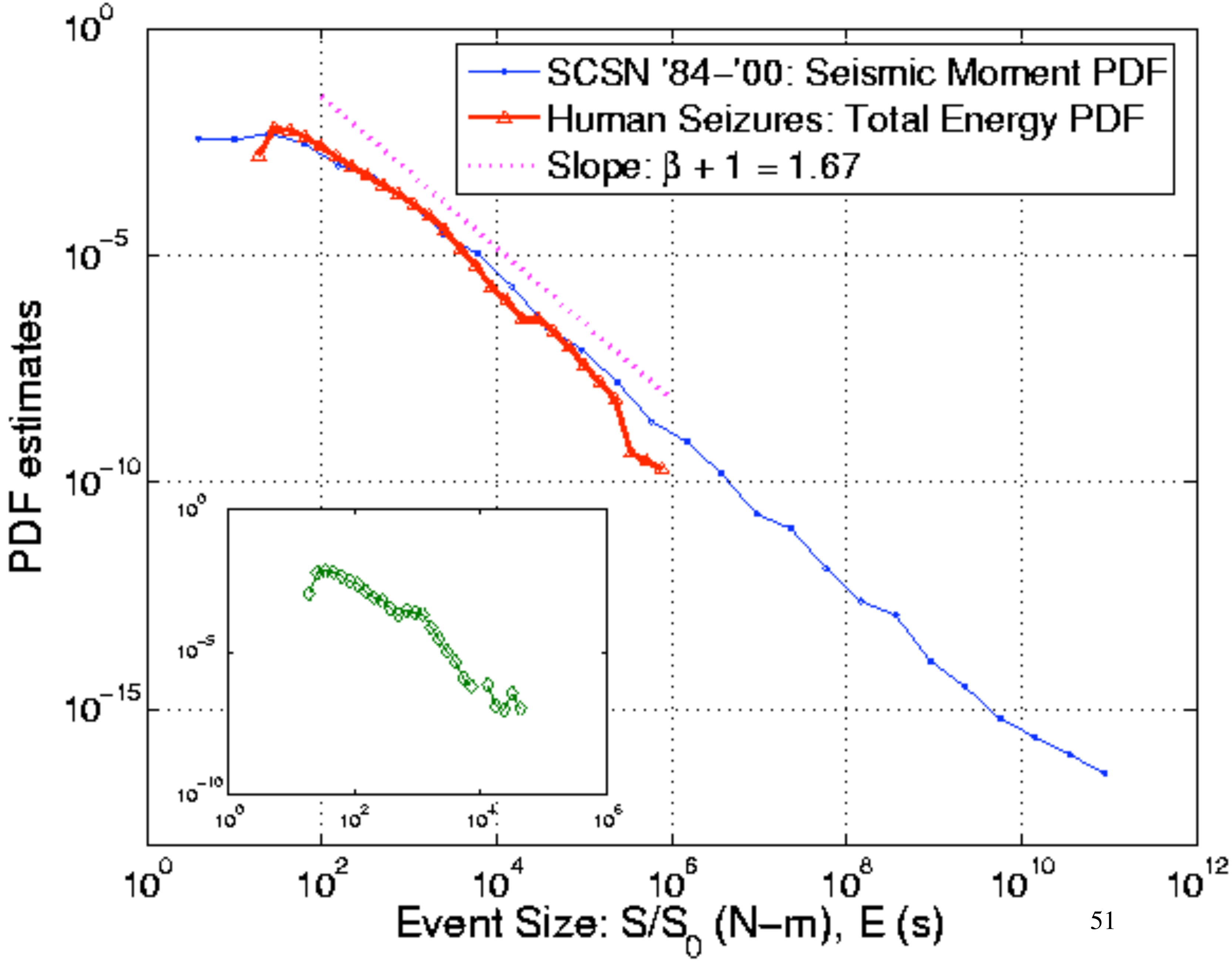




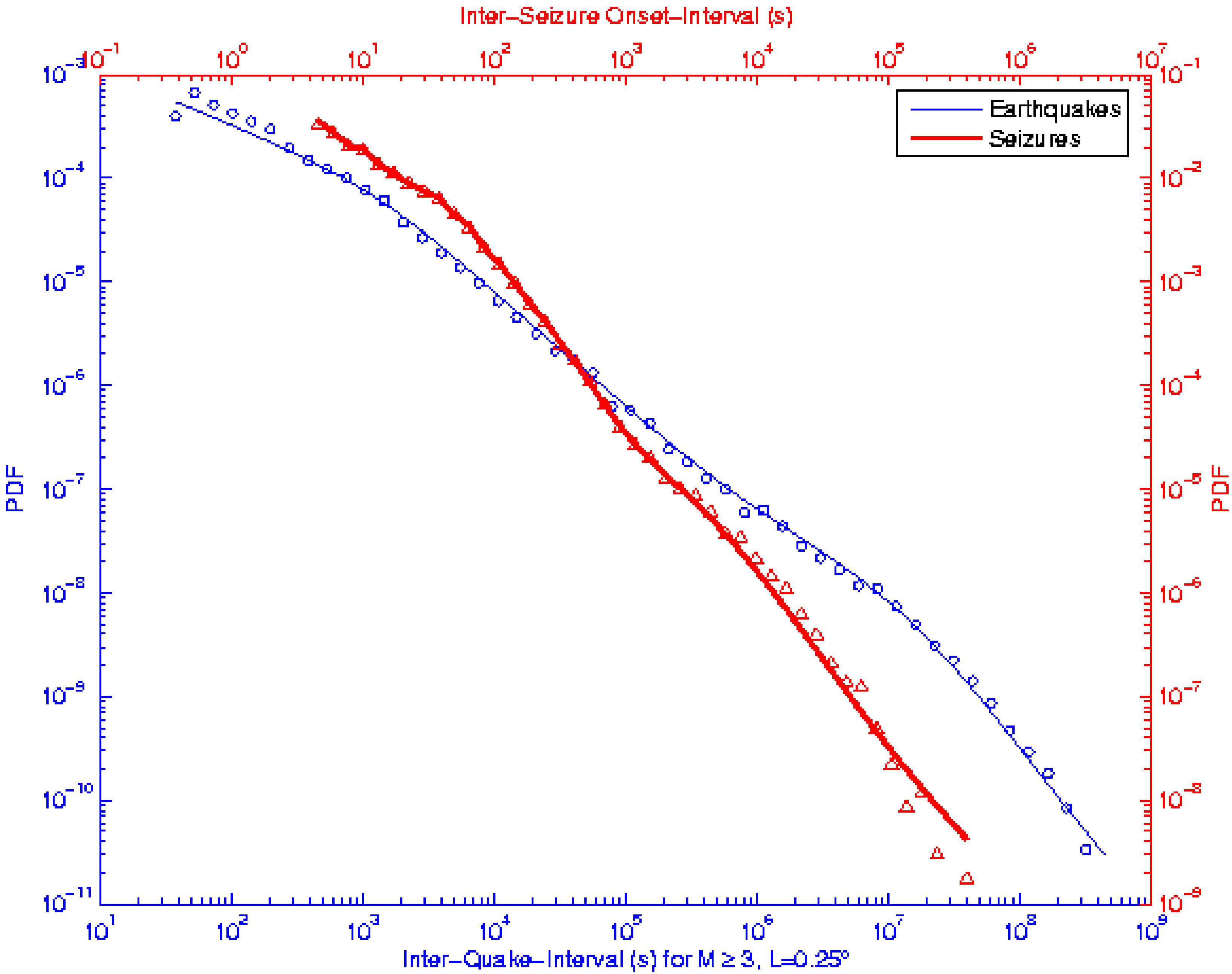

PSD
Frequency (Hz)
10^-1
10^-2
10^-3
10^-4
10^-5
0
10
20
30
40
50
60


Seizure
Earthquake
PSD estimates for 20 seizures (blue) and triaxial acceleration components for Loma Prieta Quake (red)
PSD
Frequency (Hz)

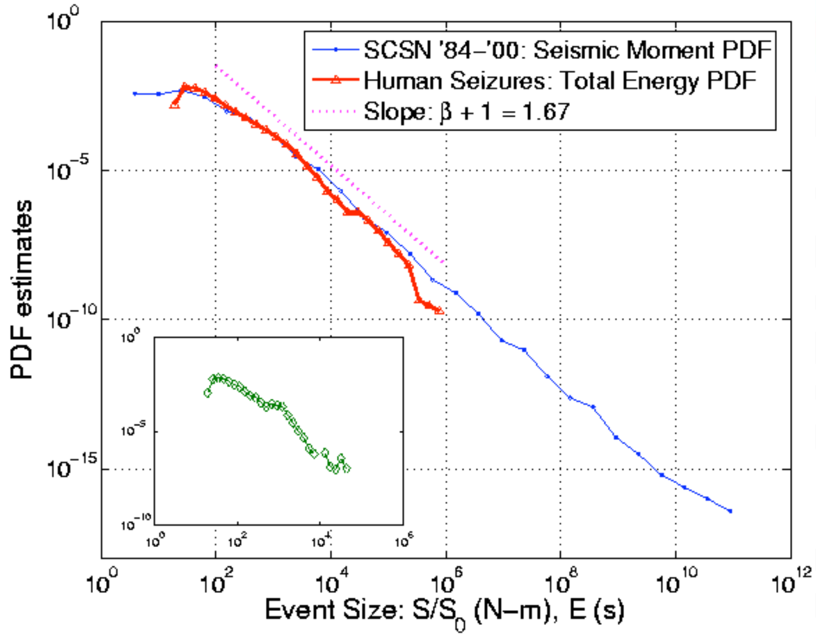
Gutenberg-Richter distribution of energies



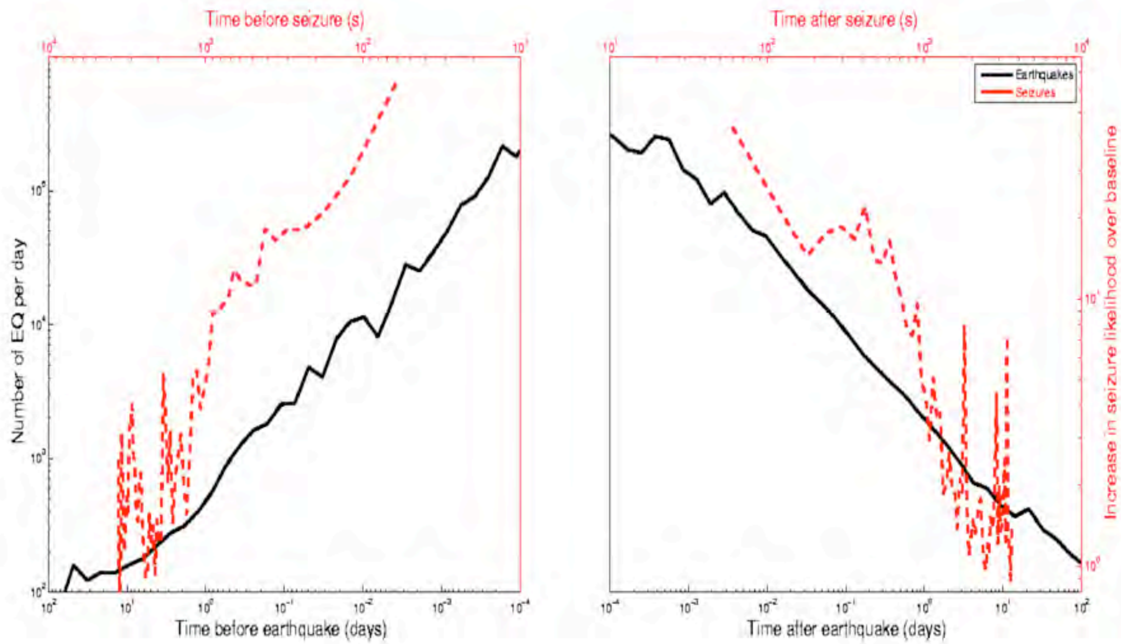
Pdf of inter-event waiting times



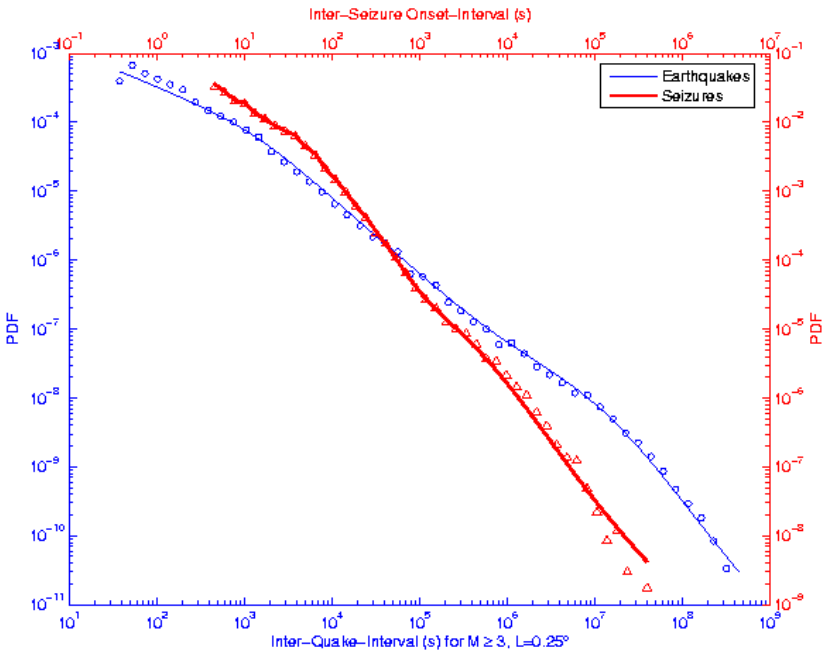
Gutenberg-Richter distribution of sizes



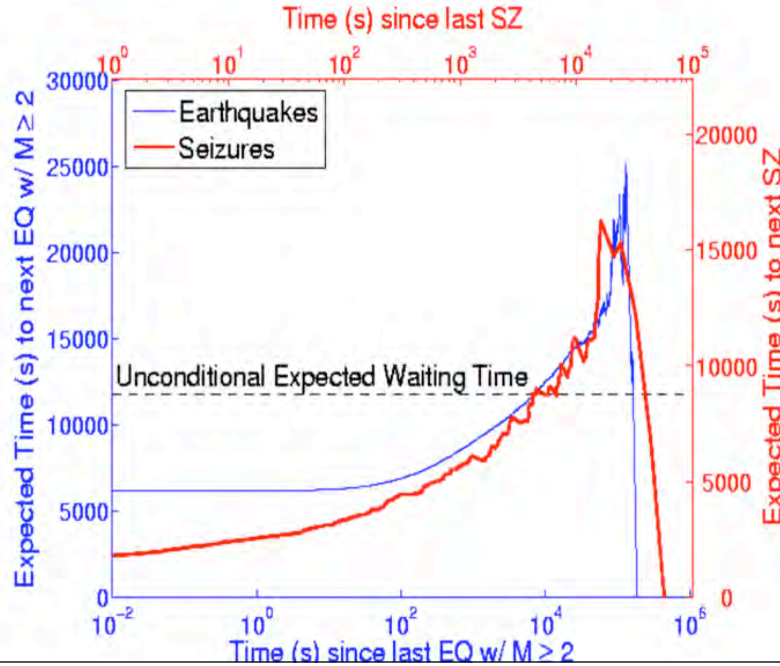
Omori law: Direct and Inverse



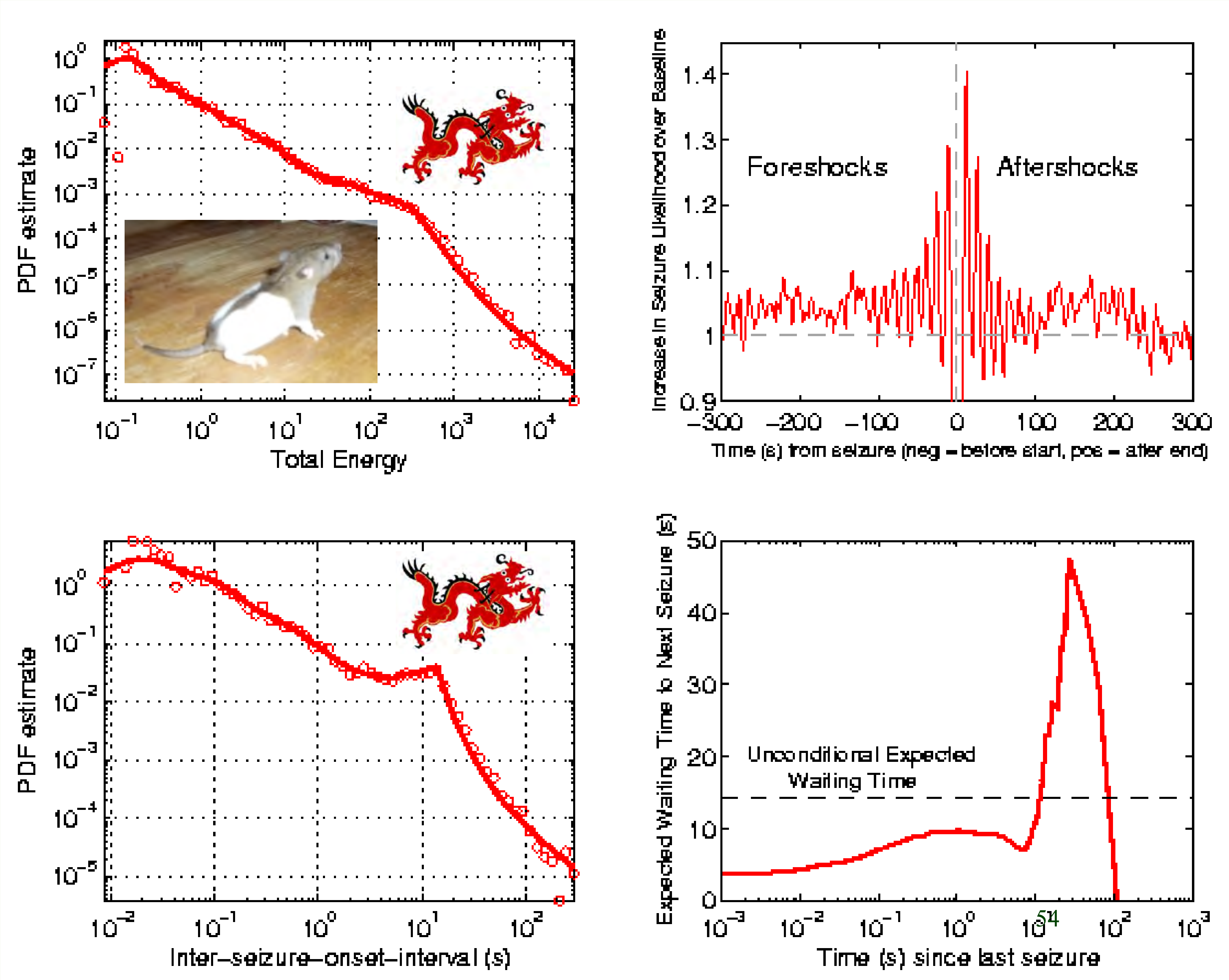
pdf of inter-event waiting times



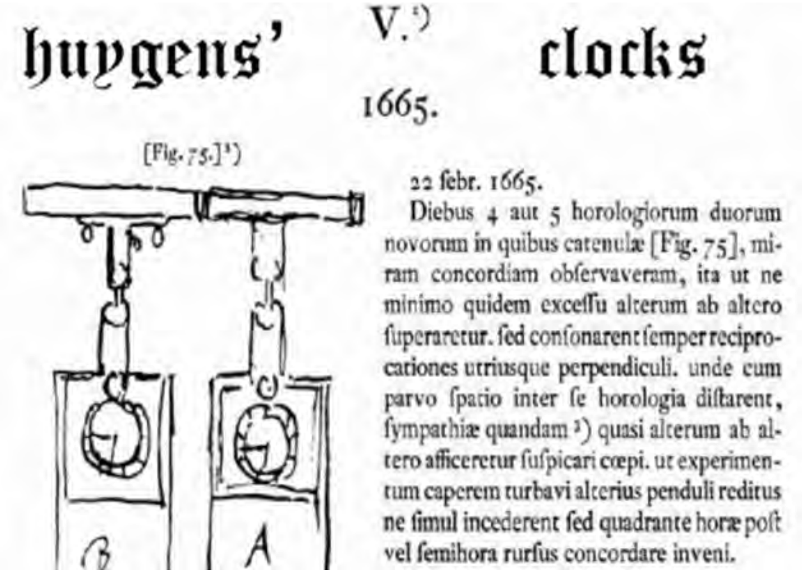
The longer it has been since the last event,
the longer it will be since the next one!



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



SYNCHRONISATION AND COLLECTIVE EFFECTS IN EXTENDED STOCHASTIC SYSTEMS


huygens' V.[1] clocks

1665.

[Fig. 75.][1])

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 [2]) 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

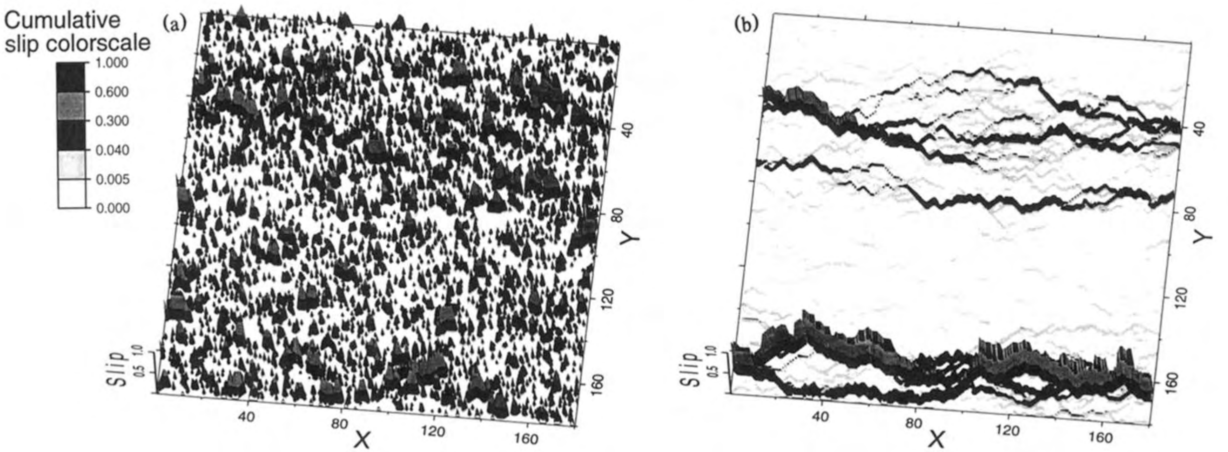
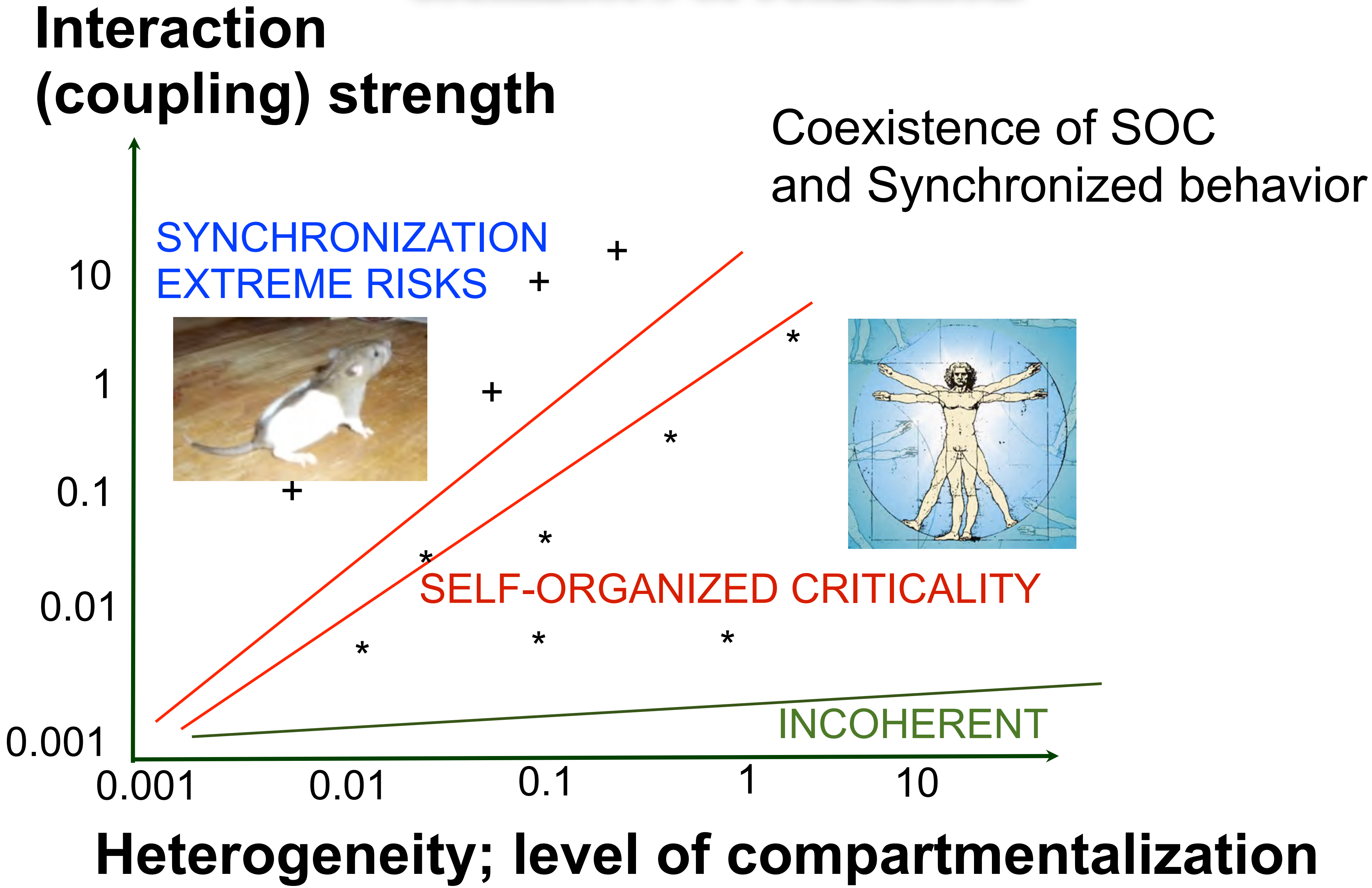


FIG. 1. Evolution of the cumulative earthquake slip, represented along the vertical axis in the white to black color code shown above the picture, at two different times: (a) early time and (b) long time, in a system of size $L=90$ by $L=90$, where $\Delta\sigma=1.9$ and $\beta=0.1$.

Miltenberger et al. (1993)

(Prof. R.E. Amritkar)

Generic diagram for coupled threshold oscillators of relaxation



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

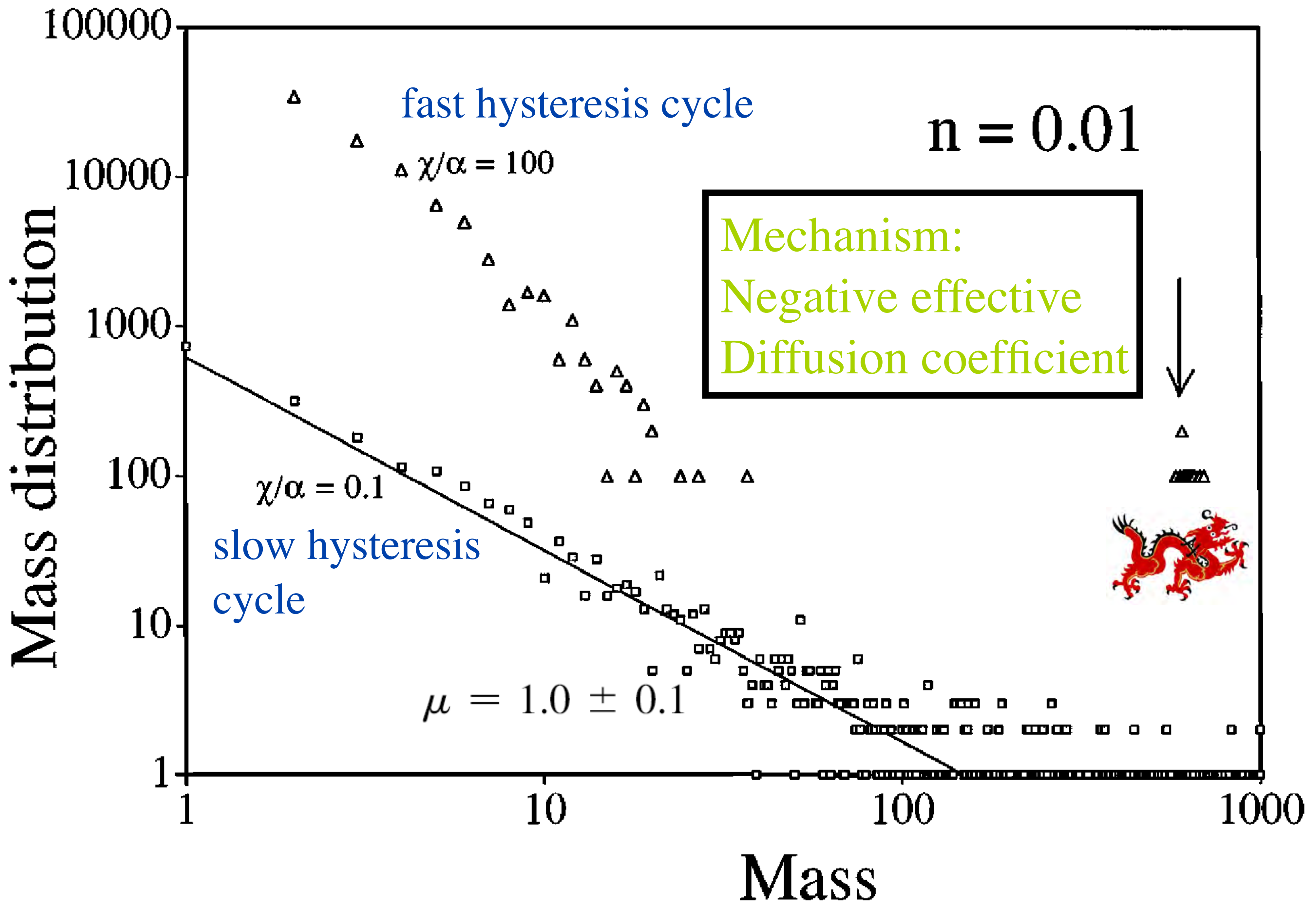
$$\mu = \left[\left(\frac{\partial h}{\partial x}\right)^2 - \left(\frac{\partial h}{\partial x}\Big|_c\right)^2\right] \qquad (2)$$

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.

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

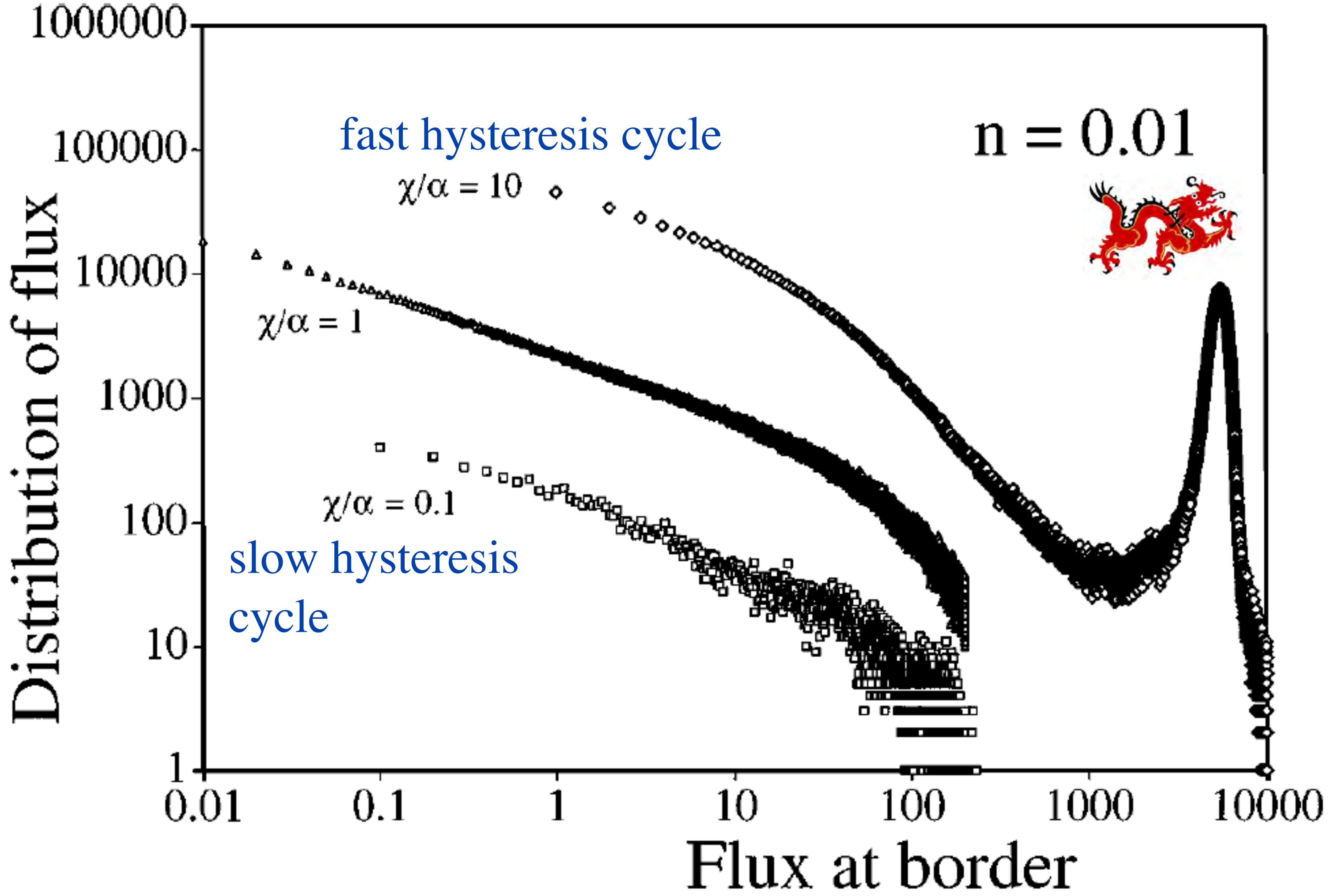
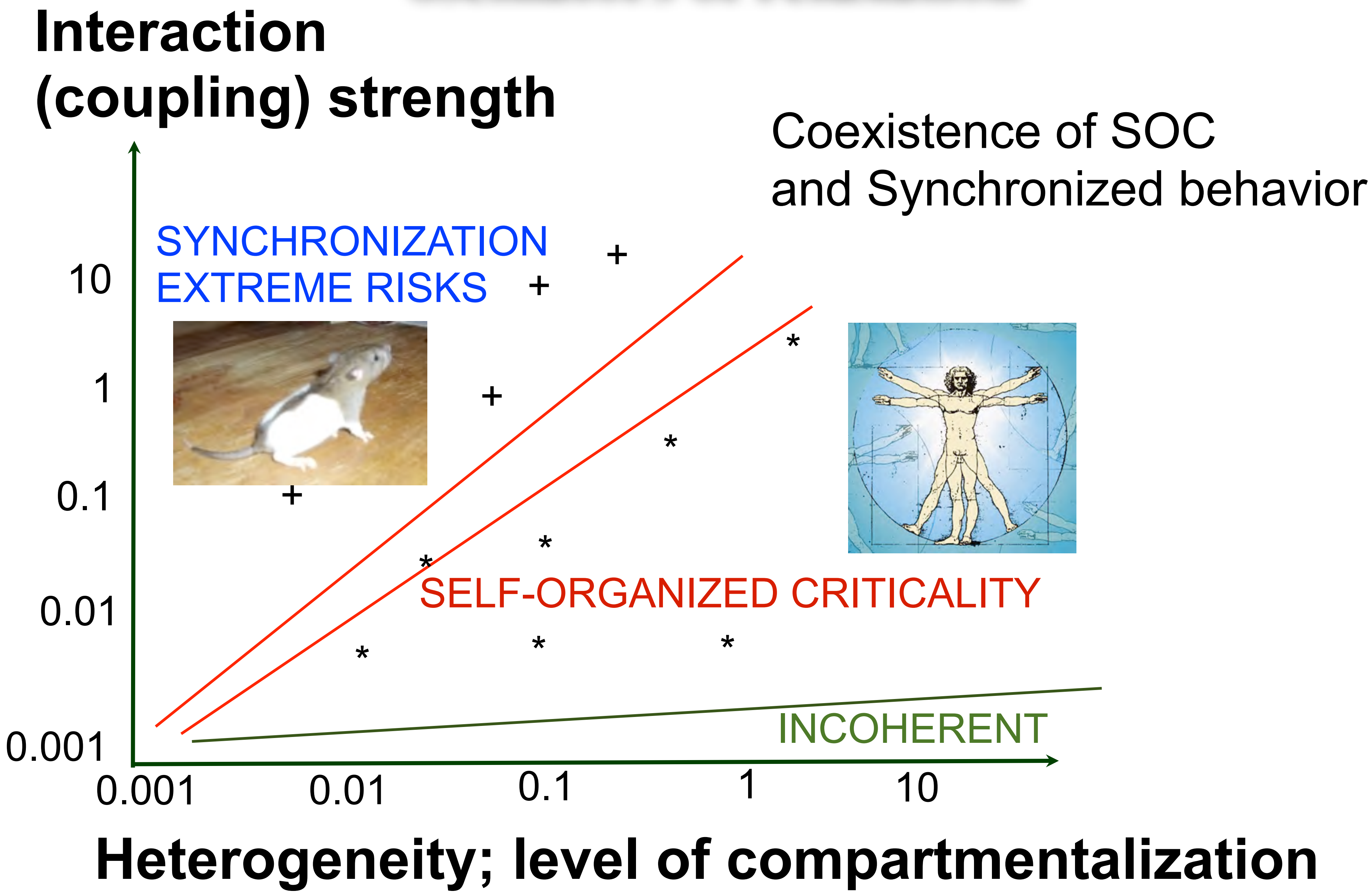
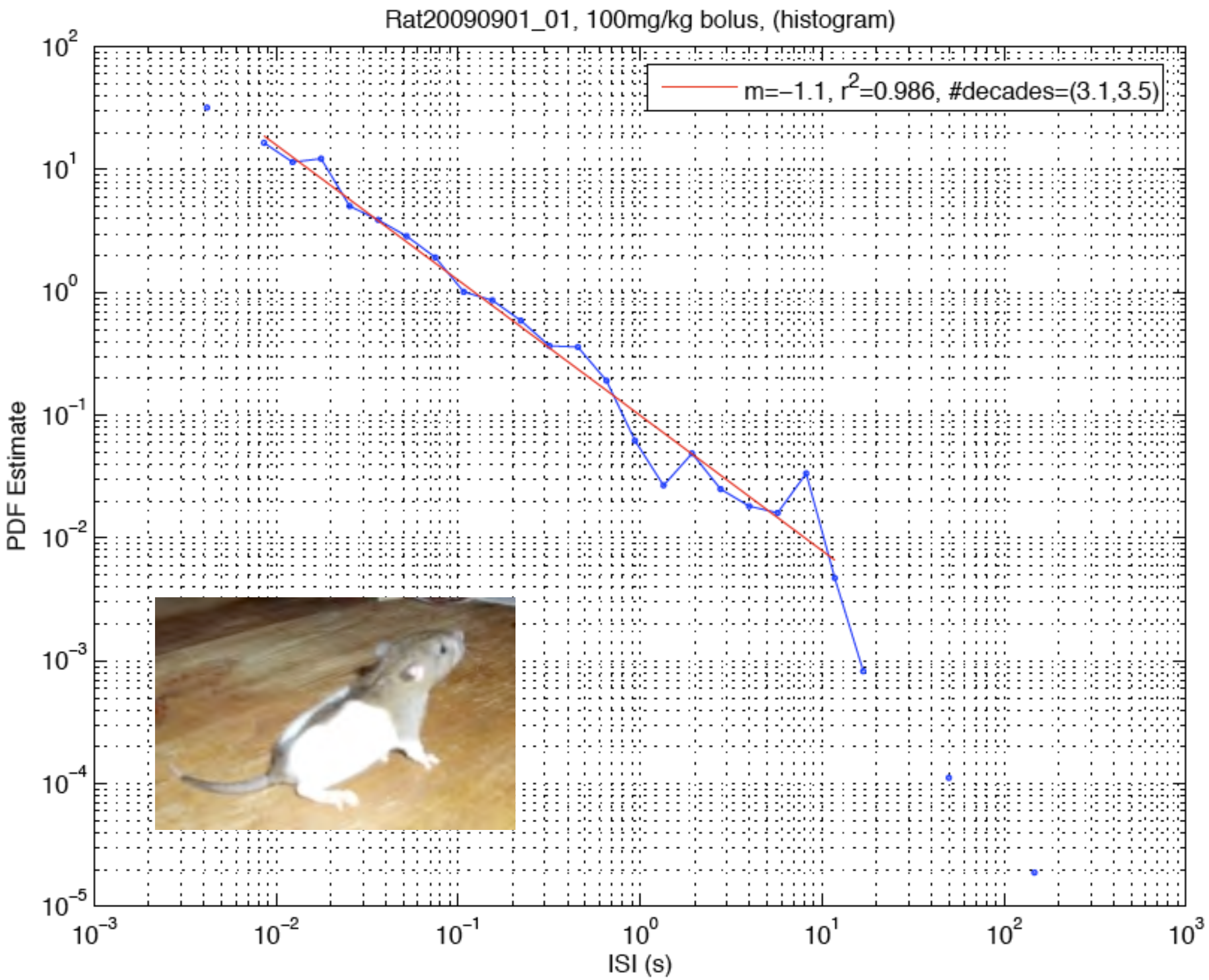


FIG. 3. Distribution $P(J)$ of flux amplitudes at the right border, in the same conditions as for Fig. 1.

Generic diagram for coupled threshold oscillators of relaxation

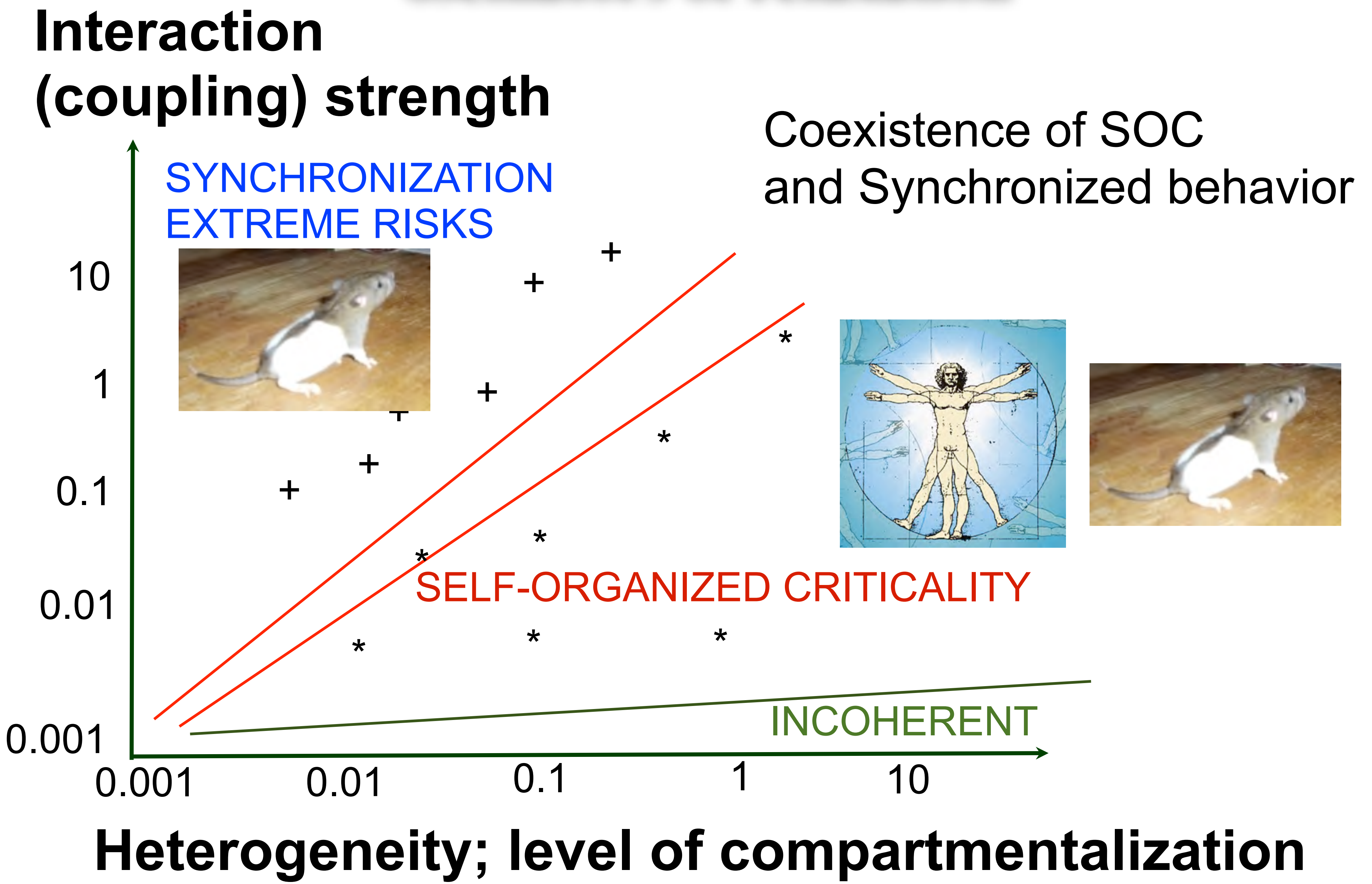


Low dose of convulsant in rats (like most humans)

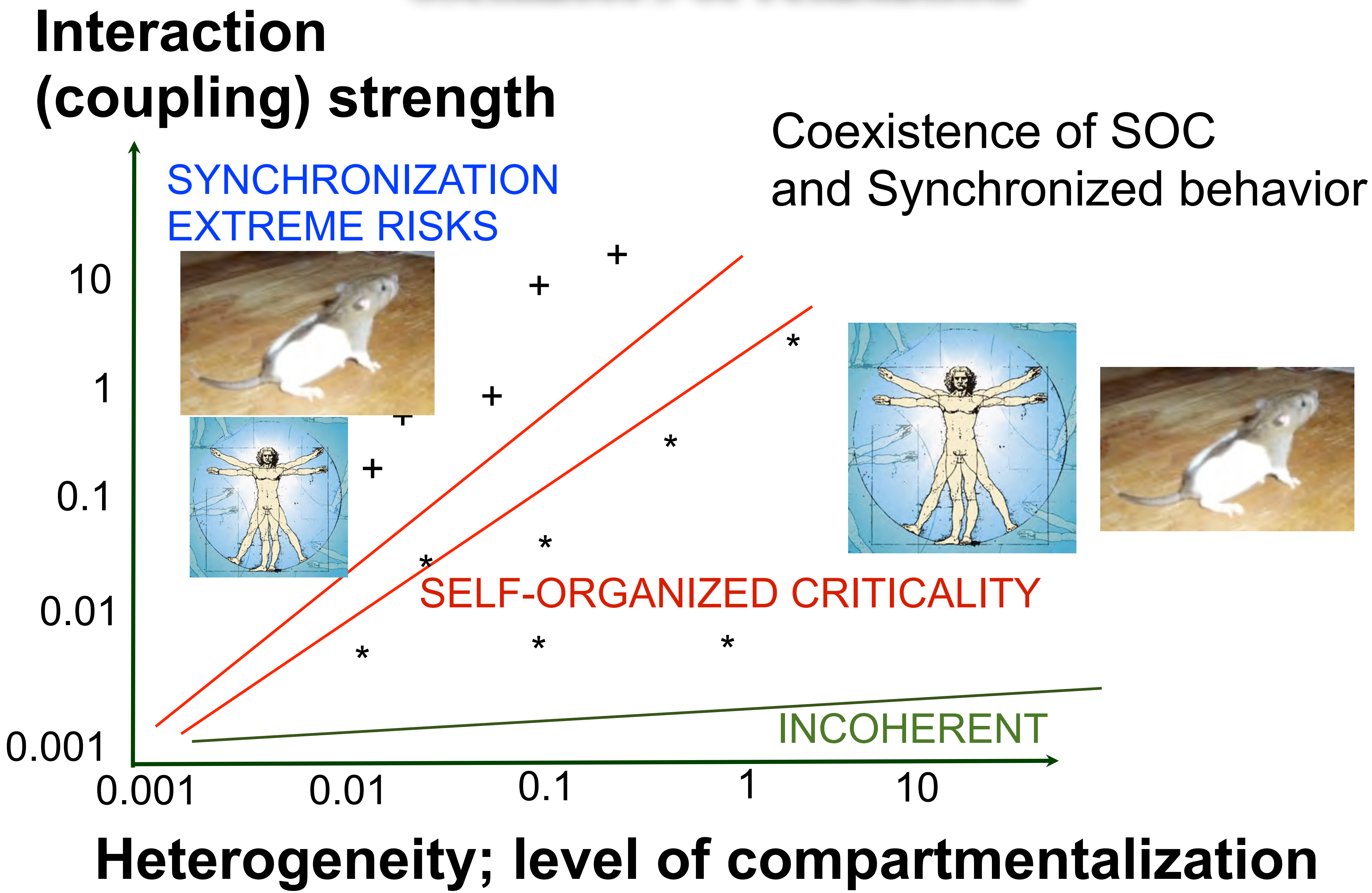


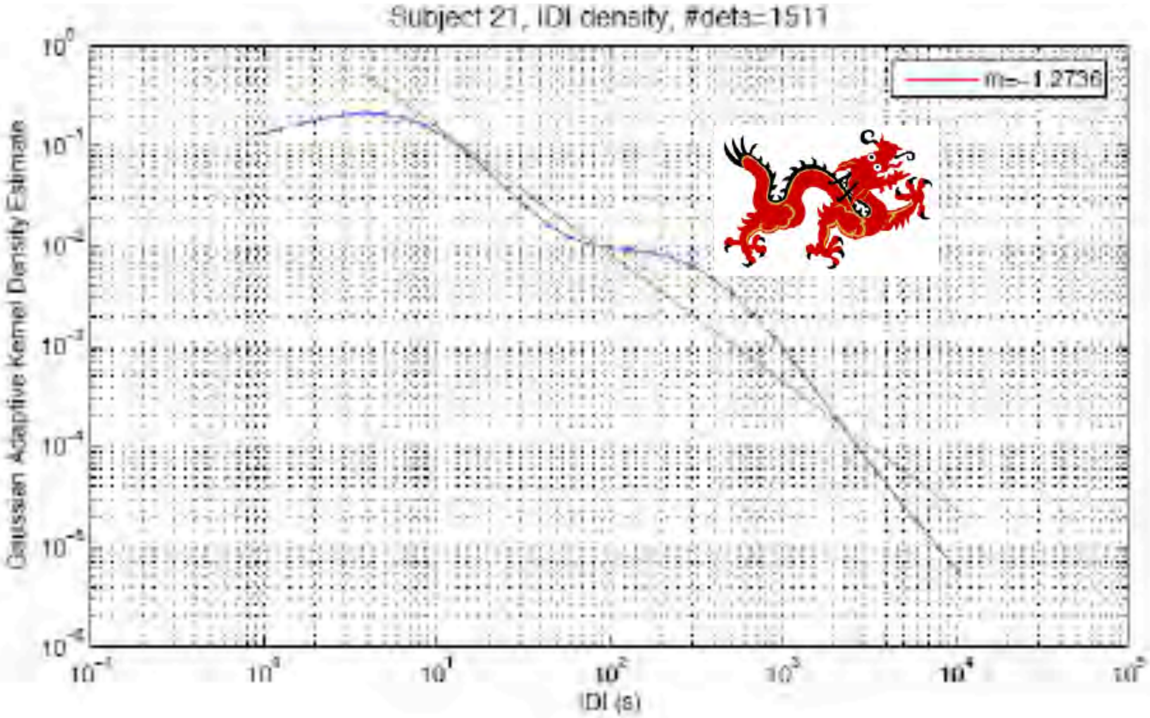
Distribution of inter-seizure time intervals for rat 5, demonstrating a pure power law, which is characteristic of the SOC state. This scale-free distribution should be contrasted with the pdf's obtained for the other rats, which are marked by a strong shoulder associated with a characteristic time scale,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

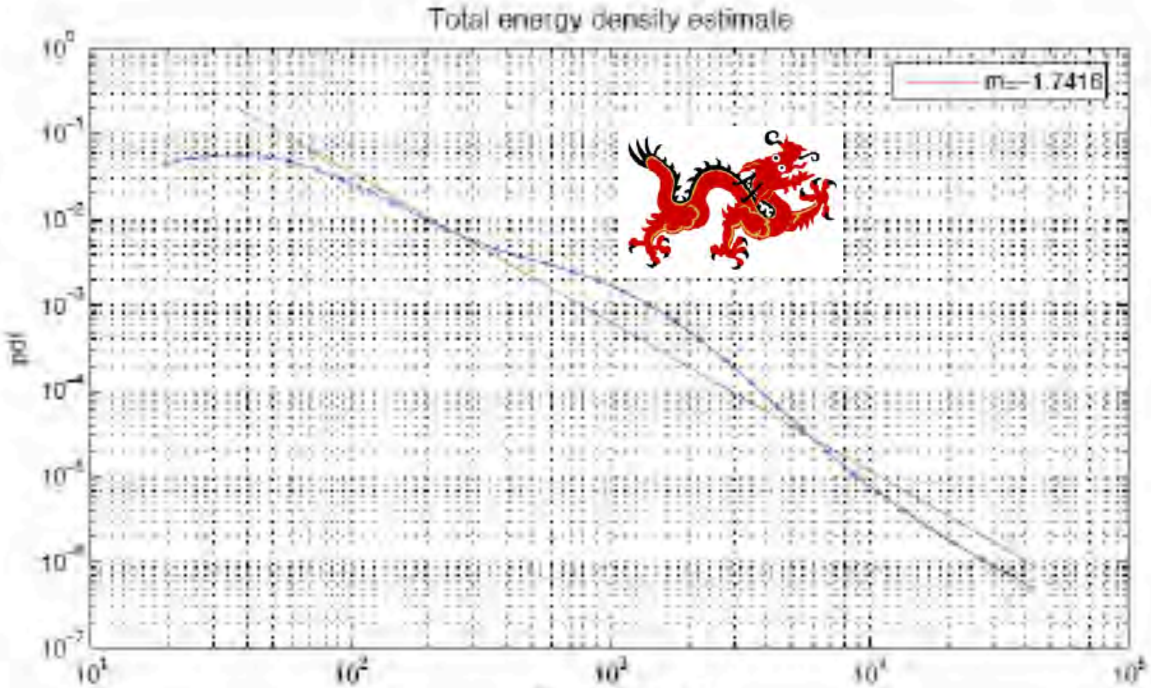
Generic diagram for coupled threshold oscillators of relaxation



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.

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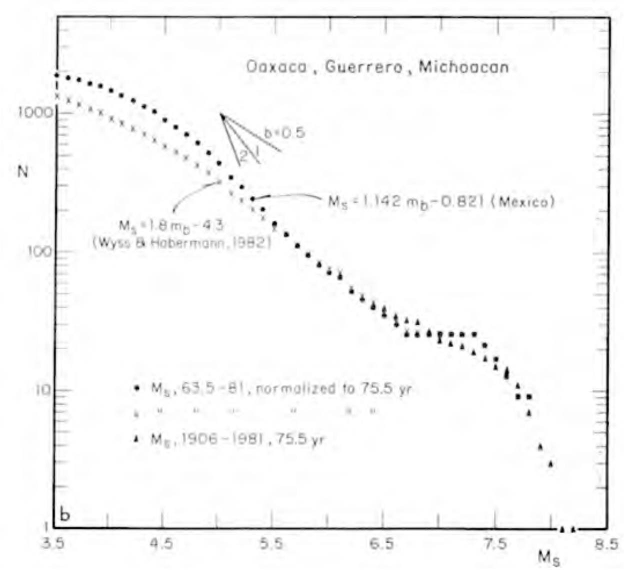
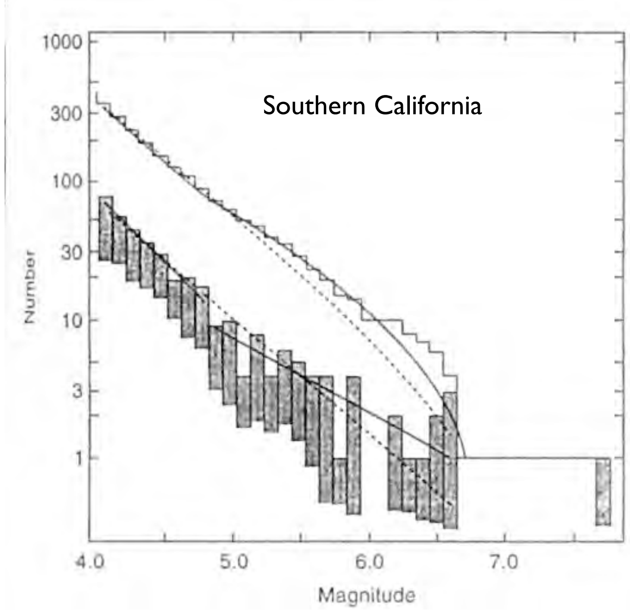
Complex magnitude distributions

Characteristic earthquakes?



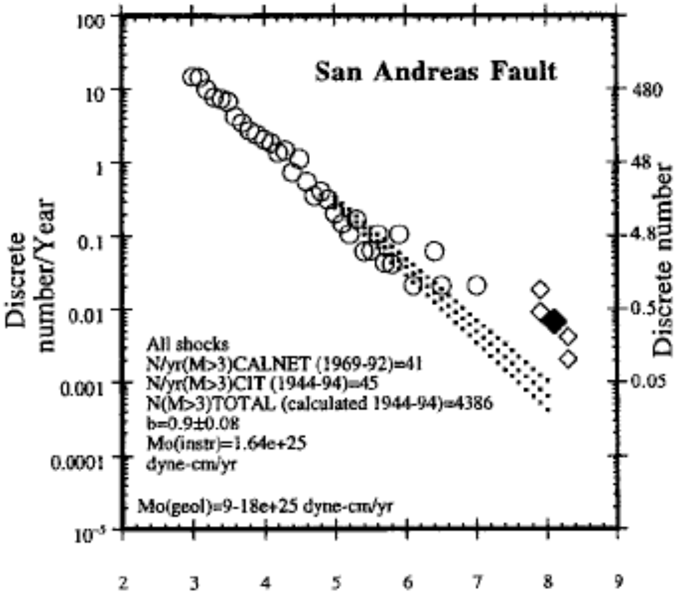
Singh, et. al., 1983, BSSA 73, 1779-1796

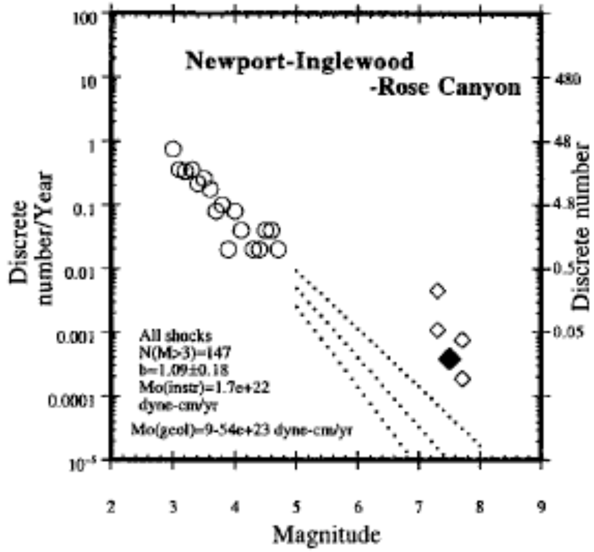


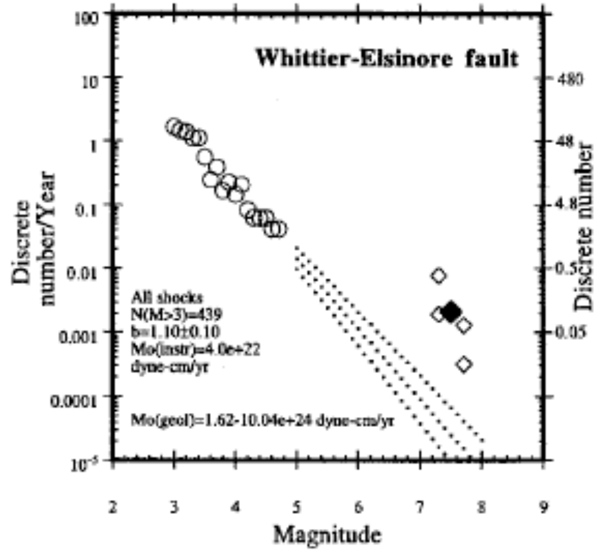
Knopoff, 2000, PNAS 97, 11880-11884

Main, 1995, BSSA 85, 1299-1308

Wesnousky, 1996, BSSA 86, 286-291



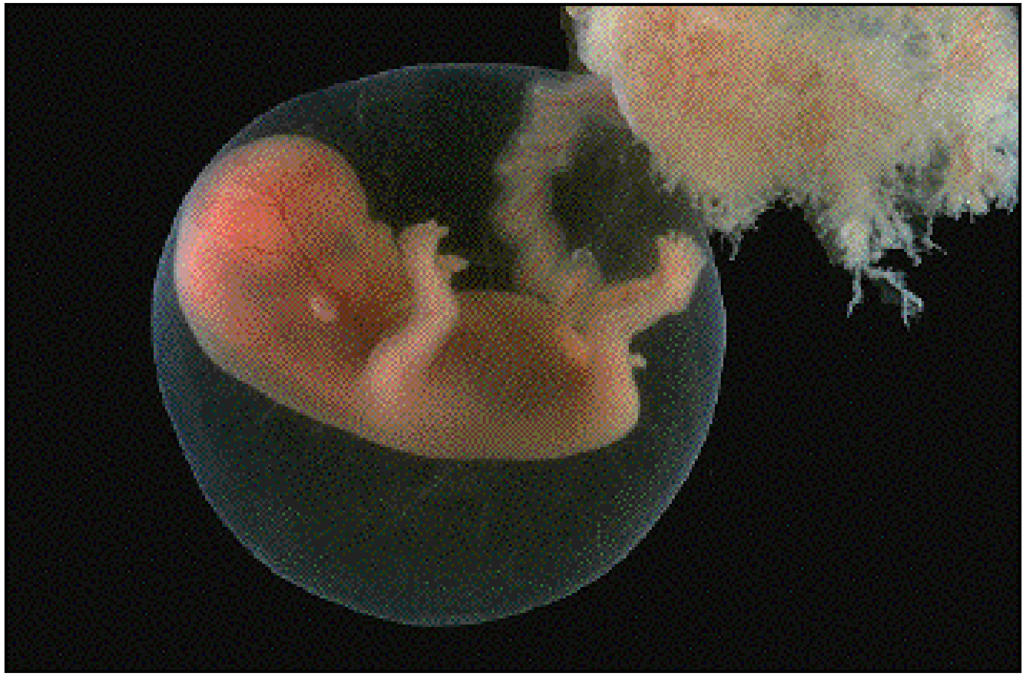




Predictability of catastrophic events: Material rupture, earthquakes, turbulence, financial crashes, and human birth

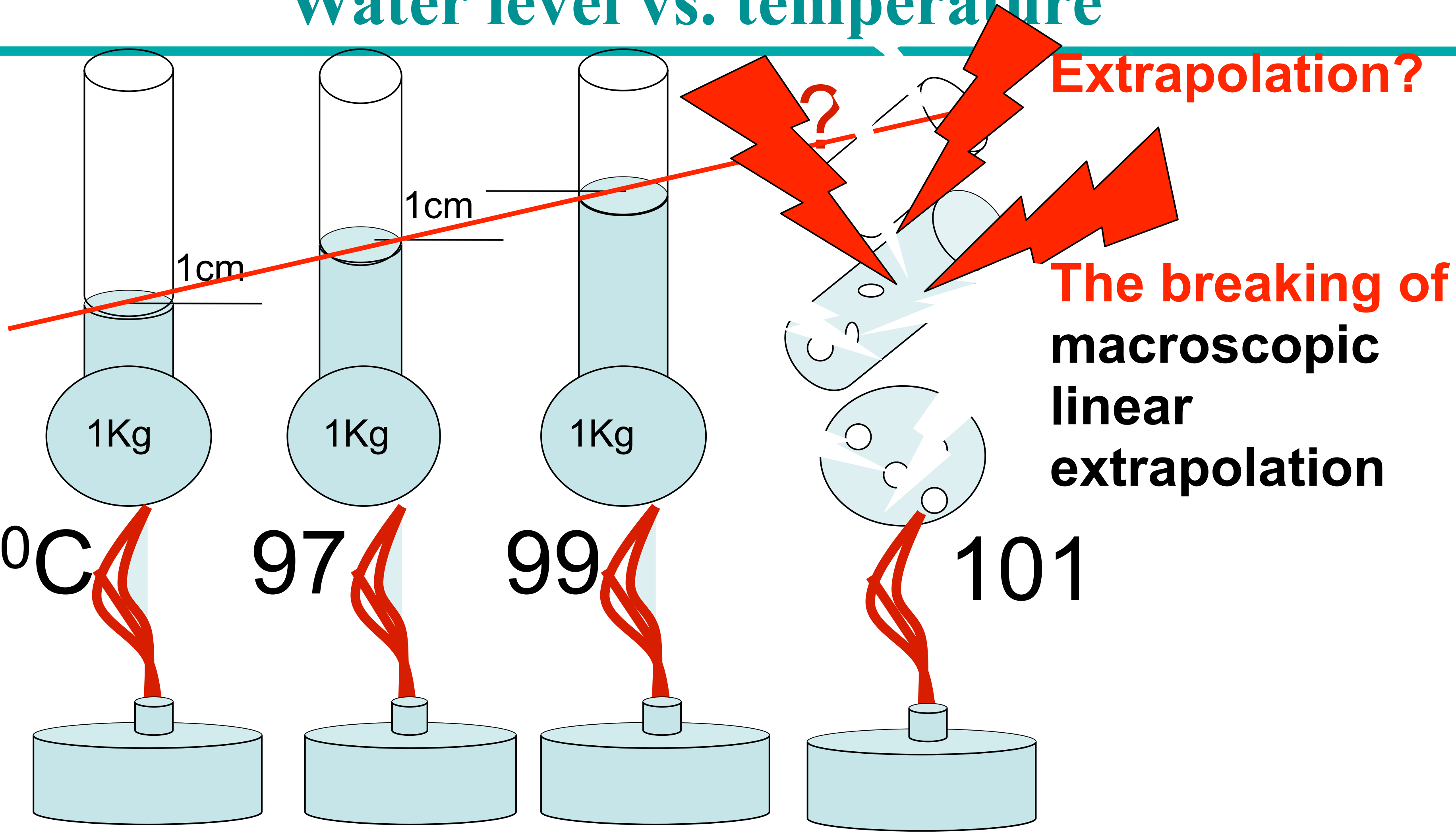
2522–2529 | PNAS | February 19, 2002 | vol. 99 | suppl. 1

D. Sornette



Simplest Example of a "More is Different" Transition

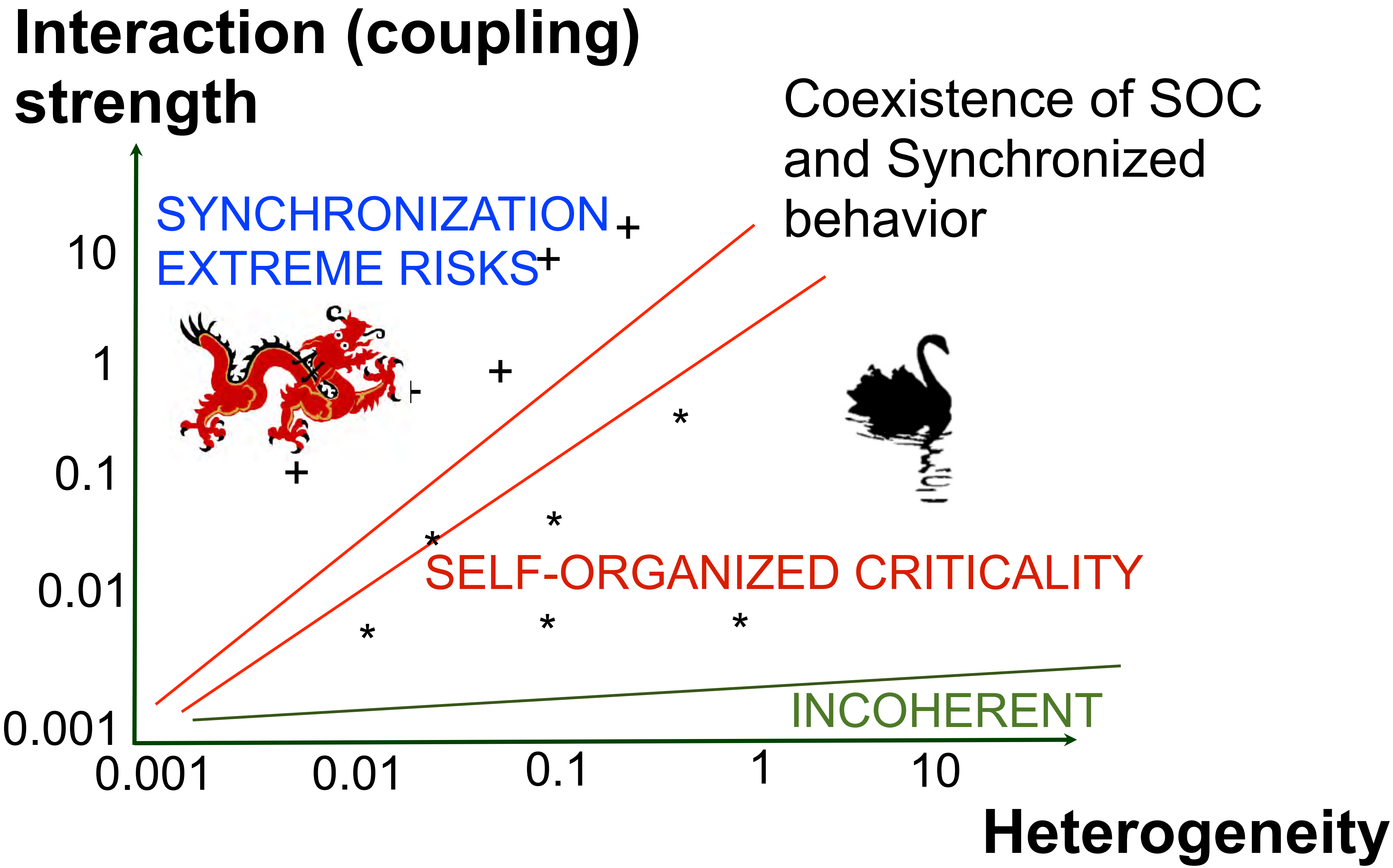
Water level vs. temperature

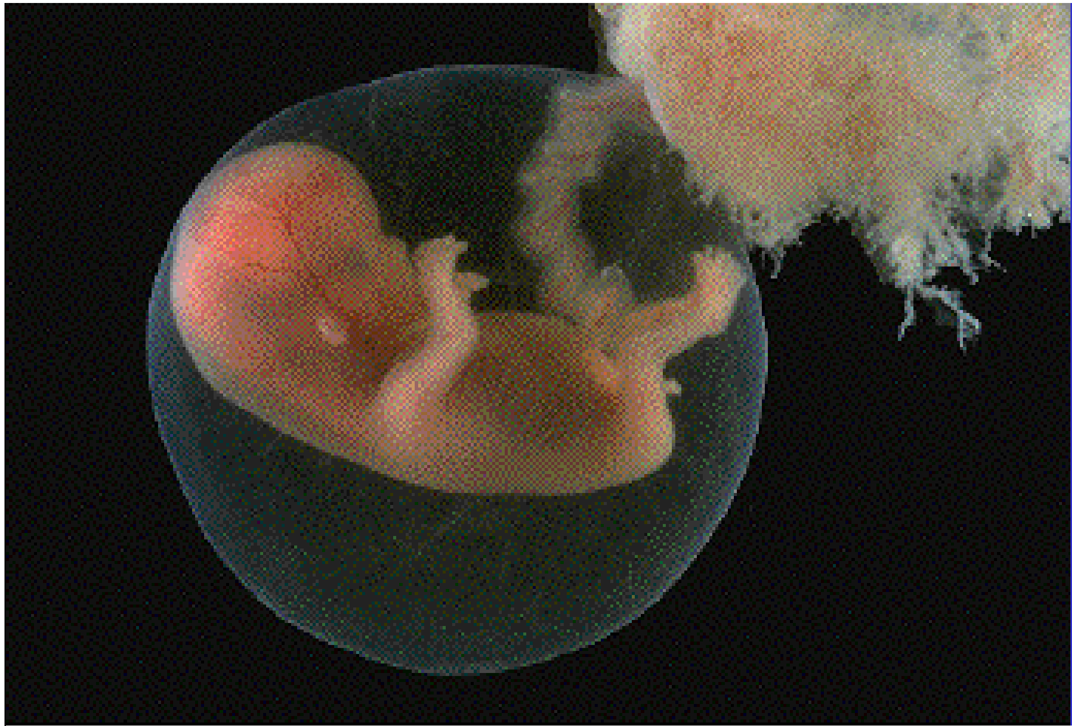


BOILING PHASE TRANSITION

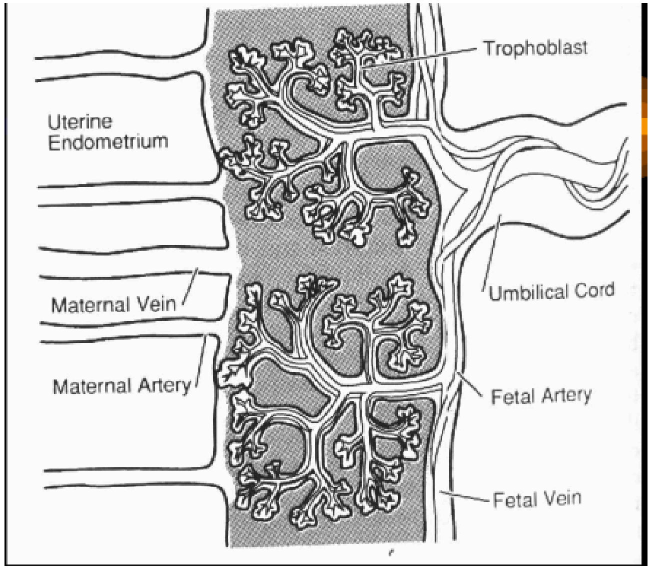
More is different: a single molecule does not boil at $100C^0$

Generic prediction diagram





Who initiates parturition?



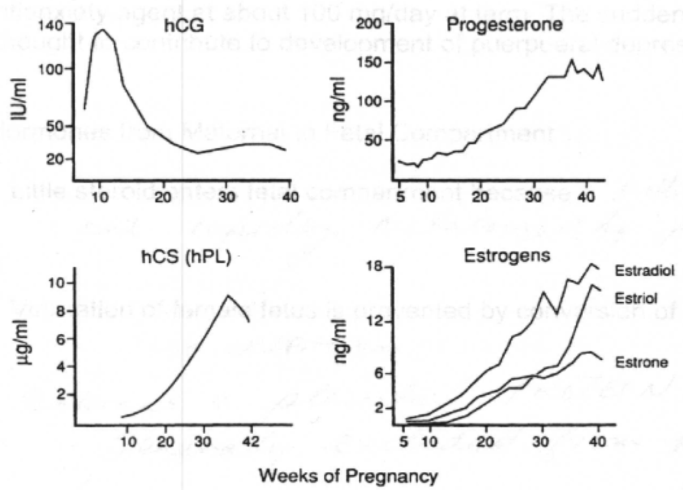


Figure 47-6. Changes in plasma levels of pregnancy hormones.

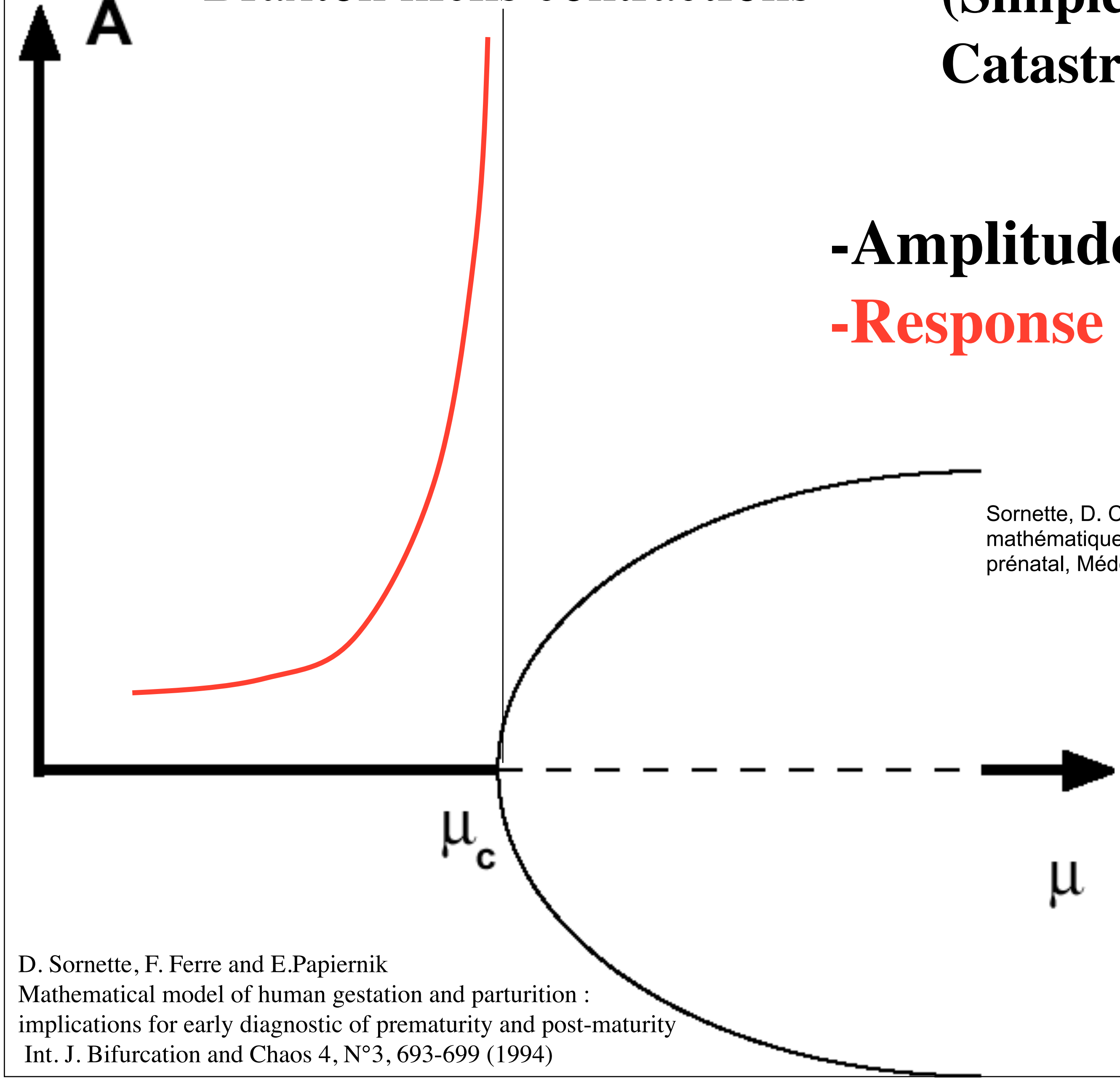
Generic Critical Precursors to a Bifurcation

Braxton hicks contractions

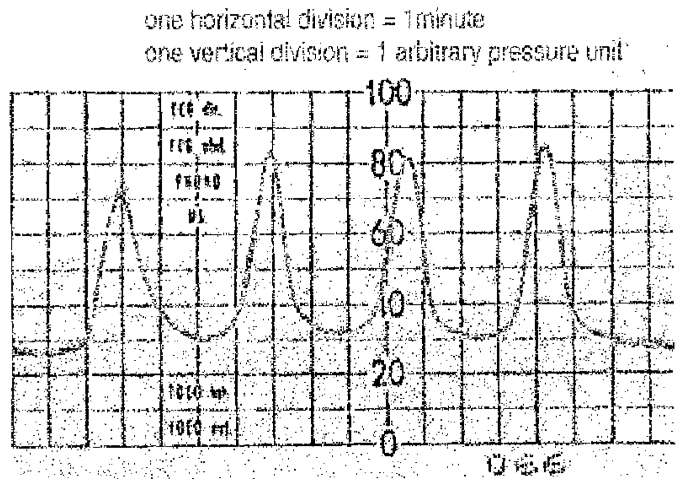
(Simple example of Catastrophe theory)

-Amplitude of fluctuations

-Response to external forcing



Sornette, D. Carbone, F.Ferre, C. Vauge and E.Papiernik, Modèle mathématique de la parturition humaine : implications pour le diagnostic prénatal, Médecine/Science 11, n°8, 1150-1153 (1995)



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)

Critical Precursory Fluctuations

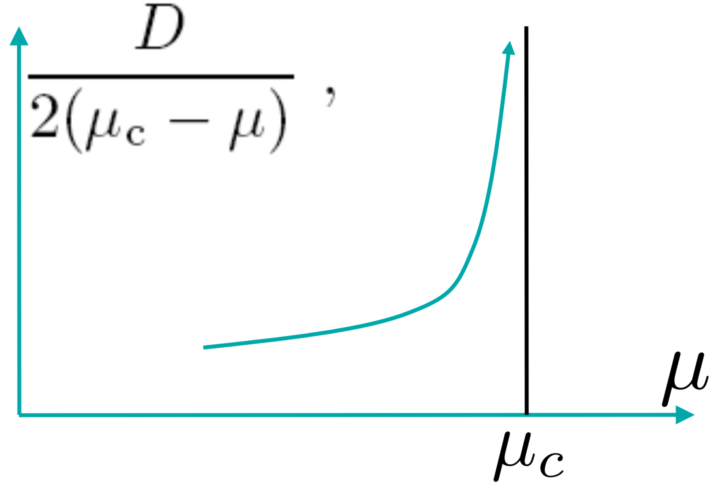
$$\frac{\mathrm{d}A}{\mathrm{d}t} = (\mu - \mu_{\mathrm{c}})A - \frac{A^3}{A_{\mathrm{s}}^2} + f(t)$$

Without NL term: $$A(t) = \int_0^t \mathrm{e}^{-\delta(t-\tau)} f(\tau)\ \mathrm{d}\tau$$

$$\delta = \mu_c - \mu$$

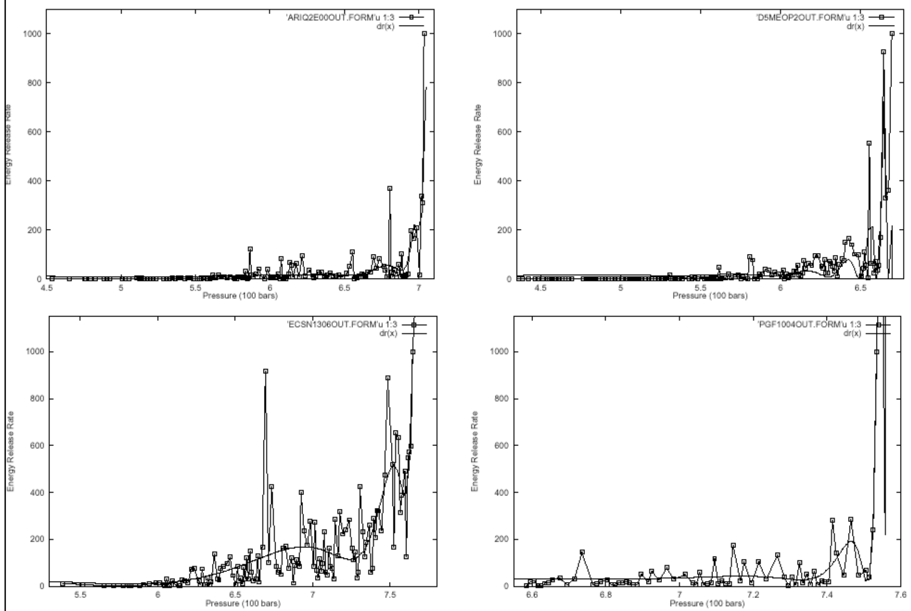
$$\langle [A(t)]^2 \rangle = \int_0^t \mathrm{d}\tau \int_0^t \mathrm{d}\tau'\, \mathrm{e}^{-\delta(t-\tau)} \mathrm{e}^{-\delta(t-\tau')} \langle f(\tau) f(\tau') \rangle$$

$$= D \int_0^t \mathrm{e}^{-2\delta(t-\tau)}\ \mathrm{d}\tau \quad \rightarrow \quad \frac{D}{2(\mu_{\mathrm{c}} - \mu)} ,$$



Methodology for predictability of crises

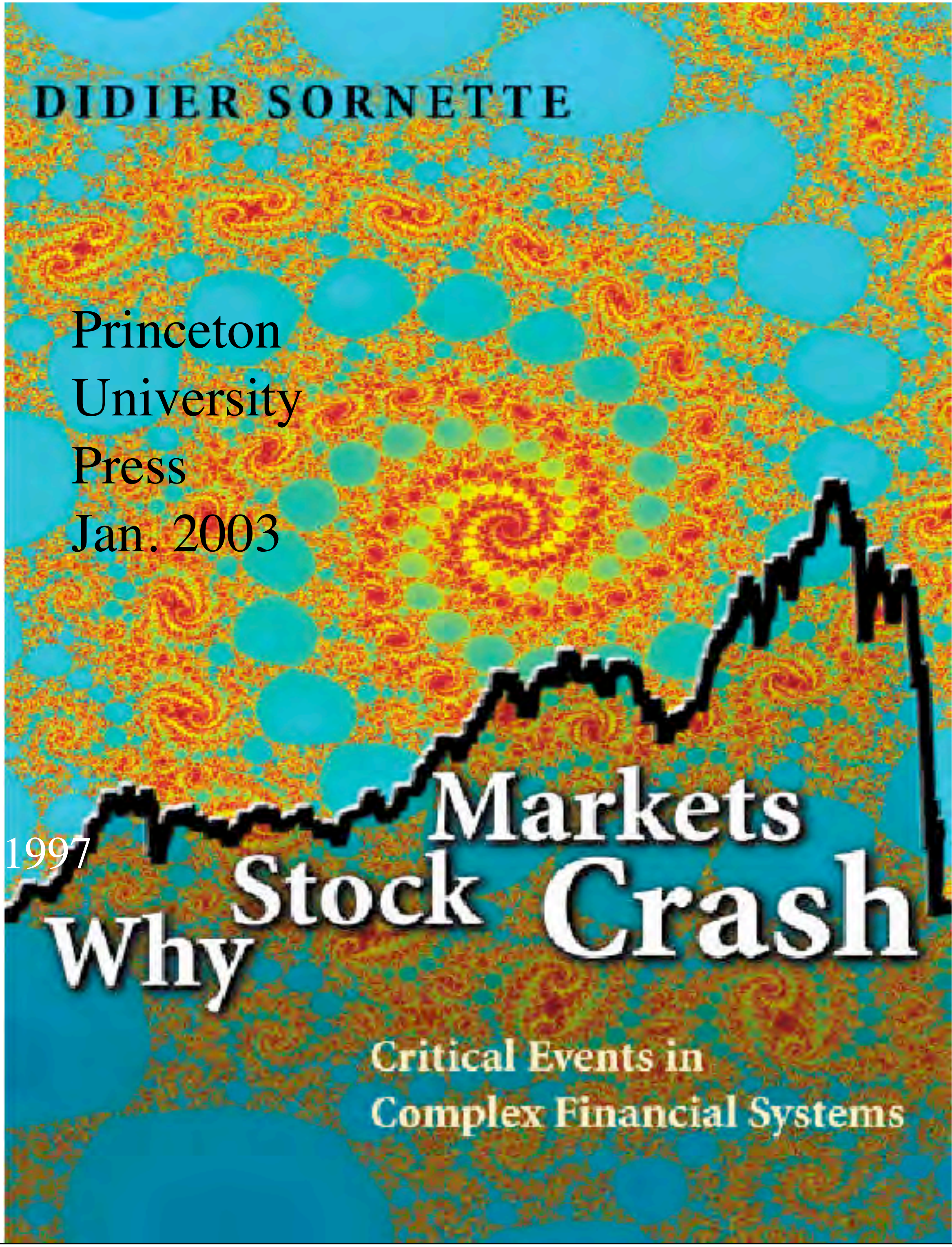
Strategy: look at the forest rather than at the tree



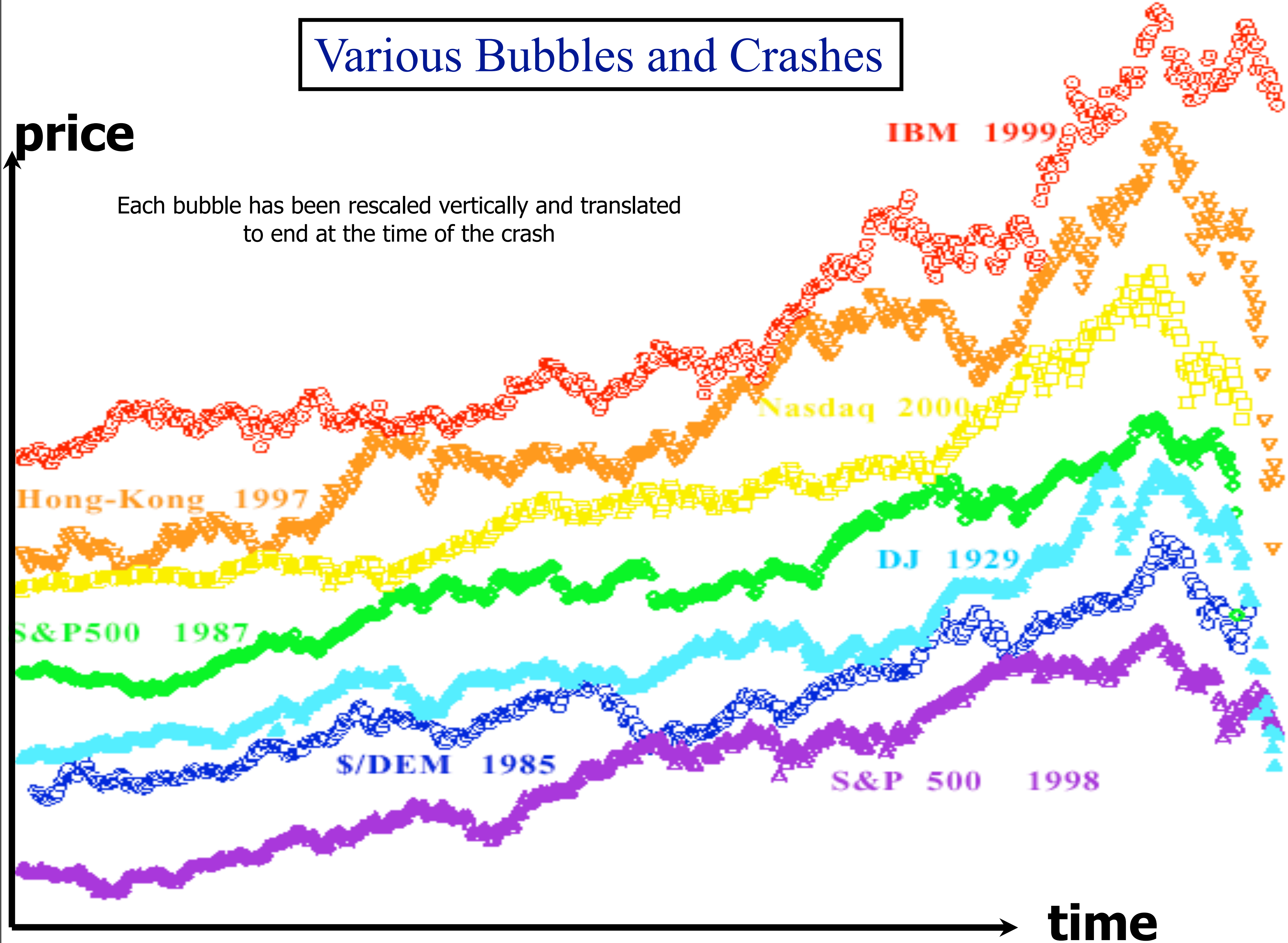
Our prediction system is now used in the industrial phase as the standard testing procedure.

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)


DIDIER SORNETTE
Princeton
University
Press
Jan. 2003
1997
Why Stock Markets Crash
Critical Events in
Complex Financial Systems

Various Bubbles and Crashes

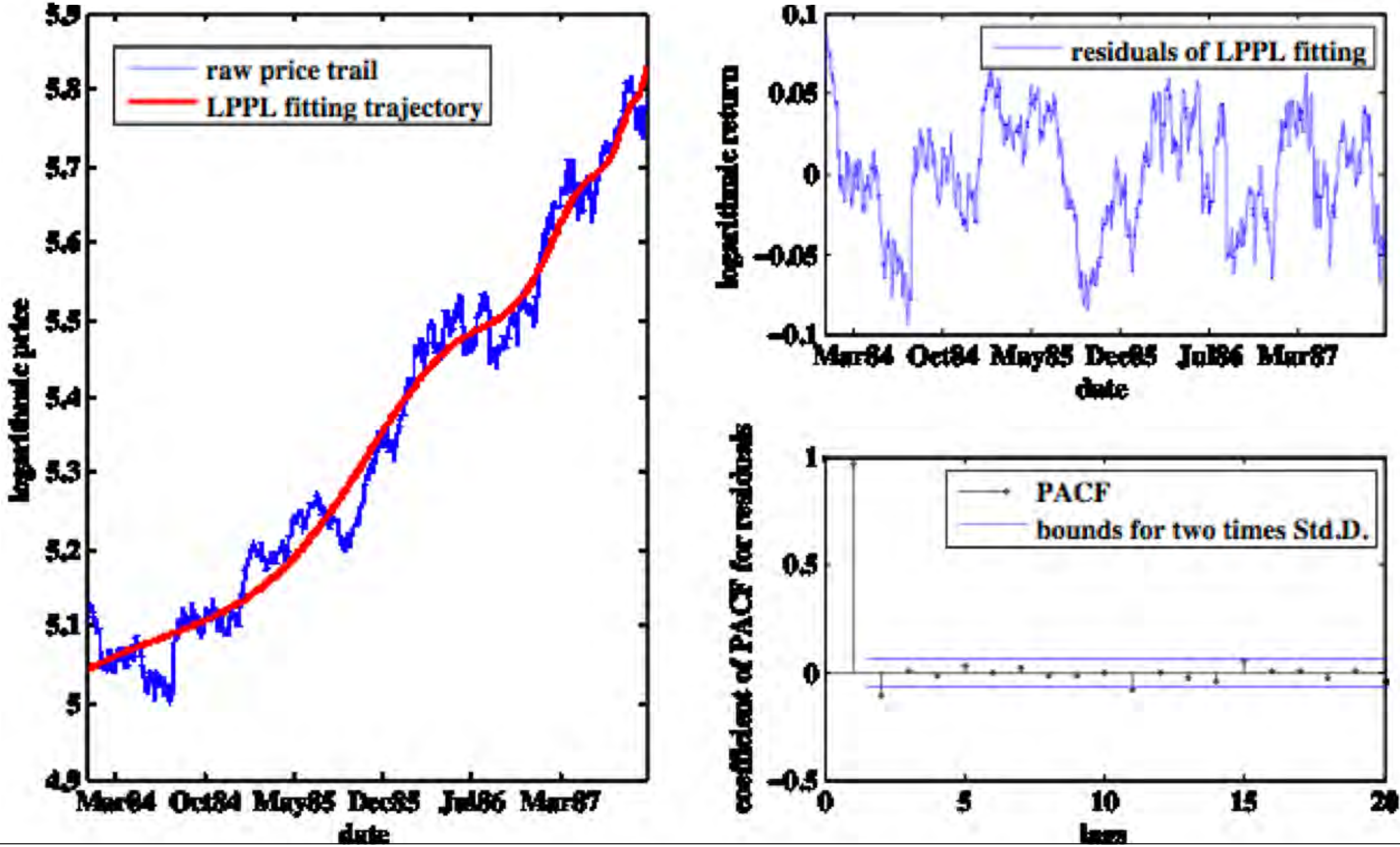


Methodology for predictability of crises

A Consistent Model of 'Explosive' Financial Bubbles With Mean-Reversing Residuals

L. Lin, R. E. Ren and D. Sornette (2009) (http://arxiv.org/abs/0905.0128)

$$\frac{dI}{I} = [r + \rho\Sigma + \kappa h(t)]dt - \alpha\rho_Y Y dt + (\sigma_Y + \sigma_W)dW$$



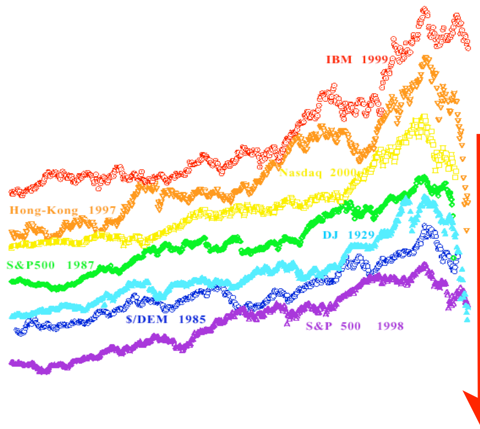
Endogenous vs exogenous crashes

1. Systematic qualification of "dragon-kings" in pdfs of drawdowns

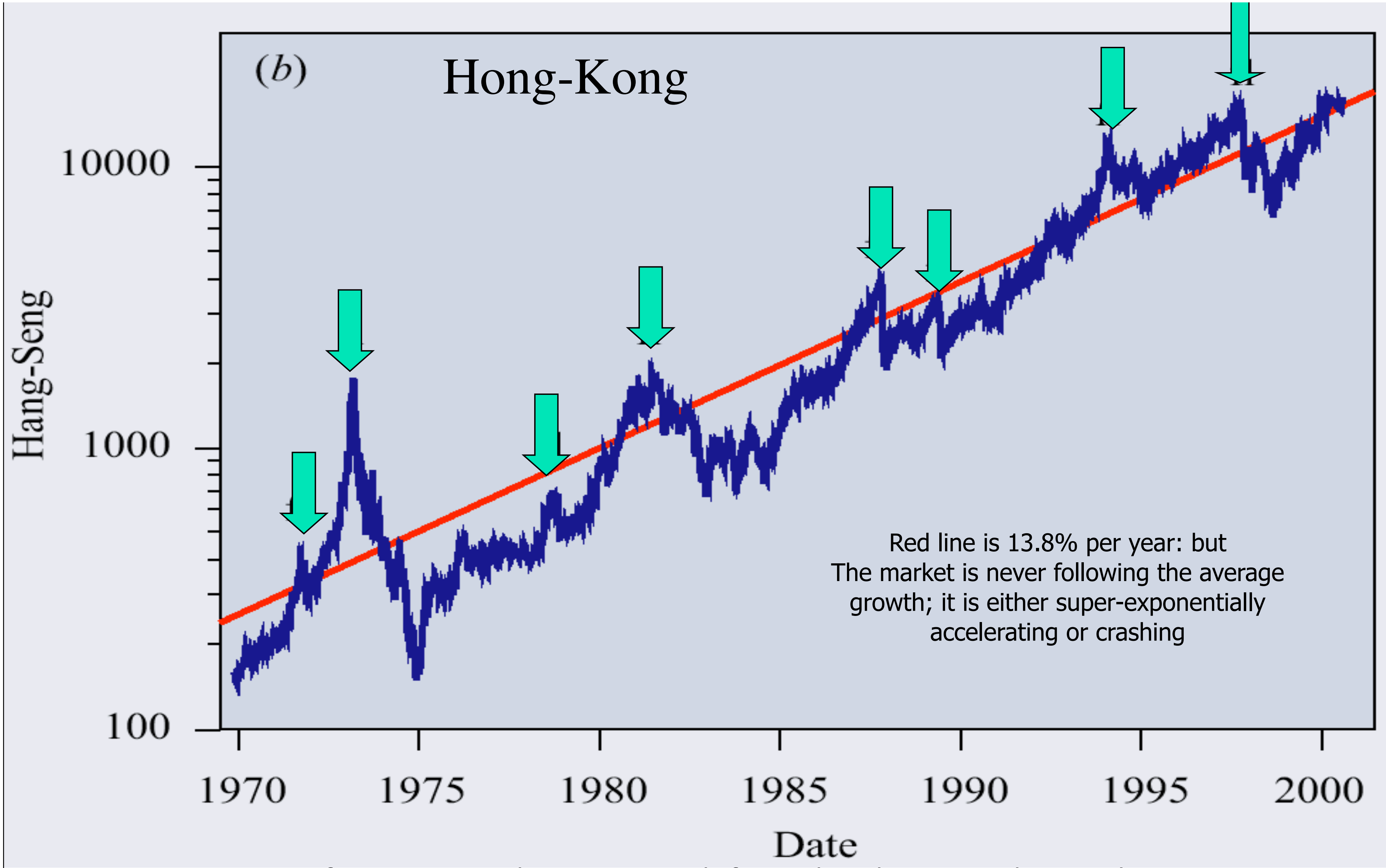
2. Existence or absence of a "critical" behavior by LPPL patterns found systematically in the price trajectories preceding this outliers

Results: In worldwide stock markets + currencies + bonds

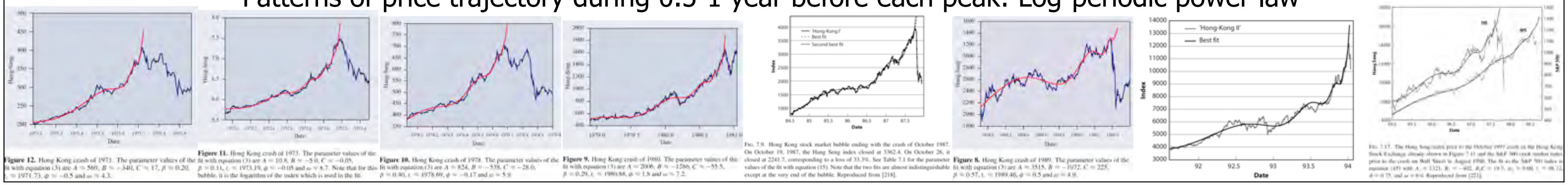
- **21 endogenous crashes**
- **10 exogenous crashes**



A. Johansen and D. Sornette, Shocks, Crashes and Bubbles in Financial Markets, Brussels Economic Review (Cahiers economiques de Bruxelles), 49 (3/4), (2006)



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

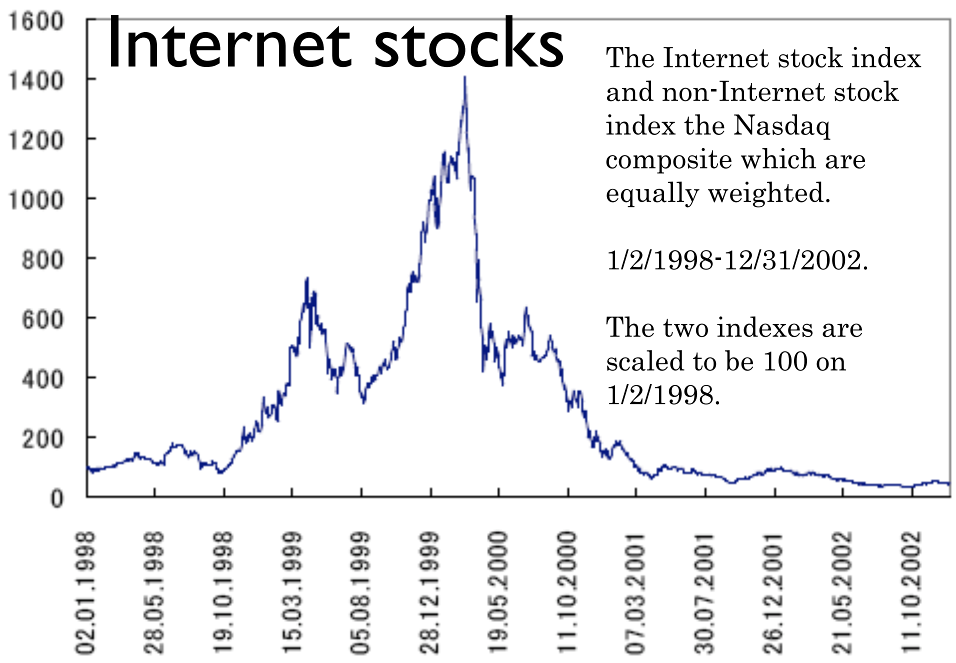


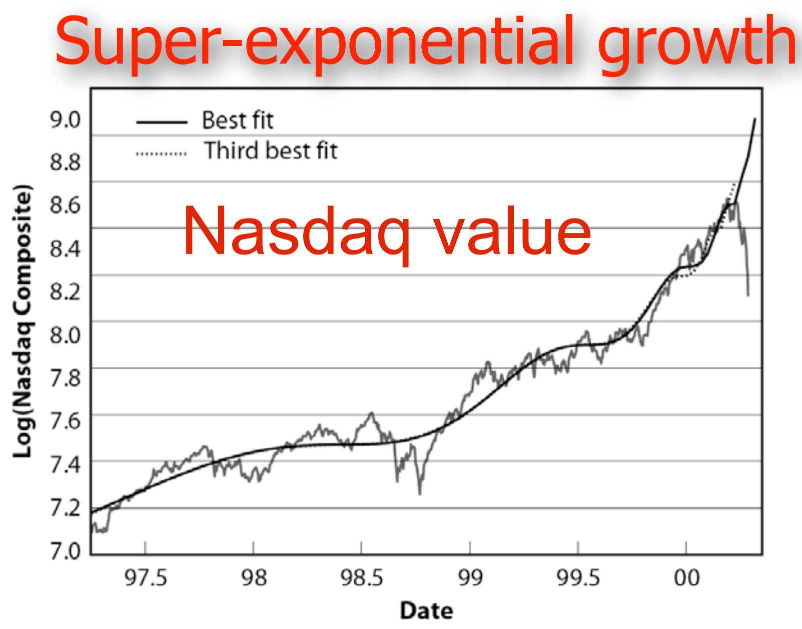
Predictability of the 2007-XXXX crisis: 15y History of bubbles and Dragon-kings

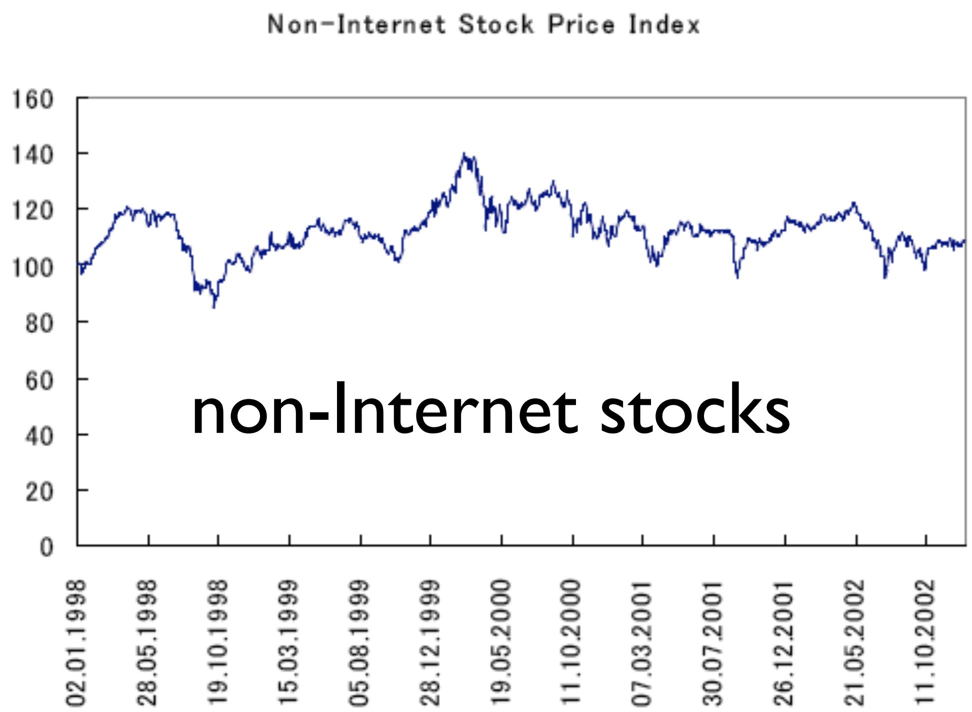
- The ITC "new economy" bubble (1995-2000)
- Slaving of the Fed monetary policy to the stock market descent (2000-2003)
- Real-estate bubbles (2003-2006)
- MBS, CDOs bubble (2004-2007) and stock market bubble (2004-2007)
- Commodities and Oil bubbles (2006-2008)

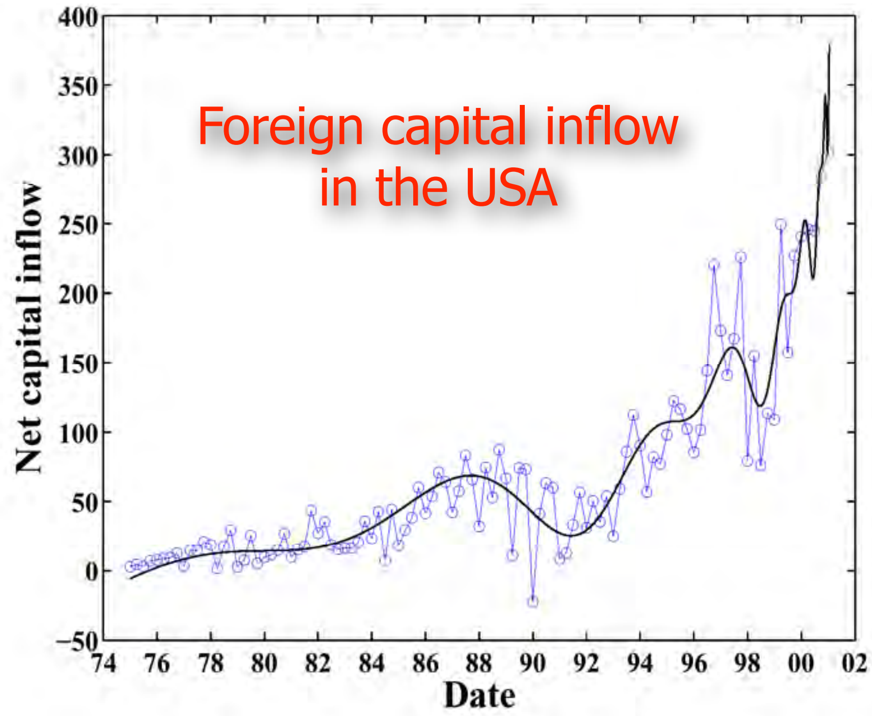
Didier Sornette and Ryan Woodard
Financial Bubbles, Real Estate bubbles, Derivative Bubbles, and the Financial and Economic Crisis (2009)
(http://arxiv.org/abs/0905.0220)

THE NASDAQ CRASH OF APRIL 2000









Real-estate in the UK

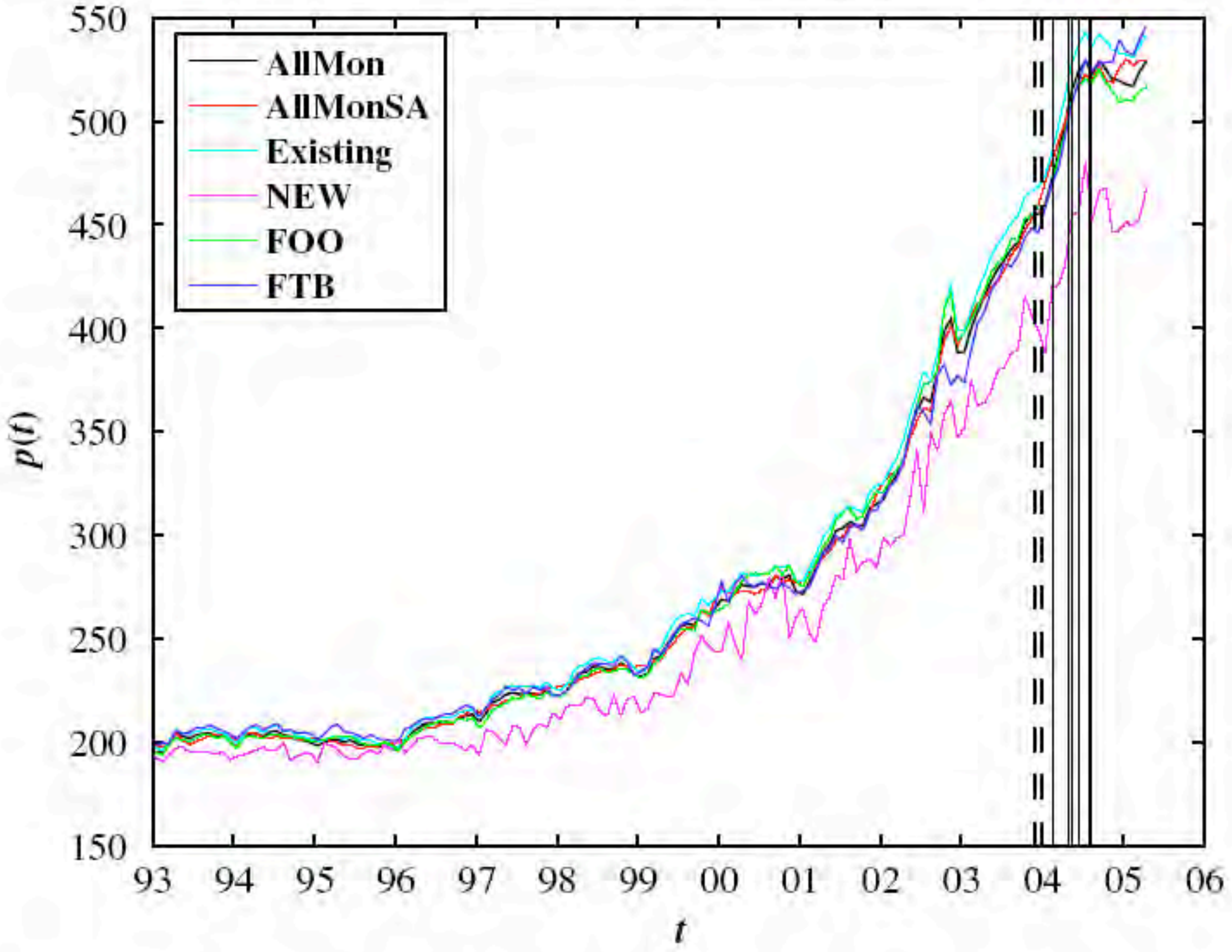


Fig. 1. (Color online) Plot of the UK Halifax house price indices from 1993 to April 2005 (the latest available quote at the time of writing). The two groups of vertical lines correspond to the two predicted turning points reported in Tables 2 and 3 of [1]: end of 2003 and mid-2004. The former (resp. later) was based on the use of formula (2) (resp. (3)). These predictions were performed in February 2003.

W.-X. Zhou, D. Sornette, 2000–2003 real estate bubble in the UK but not in the USA, Physica A 329 (2003) 249–263.

Real-estate in the USA

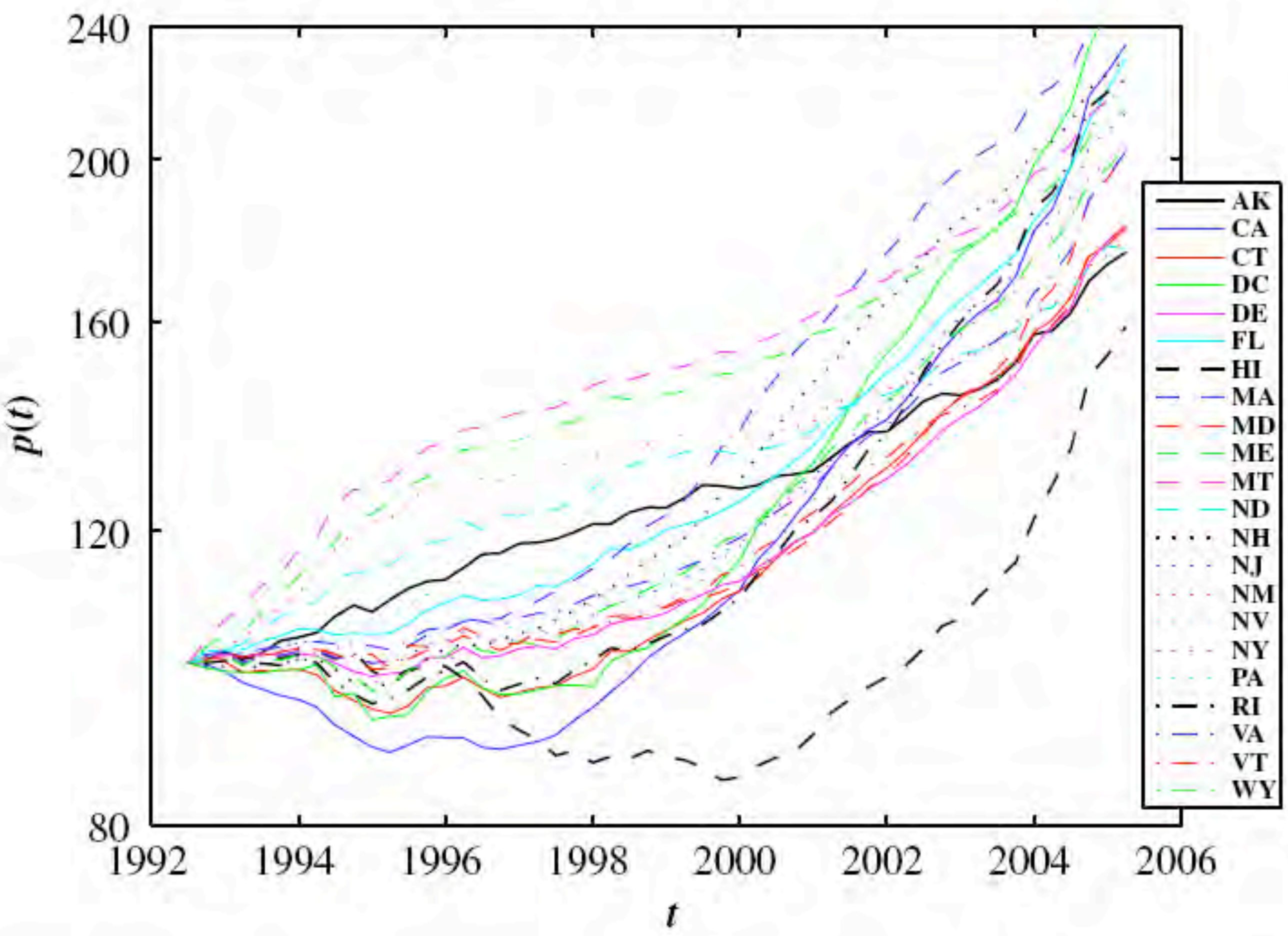
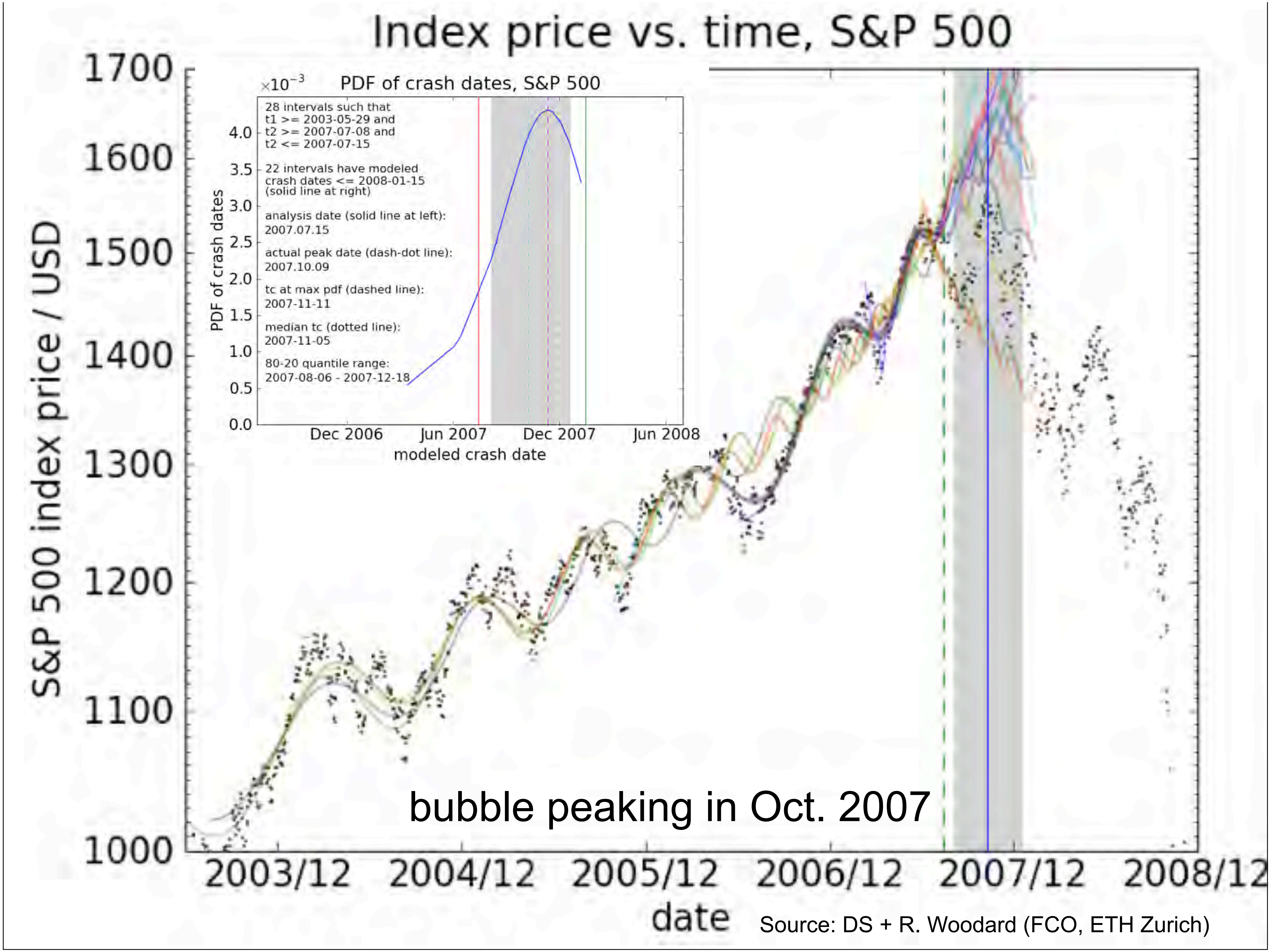
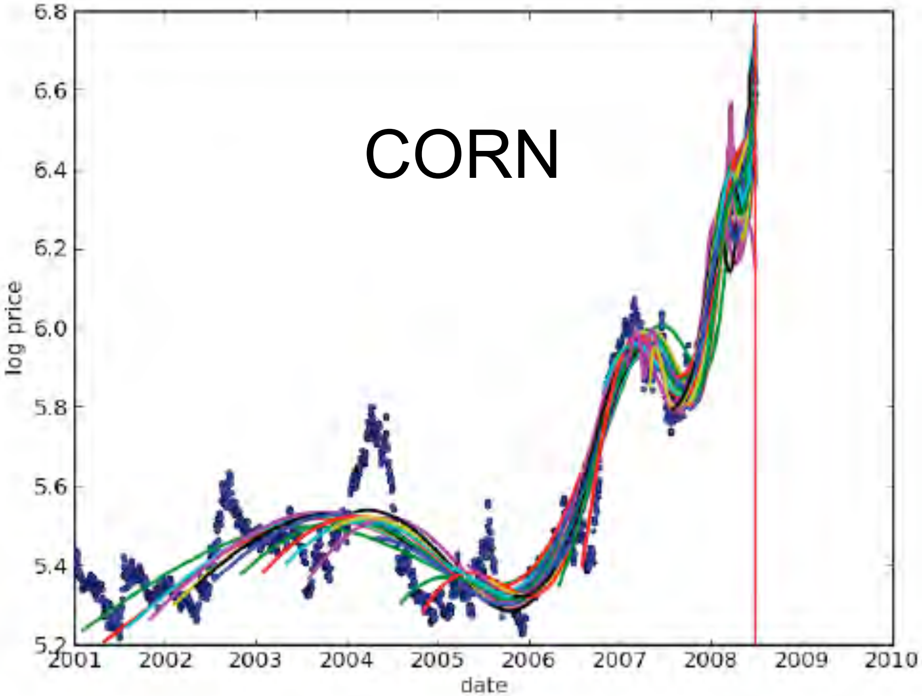


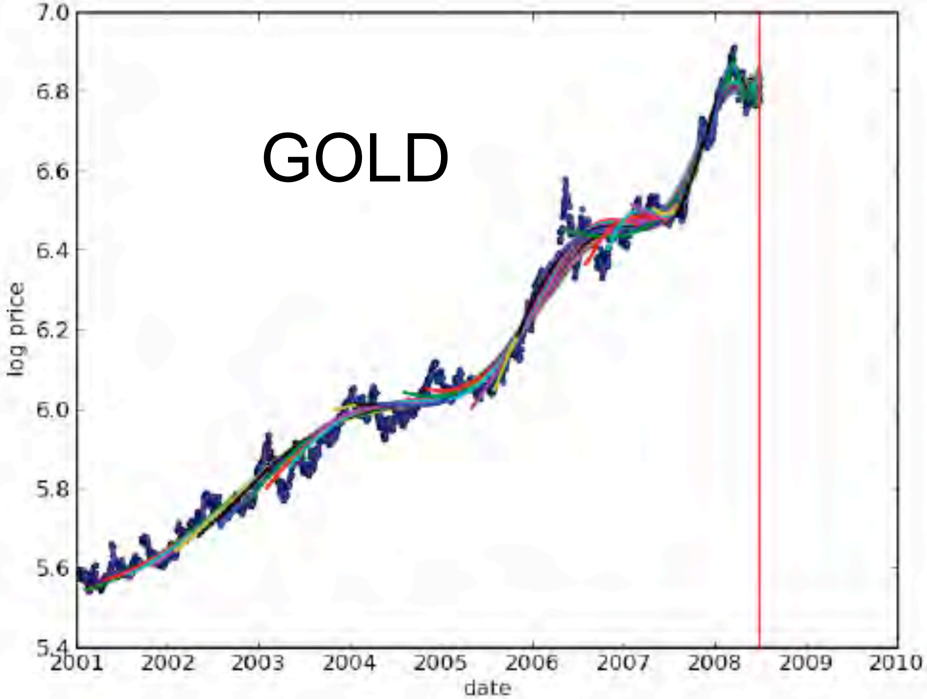
Fig. 5. (Color online) Quarterly average HPI in the 21 states and in the District of Columbia (DC) exhibiting a clear upward faster-than-exponential growth. For better representation, we have normalized the house price indices for the second quarter of 1992 to 100 in all 22 cases. The corresponding states are given in the legend.

W.-X. Zhou, D. Sornette / Physica A 361 (2006) 297–308

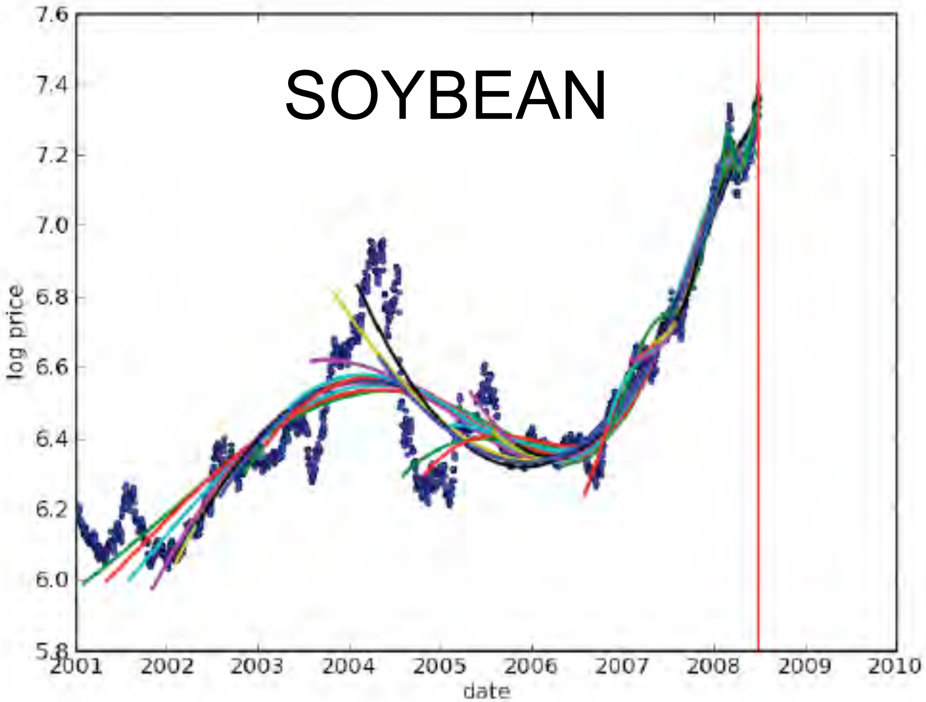


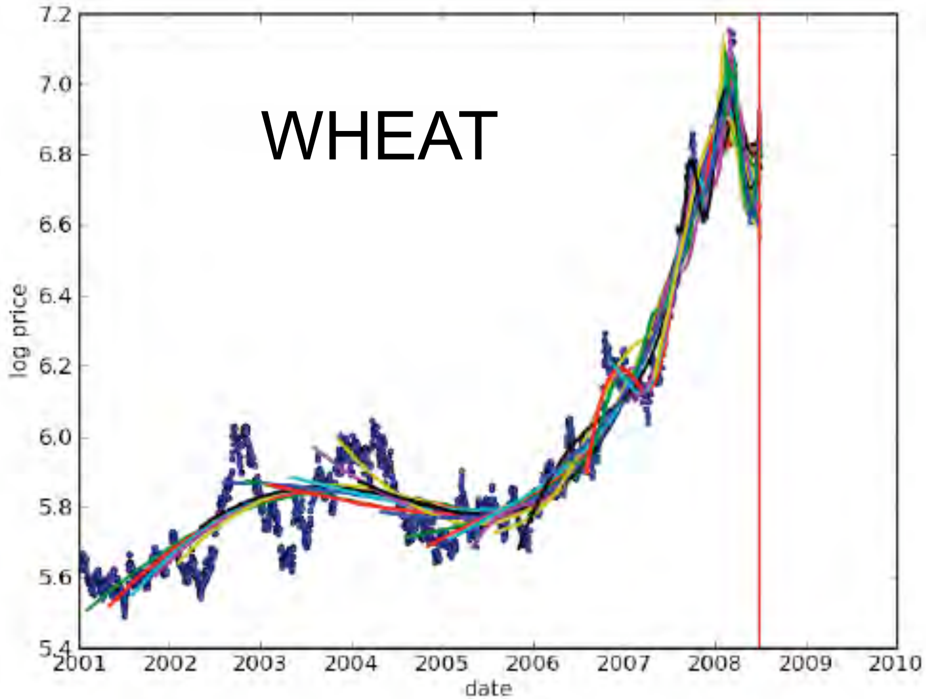
Index price vs. time, S&P 500
S&P 500 index price / USD
1700
1600
1500
1400
1300
1200
1100
1000
2003/12
2004/12
2005/12
2006/12
2007/12
2008/12
date
PDF of crash dates, S&P 500
×10^-3
PDF of crash dates
28 intervals such that
t1 >= 2003-05-29 and
t2 >= 2007-07-08 and
t2 <= 2007-07-15
22 intervals have modeled
crash dates <= 2008-01-15
(solid line at right)
analysis date (solid line at left):
2007.07.15
actual peak date (dash-dot line):
2007.10.09
tc at max pdf (dashed line):
2007-11-11
median tc (dotted line):
2007-11-05
80-20 quantile range:
2007-08-06 - 2007-12-18
Dec 2006
Jun 2007
Dec 2007
Jun 2008
modeled crash date
bubble peaking in Oct. 2007
Source: DS + R. Woodard (FCO, ETH Zurich)



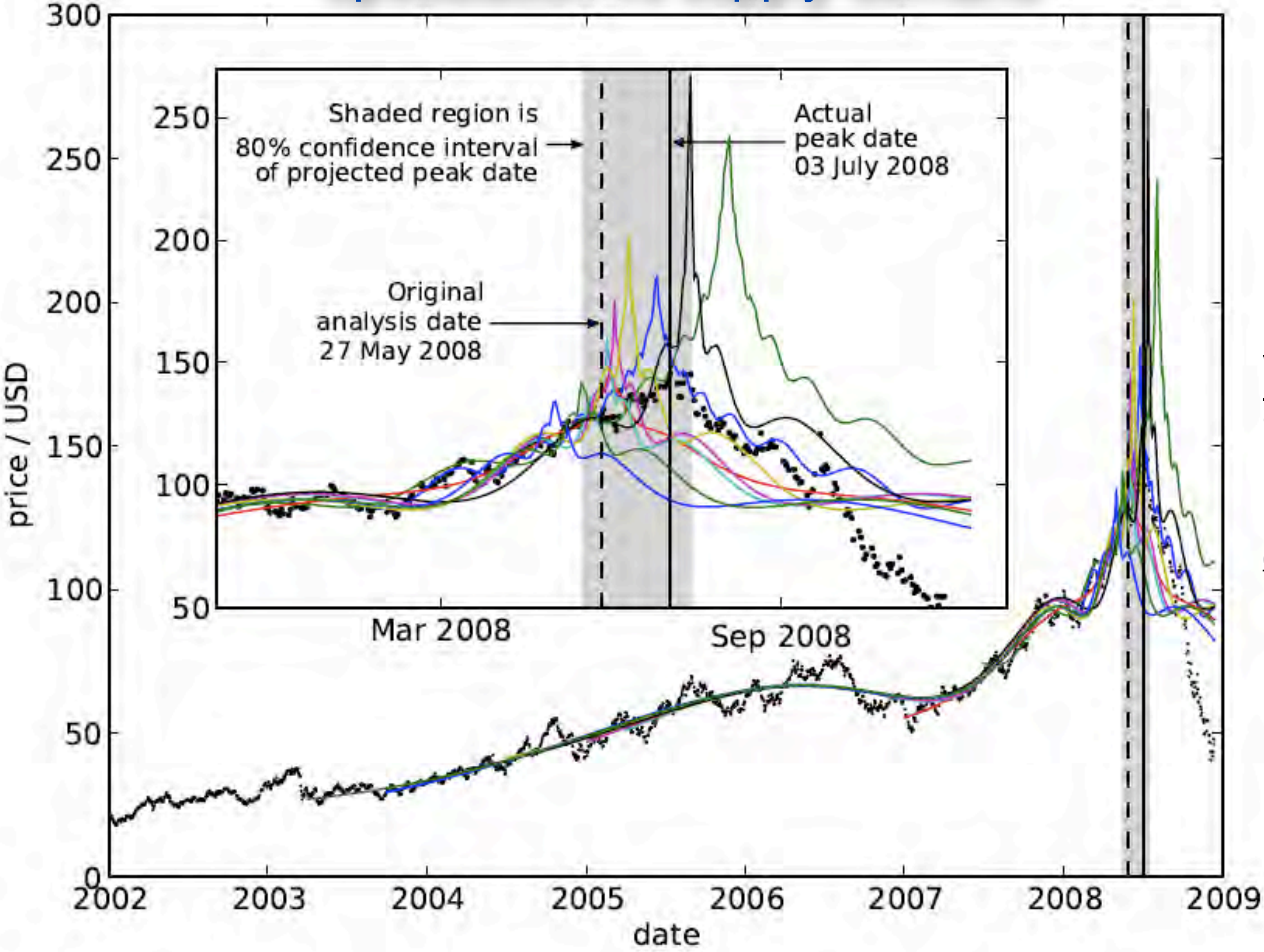


R.Woodard and D.Sornette (2008)





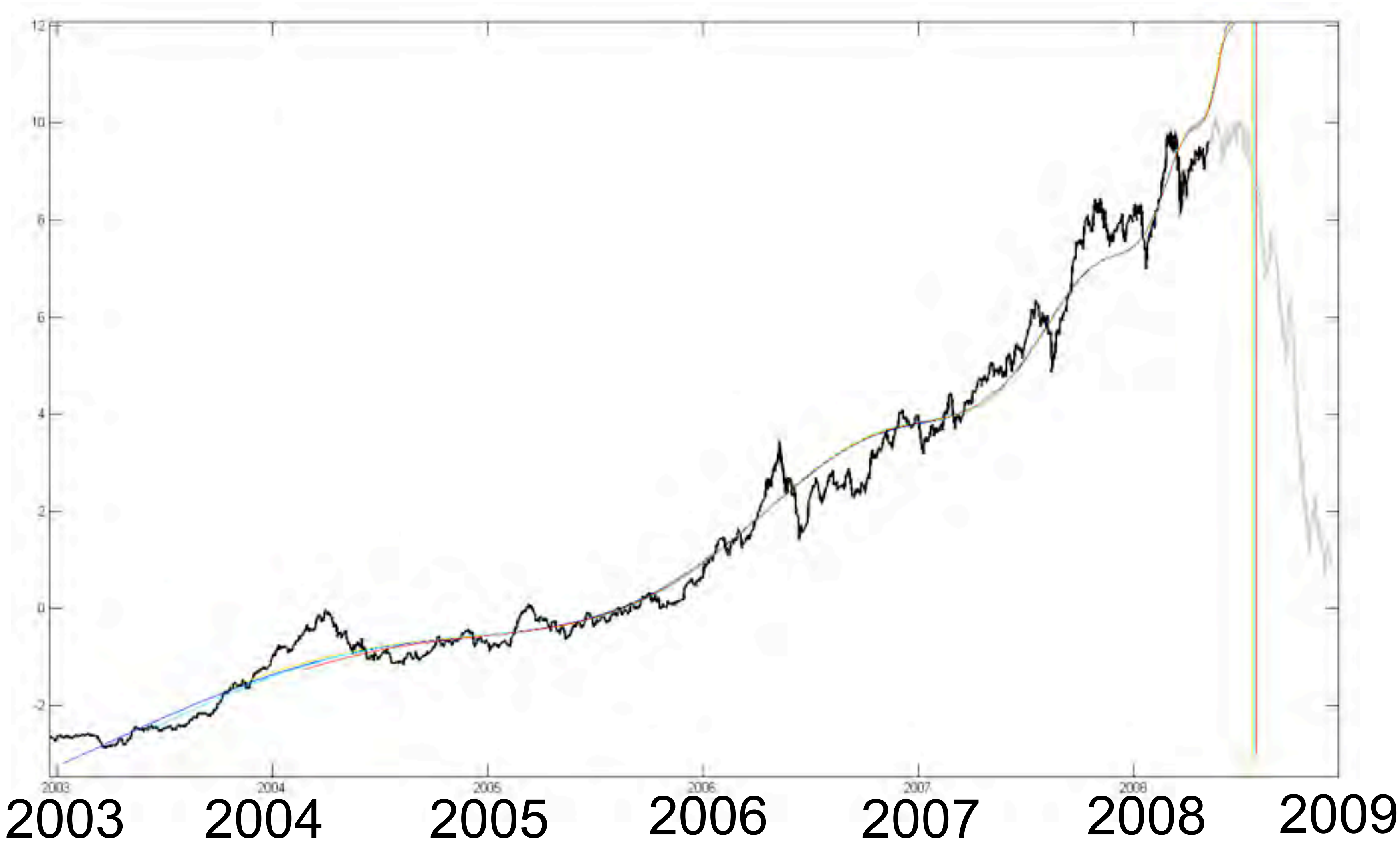
2006-2008 Oil bubble
Speculation vs supply-demand



D. Sornette, R. Woodard and W.-X. Zhou, The 2006-2008 Oil Bubble and Beyond, Physica A 388, 1571-1576 (2009) (arXiv.org/abs/0806.1170)

Typical result of the calibration of the simple LPPL model to the oil price in US$ in shrinking windows with starting dates t_{start} moving up towards the common last date t_{last} = May 27, 2008.

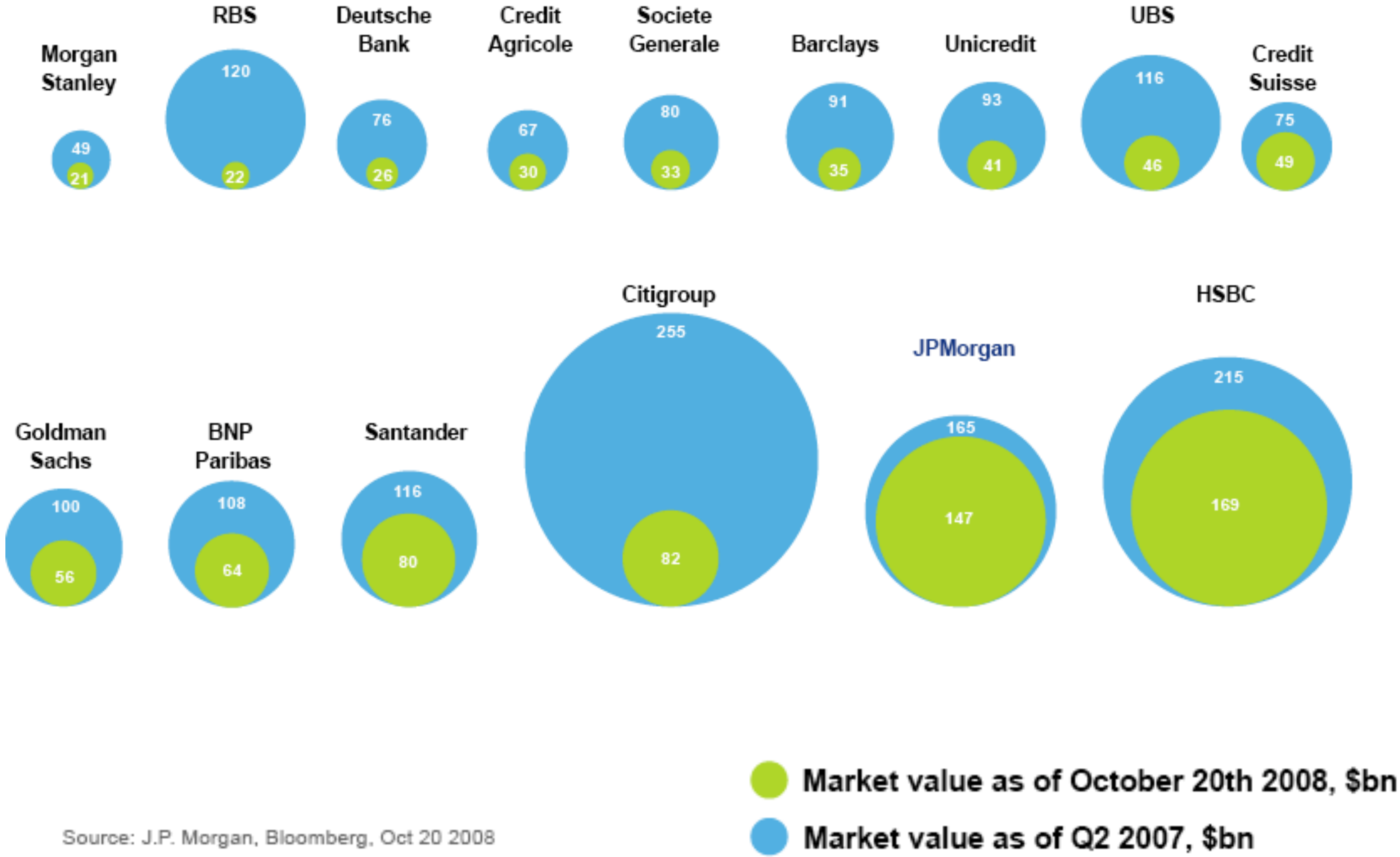
The Global BUBBLE



PCA first component on a data set containing, emerging markets equity indices, freight indices, soft commodities, base and precious metals, energy, currencies...

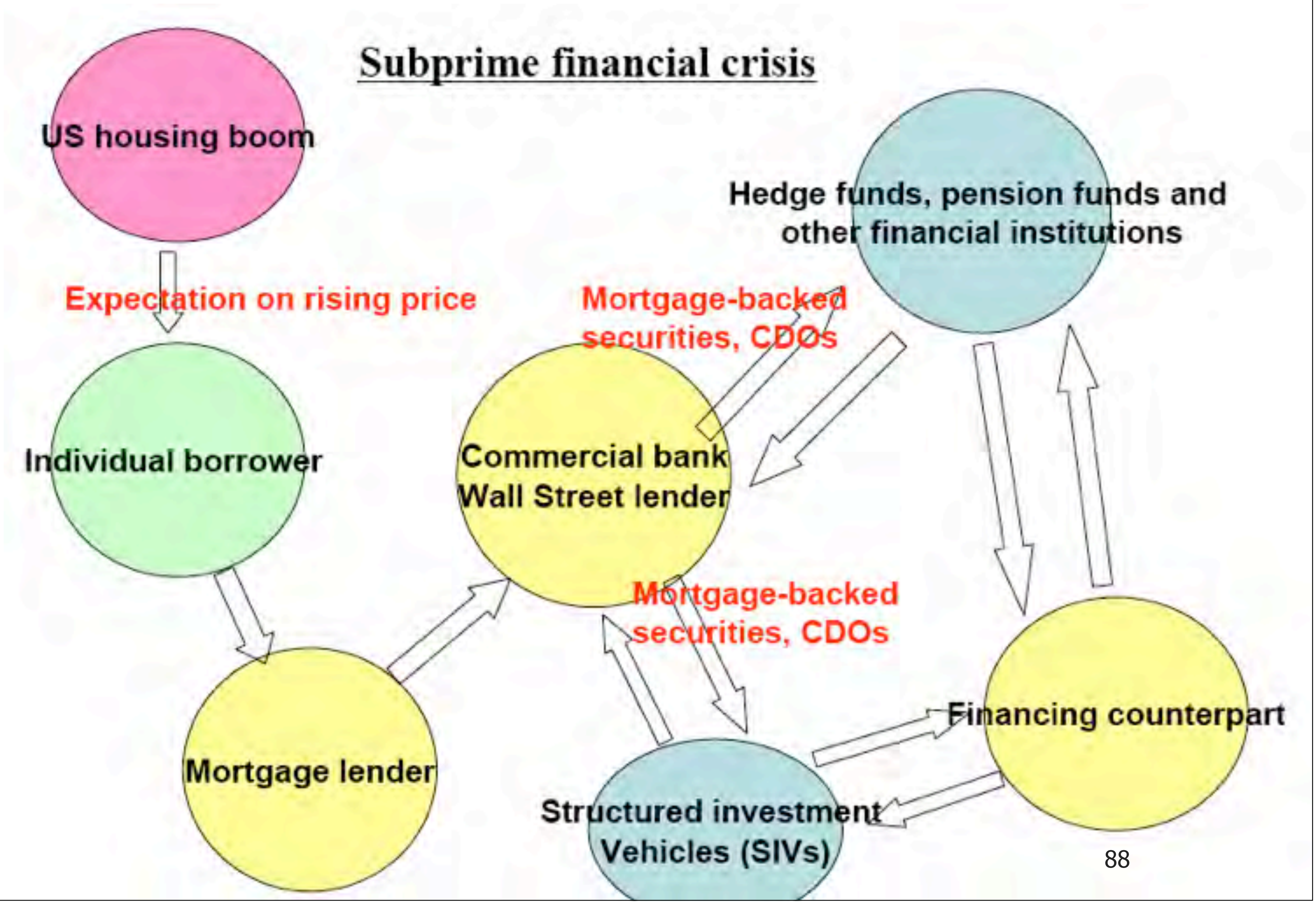
(Peter Cauwels FORTIS BANK - Global Markets)

The illusionary "PERPETUAL MONEY MACHINE"



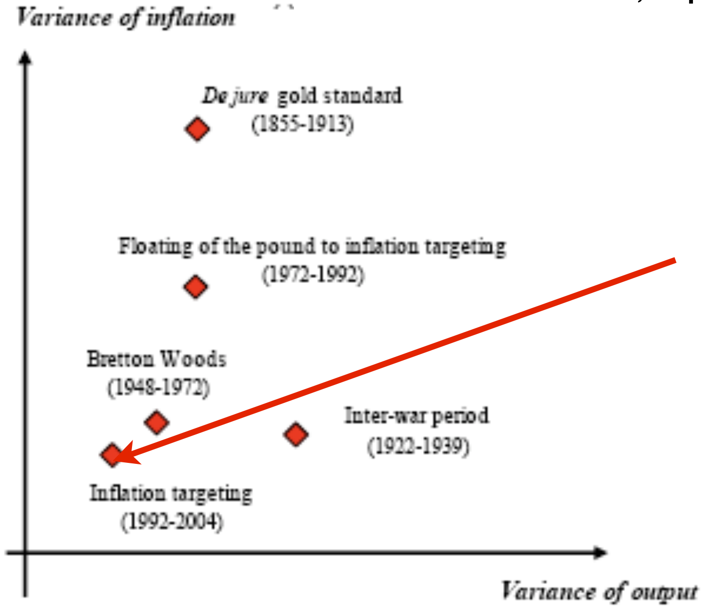
Source: J.P. Morgan, Bloomberg, Oct 20 2008

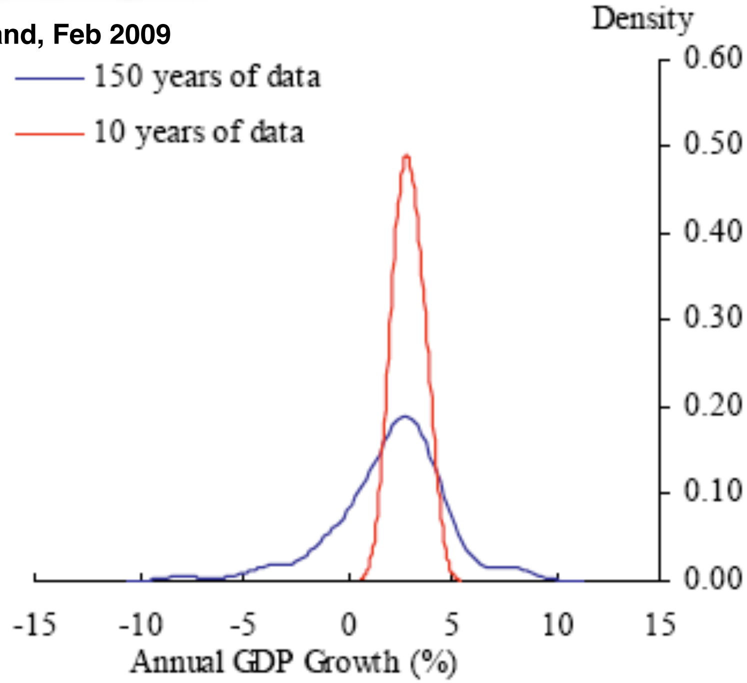
Securitization of non-financial assets
(commodities, real-estate, credit)

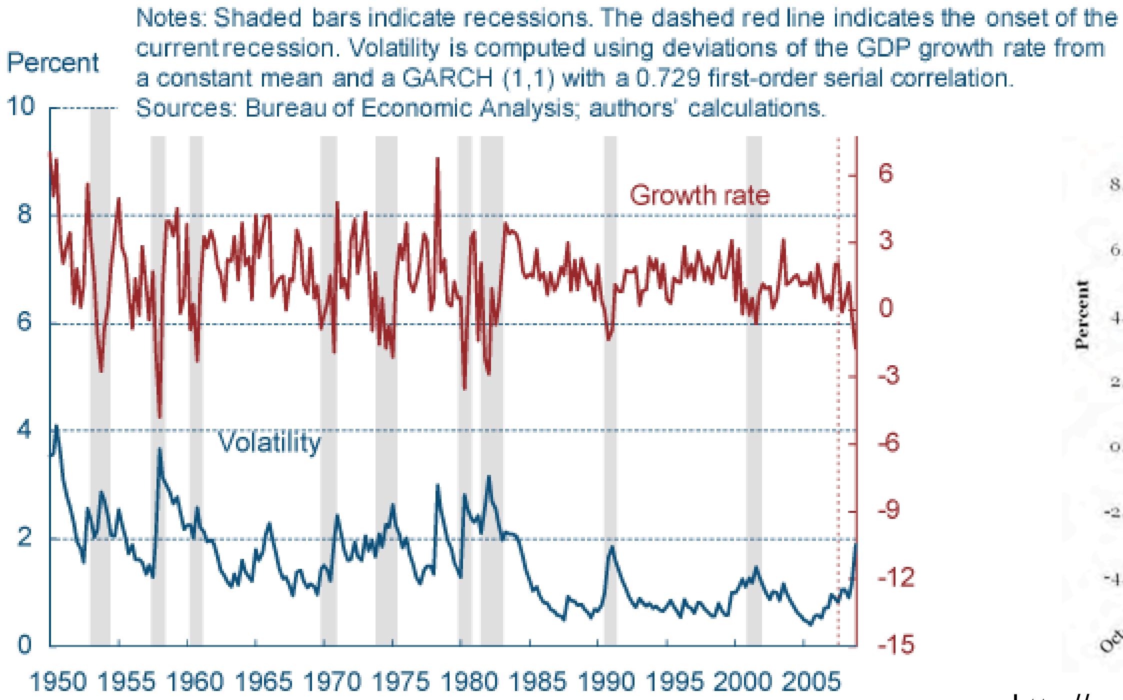


THE GREAT MODERATION

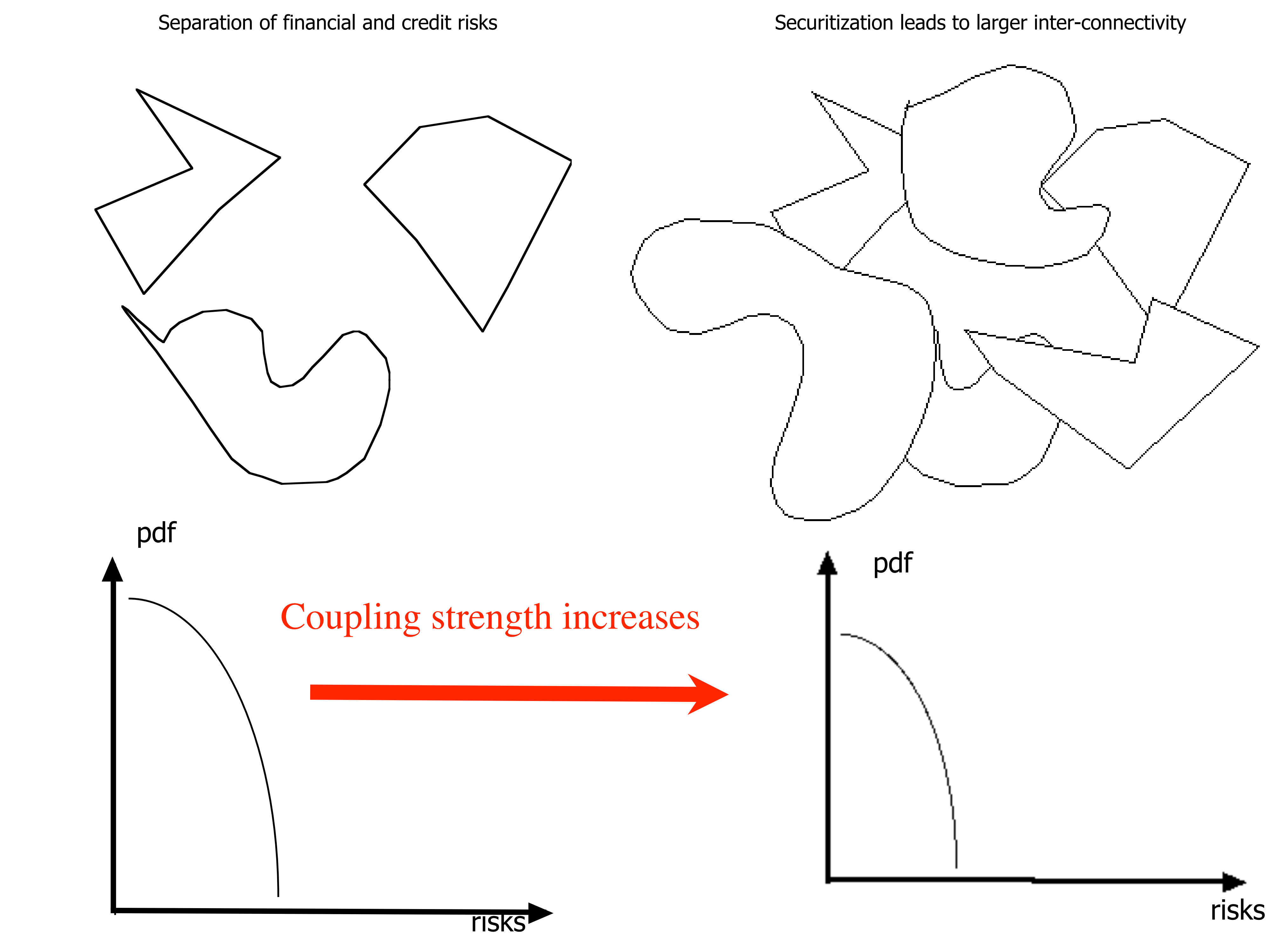
Source: SIR JOHN GIEVE, Deputy Governor, Bank of England, Feb 2009





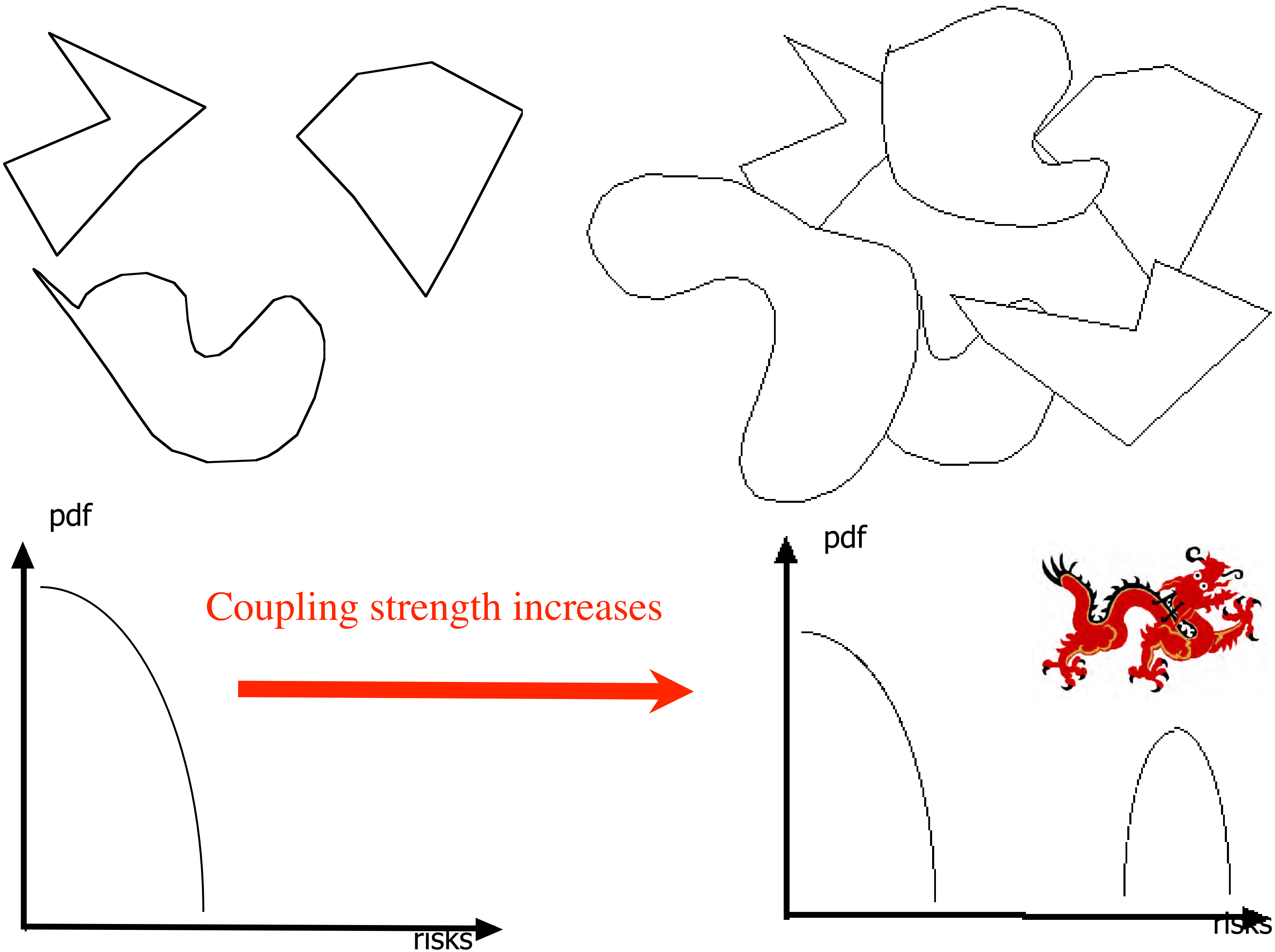


http://www.clevelandfed.org/research/trends/2009/0309/03ecoact.cfm


Separation of financial and credit risks
Securitization leads to larger inter-connectivity
pdf
Coupling strength increases
risks
pdf
risks

Separation of financial and credit risks

Securitization leads to larger inter-connectivity



In summary

Each excess is partially “solved” by the subsequent excess... leading to a succession of
-unsustainable wealth growth
-instabilities

The present crisis+recession is the consolidation after this series of unsustainable excesses.

One could conclude that the extraordinary severity of this crisis is not going to be solved by the same of implicit or explicit “bubble thinking”.

"The problems that we have created cannot be solved at the level of thinking that created them." Albert Einstein

Absence of fundamental change

-March-August 09 equities rally esp. based on financials that have reported excellent Q1 figures based on trading (root of the actual problem), there is a lot to be told about that...

- financial institutions accounting is more opaque and creative as ever, just look at the recent changes, launched, actually in order to solve the problem (which roots again in creativity of frying air).

- TARP and PPIP are launched in order to artificially pump up asset prices based on leverage and asymmetric upside downside risk taking (investors vs tax payers) - again the roots of the current crisis.

-Debts of private institutions has been transformed into government debts (sustainable?)

TARP: trouble asset release program
PPIP: public-private investment program

a Financial Crisis Observatory

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

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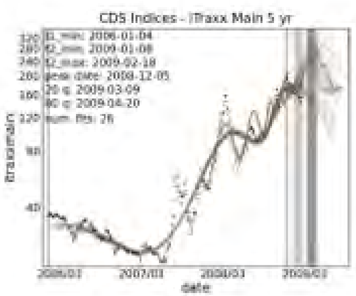
ETH Zurich - D-MTEC - Welcome to the Chair of Entrepreneurial Risks - Financial Crisis Observatory

Financial Crisis Observatory

Financial Crisis Observatory
- Description
- Highlights
- Is there an oil bubble?
- Pertinent articles
- Websites and Blogs
- Market Anxiety Measures

The Financial Crisis Observatory (FCO) is a scientific platform aimed at testing and quantifying rigorously, in a systematic way and on a large scale the hypothesis that financial markets exhibit a degree of inefficiency and a potential for predictability, especially during regimes when bubbles develop.

Current analysis and forecasts



CDS (19 February 2009)
Our analysis has been performed on data kindly provided by Amjed Younis of Fortis on 19 February 2009. It consists of 3 data sets: credit default swaps (CDS); German bond futures prices; and spread evolution of several key euro zone sovereigns. The date range of the data is between 4 January 2006 and 18 February 2009. Our log-periodic power law (LPPL) analysis shows that credit default swaps appear bubbly, with a projected crash window of March-May, depending on the index used. German bond futures and European sovereign spreads do not appear bubbly. (See report for more information.)

OIL (27 May 2008)
Oil prices exhibited a record rise followed by a spectacular crash in 2008. The peak of $145.29 per barrel was set on 3 July 2008

The Financial Bubble Experiment

advanced diagnostics and forecasts of bubble terminations

• ***Hypothesis H1*: financial (and other) bubbles can be diagnosed in real-time before they end.**

• ***Hypothesis H2*: The termination of financial (and other) bubbles can be bracketed using probabilistic forecasts, with a reliability better than chance (which remains to be quantified).**

The Financial Bubble Experiment: advanced diagnostics and forecasts of bubble terminations

The Financial Crisis Observatory*
Department of Management, Technology and Economics, ETH Zurich, Kreuzplatz 5, CH-8032 Zurich, Switzerland
(Dated: November 2, 2009)

Publication date	MD5SUM SHA256SUM SHA512SUM
2009-11-02	6d9479eb2849115a12c219cfa902990e d7ad5c9531166917ba97f871fb61bd1f6290b4b4ce54e3ba0c26b42e2661dc06 808bbfaddbca3db8d0f55d74cabedf5201ecd70340f86e27dfac589ce682144f52f6fc4b3ff1ac75231038d86dae58bd320e7fb17ef321b4bc61a19e88071039
2009-11-02	5d375b742a9955d4aeea1bd5c7220b2b 5a9c395b9ab1d2014729ac5ff3bb22a352e14096fa43c59836ea0d4ae0e3b453 e7ef9150b4738253f4021b0600eff1cd455b2671e421b788b9268b518439b56699994b3f8b395742bdc7622b5536034e74ade86e0a46bff71ed5ff9a293f809f
2009-11-02	fd85000d0ce3231892ef1257d2f7ab1e d3f3d504d85d50eb3dc0fe2c3042746db2f010509f4d1717370d14012972e86f 91a8fa82b7f08deea2df2a1f7cef266f5aa155bb0c047f65b14315f7229d92976cc7b30453453fb8ecd0350783907c83652192d32ba90fb1cce128385832e63a

TABLE I: Checksums of Financial Bubble Experiment forecast documents.

Thursday, November 05, 2009

Forecasting financial crashes: the ultimate experiment begins

If a new technique for predicting crashes really works, a bold new experiment will measure how well.

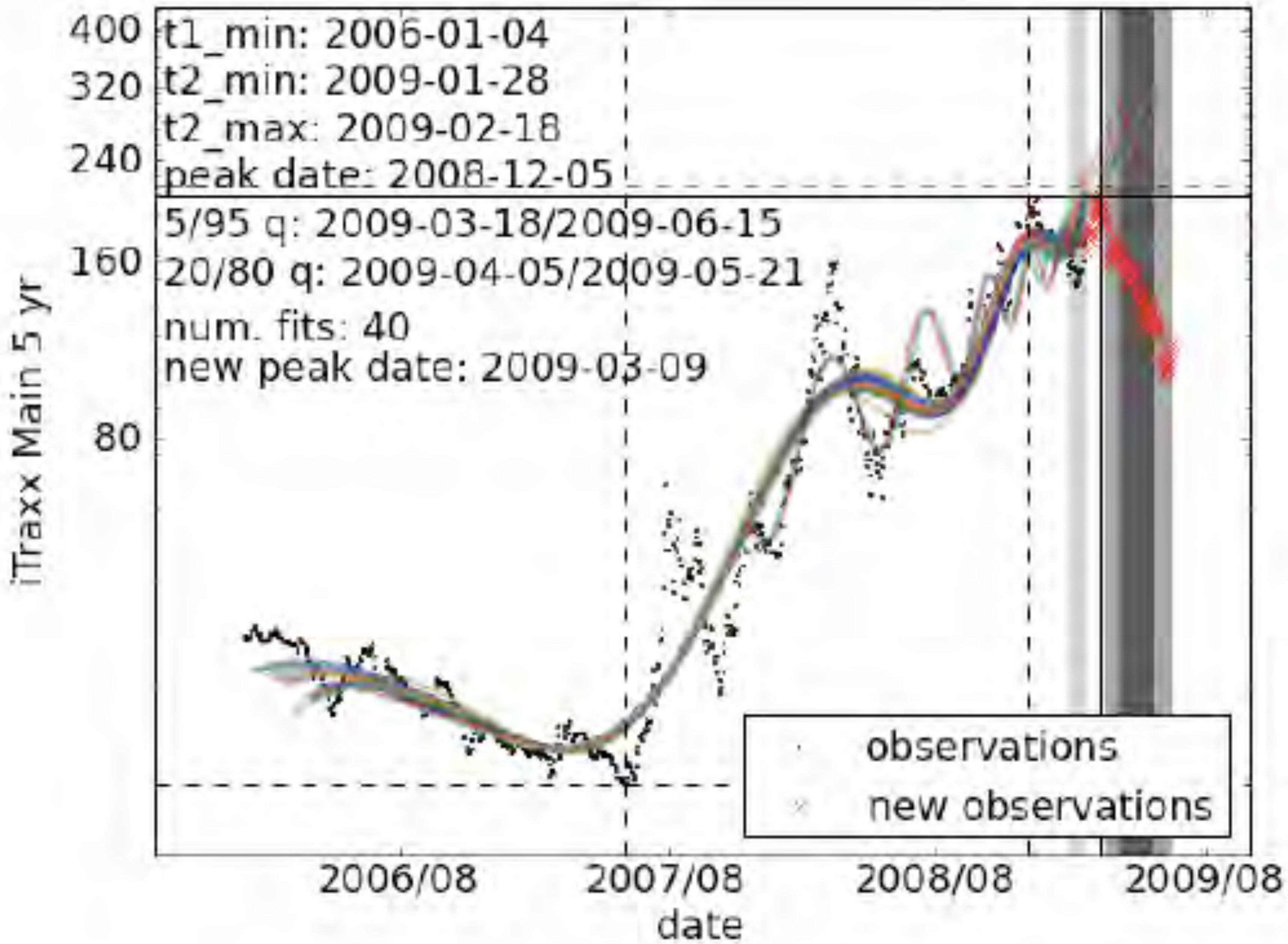
Technology Review PUBLISHED BY MIT

Is it really possible to predict the end of financial bubbles? Didier Sornette at the Swiss Federal Institute of Technology in Zurich thinks so and has set up the Financial Crisis Observatory at ETH to study the idea.

We've looked at his extraordinary predictions before. Earlier this year, he identified a bubble in the Shanghai Composite Index and much to this blog's surprise, forecast its end with remarkable accuracy.

Credit default swap

18 Feb 2009 to 18 June 09



The Chinese Equity Bubble: Ready to Burst

K. Bastiaensen, P. Cauwels, D. Sornette, R. Woodard and W.-X. Zhou

July 10, 2009 (http://arxiv.org/abs/0907.1827)

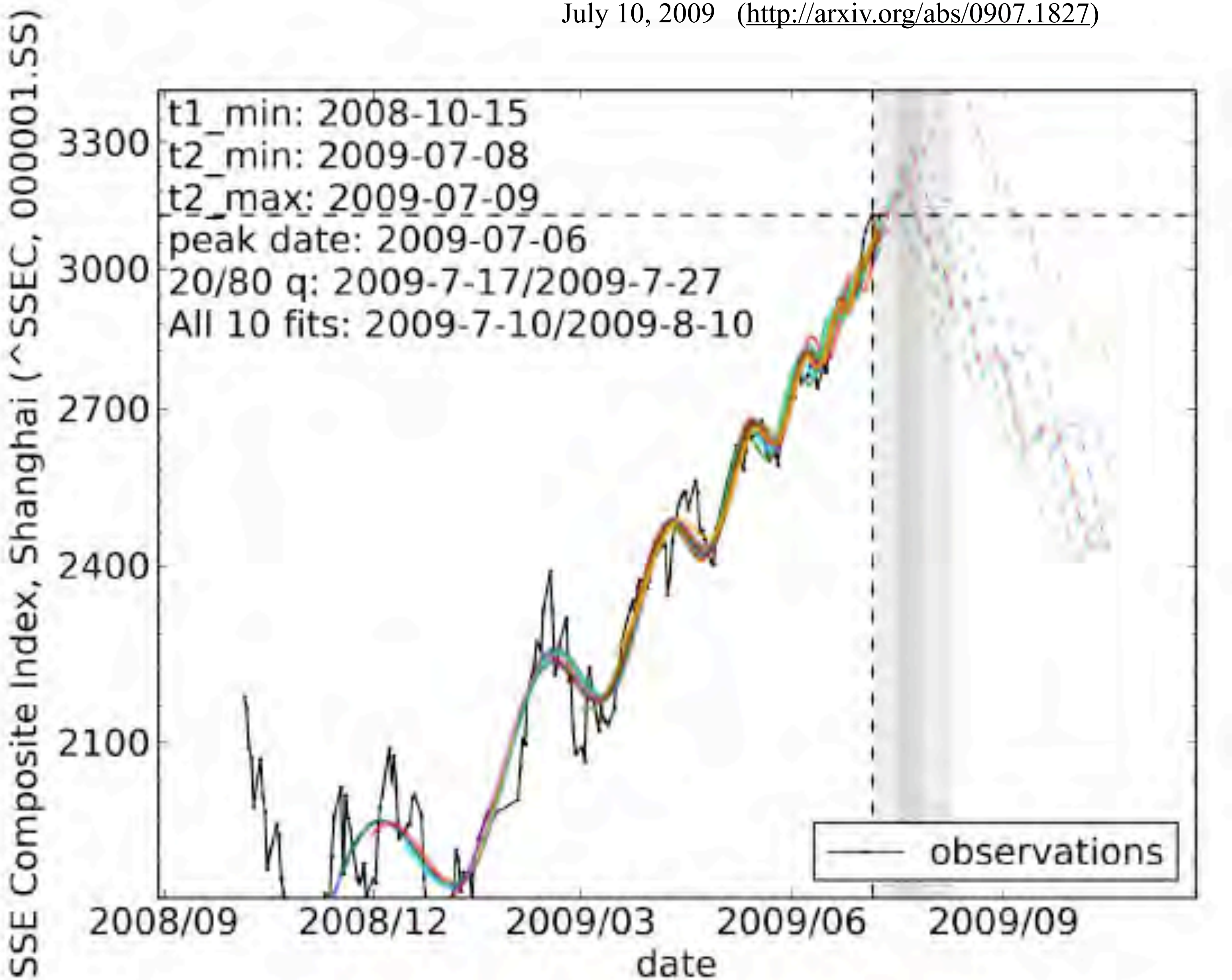
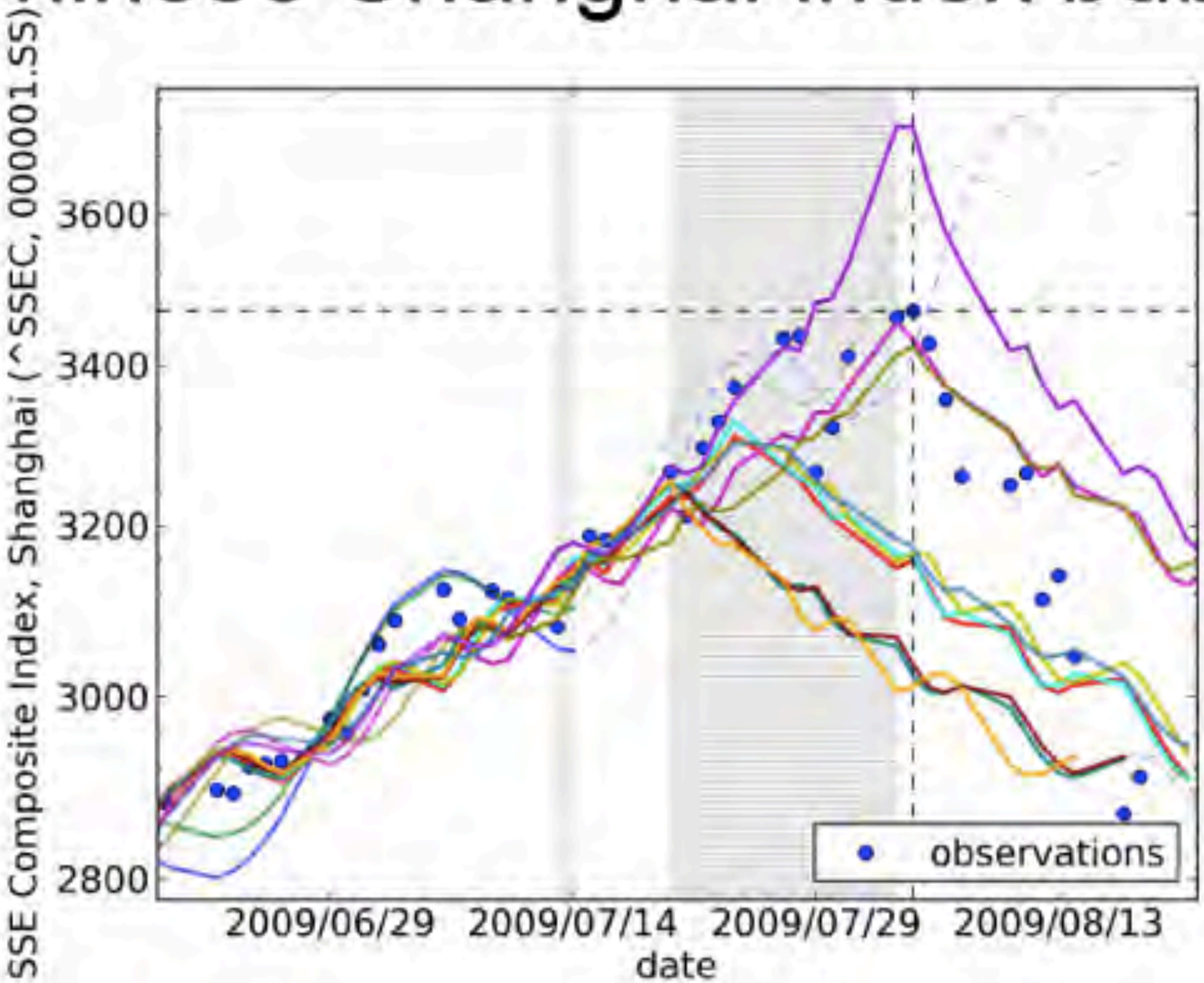


Figure 1: Shanghai Composite Index with LPPL result.

10 July 2009

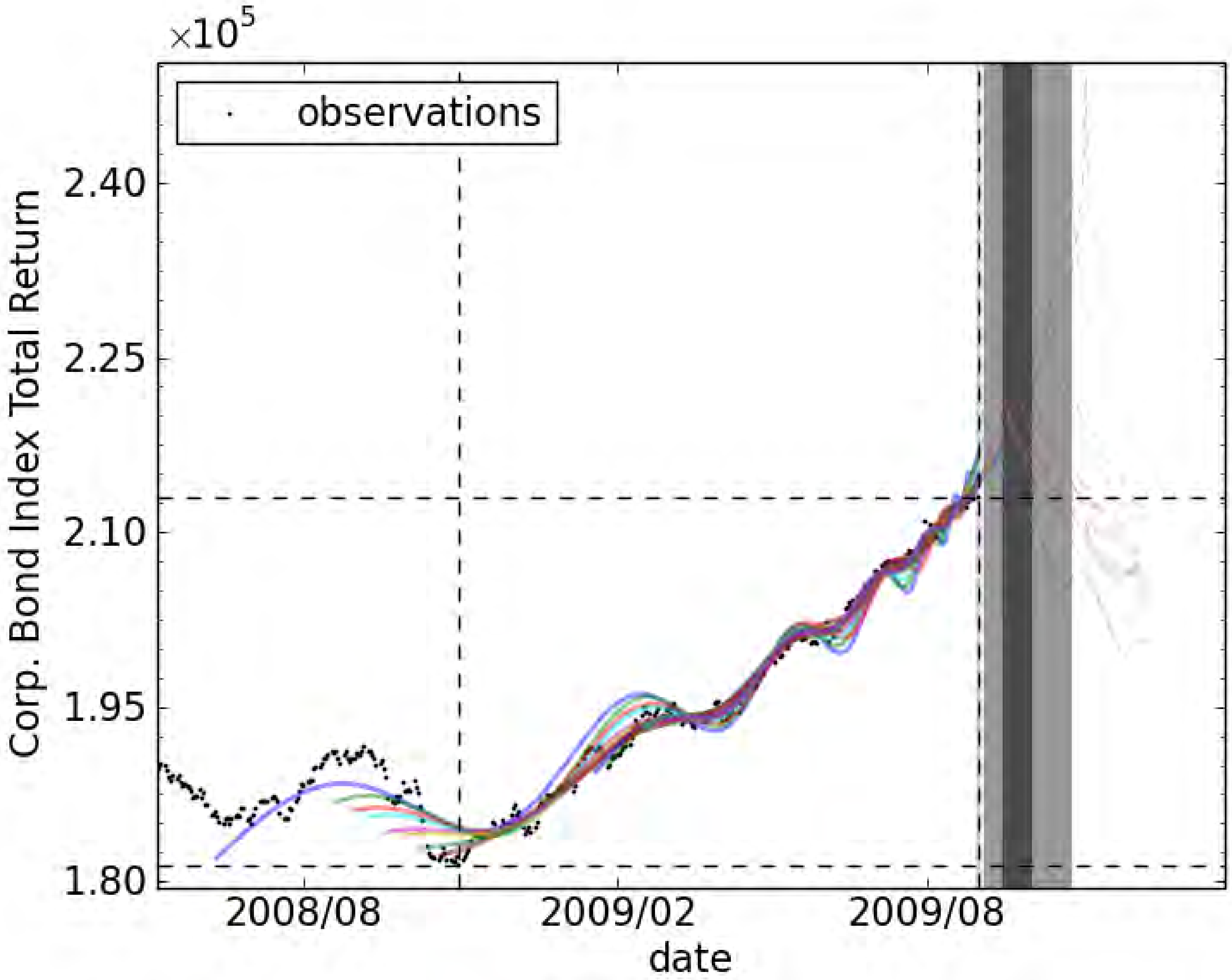
Successful forecast of end of Chinese Shanghai index bubble



The Chinese Equity Bubble: Ready to Burst,

K. Bastiaensen, P. Cauwels, D. Sornette, R. Woodard and W.-X. Zhou, July 10, 2009 (http://arxiv.org/abs/0907.1827)

Merrill Lynch index on Corporates non financials (10 sept 09)



90% confidence: tc < 24 October 2009

60% confidence: tc < 30 September 2009

- a defense of trans-disciplinarity
- out-of-equilibrium view of the world (economics, geosciences, biology...)
- extreme events are the rule rather than the exception. Their study reveal important new mechanisms.
- the question of prediction

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

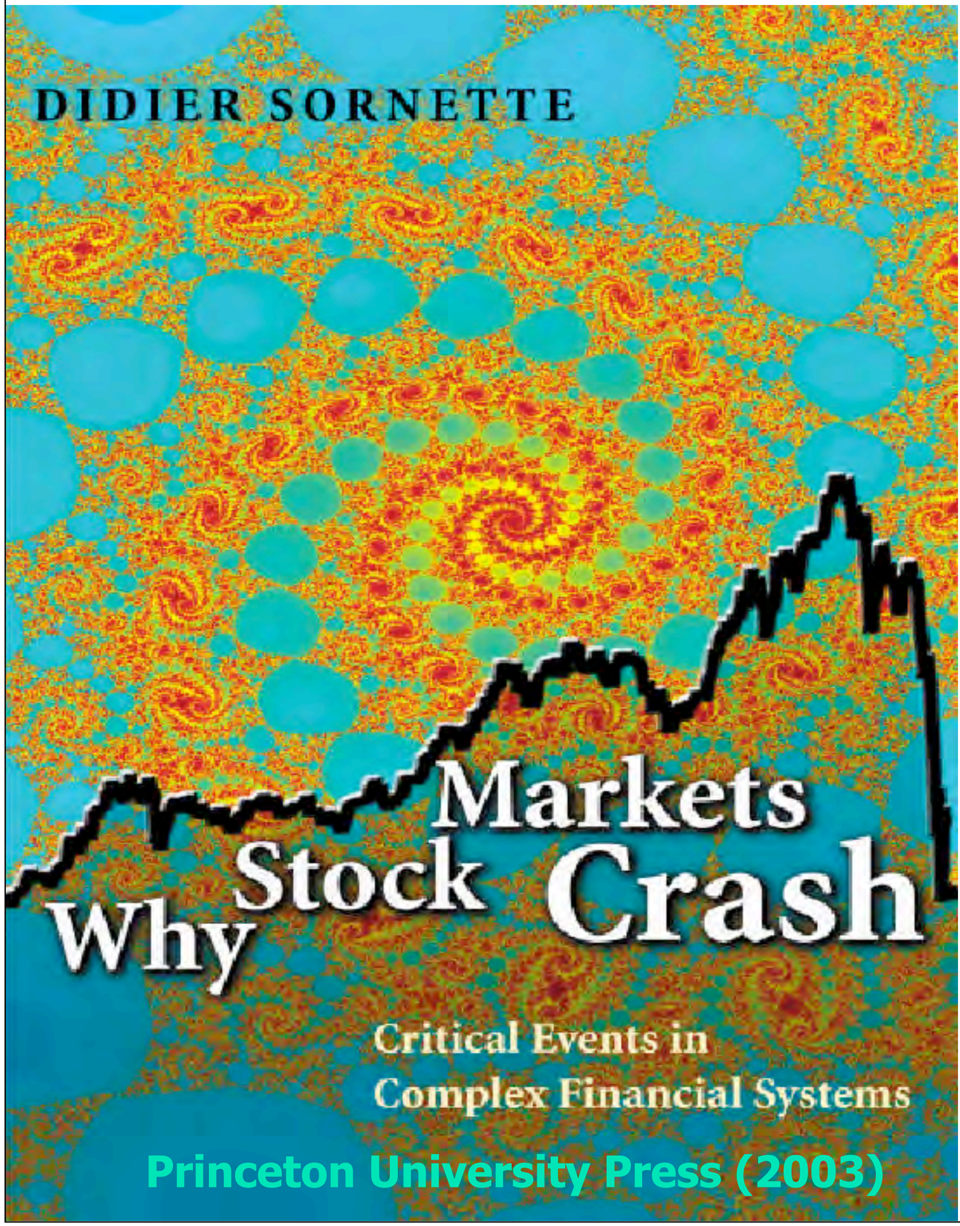
3-Need to make endogenous policy makers and regulators ("creationist" view of government role, illusion of control and law of unintended consequences of regulations)

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

A Complex System View on the Financial and Economic Crisis



Department of Management, Technology and Economics, ETH Zurich, Switzerland

Member of the Swiss Finance Institute

co-founder of the Competence Center for Coping with Crises in Socio-Economic Systems, ETH Zurich (http://www.ccss.ethz.ch/)

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J. Andersen (CNRS, France)
D. Darcet (Insight Research)
K. Ide (UCLA)
A. Johansen (Denmark)
Y. Malevergne (Univ. Lyon, France)
V: Pïsarenko (Acad. Sci. Moscow, Russia)
W.-X. Zhou (ECUST, Shanghai)
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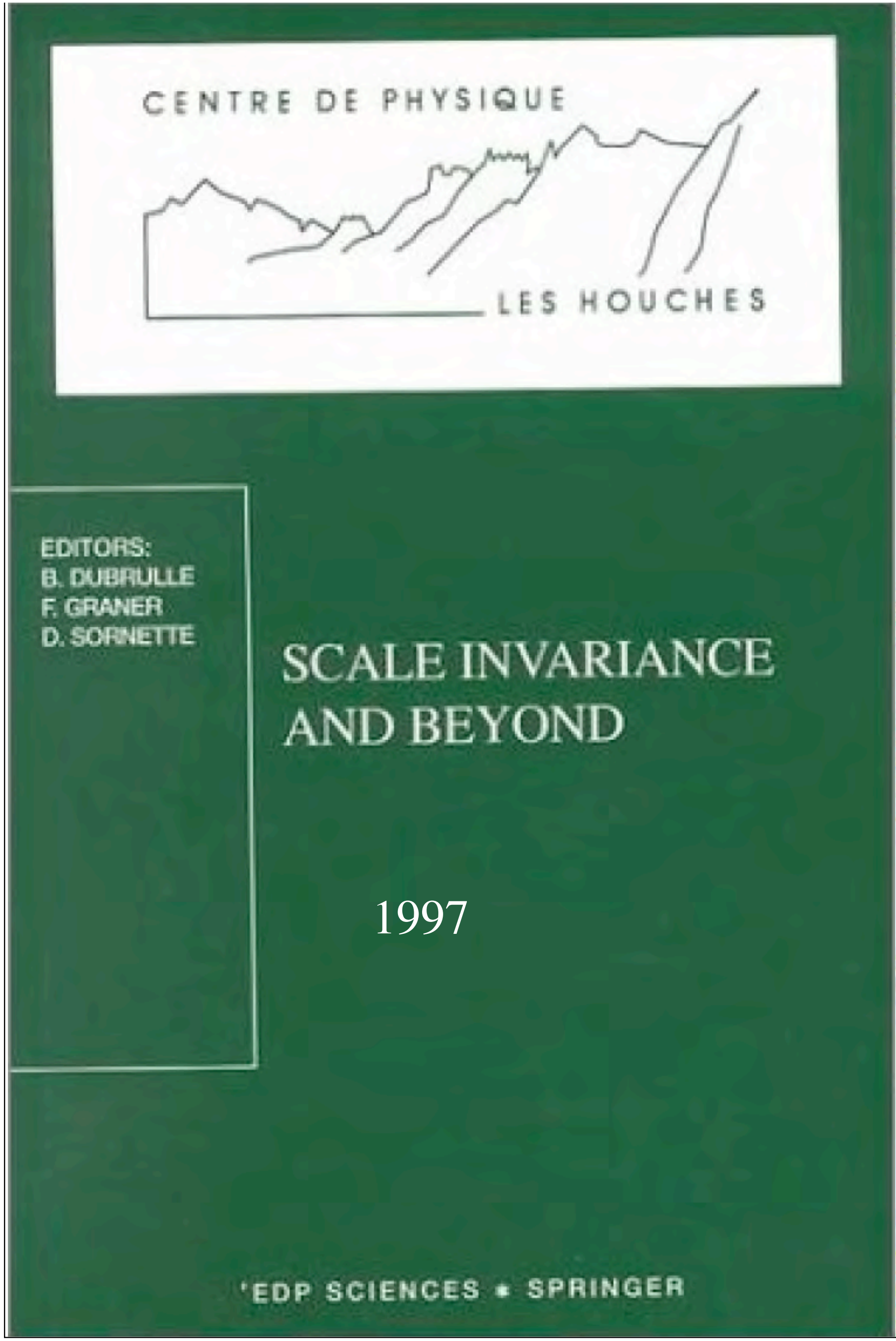
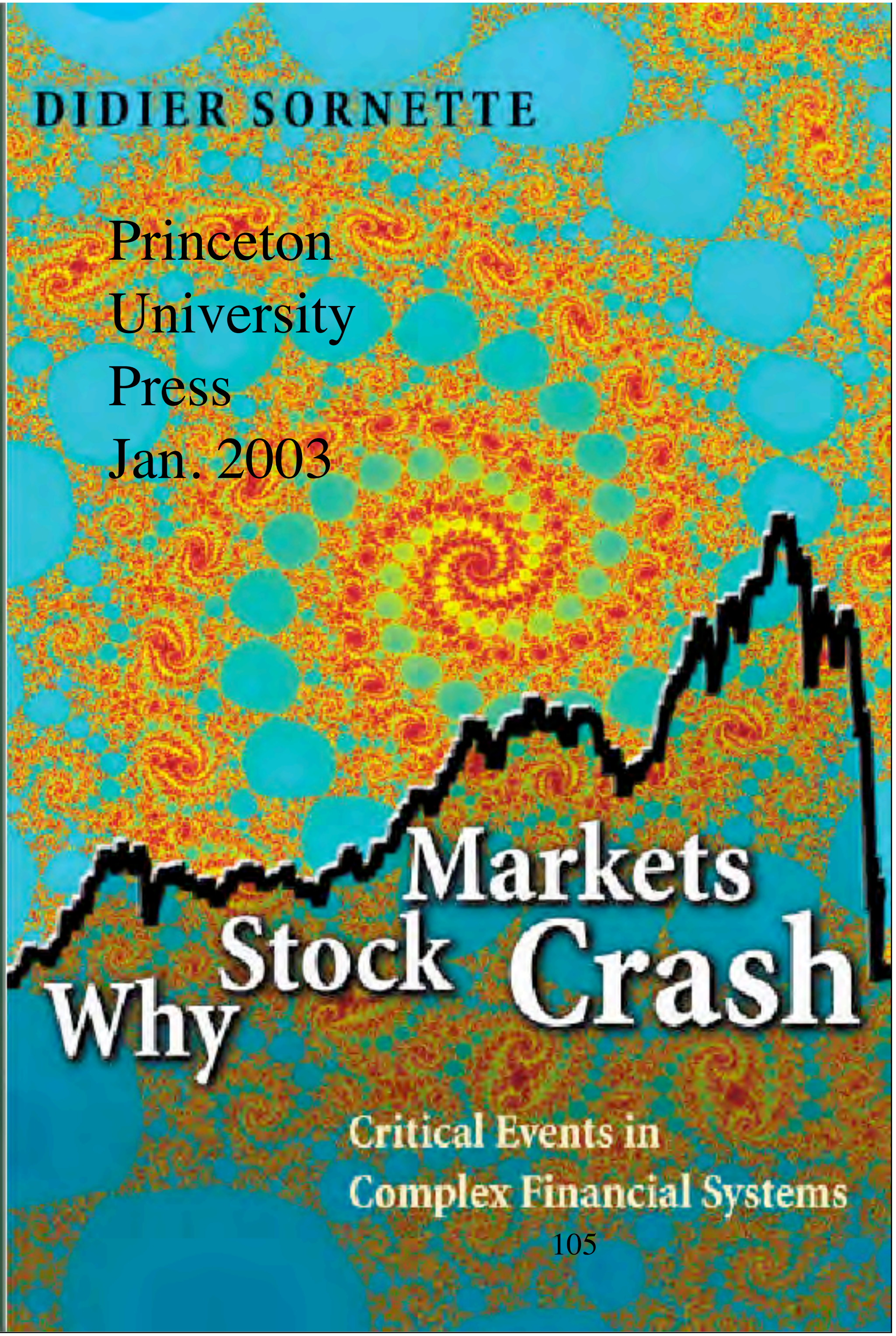
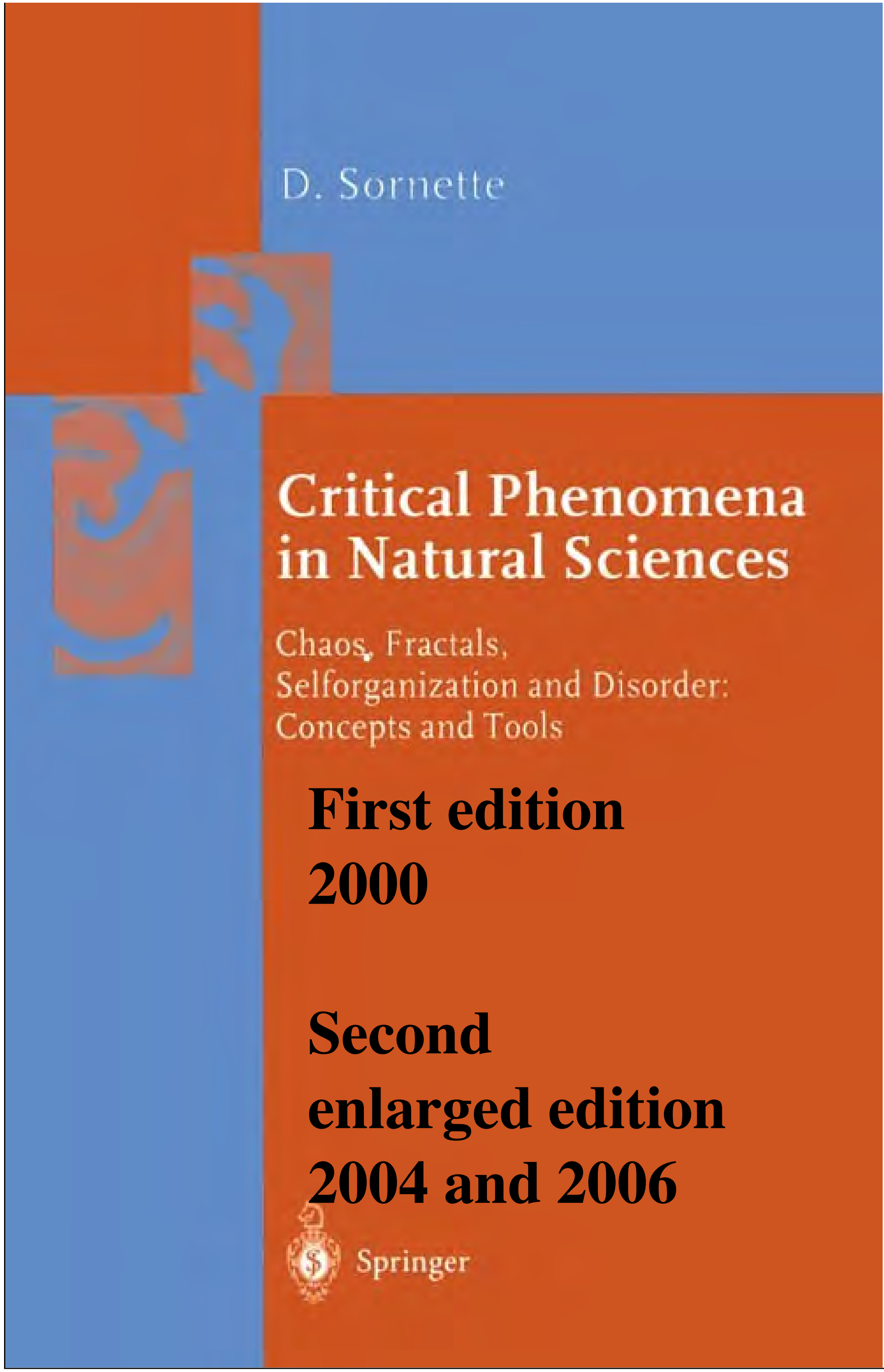
T. Kaizoji (Tokyo)
A. Saichev (ETH Zurich and Nizhny Novgorod)
R. Woodard and H. Woodard (ETH Zurich)
W. Yan (ETH Zurich)
A. Huesler (ETH Zurich)
M. Fedorovsky (ETH Zurich)
S. Reimann (ETH Zurich)



1997



Princeton University Press Jan. 2003



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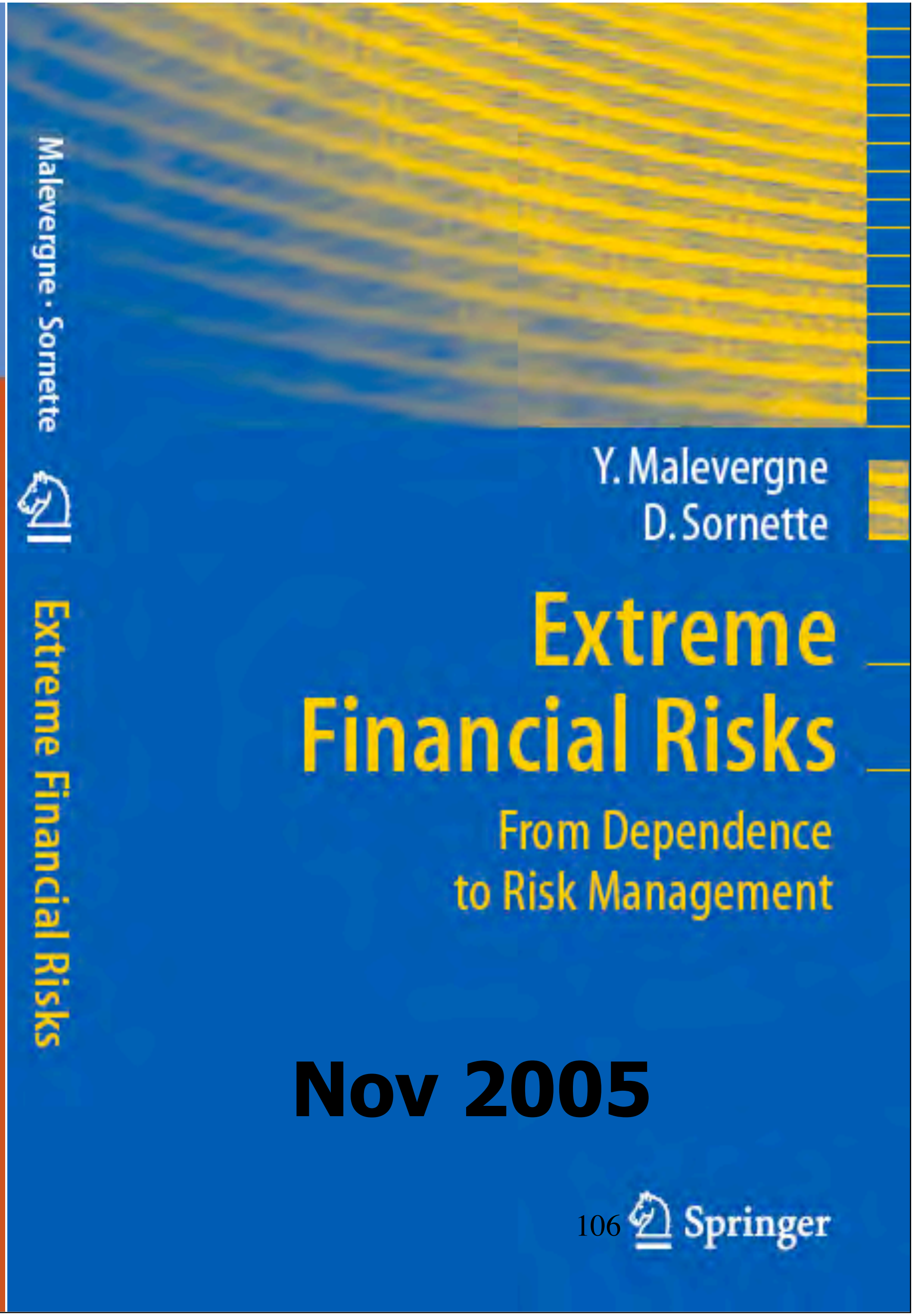

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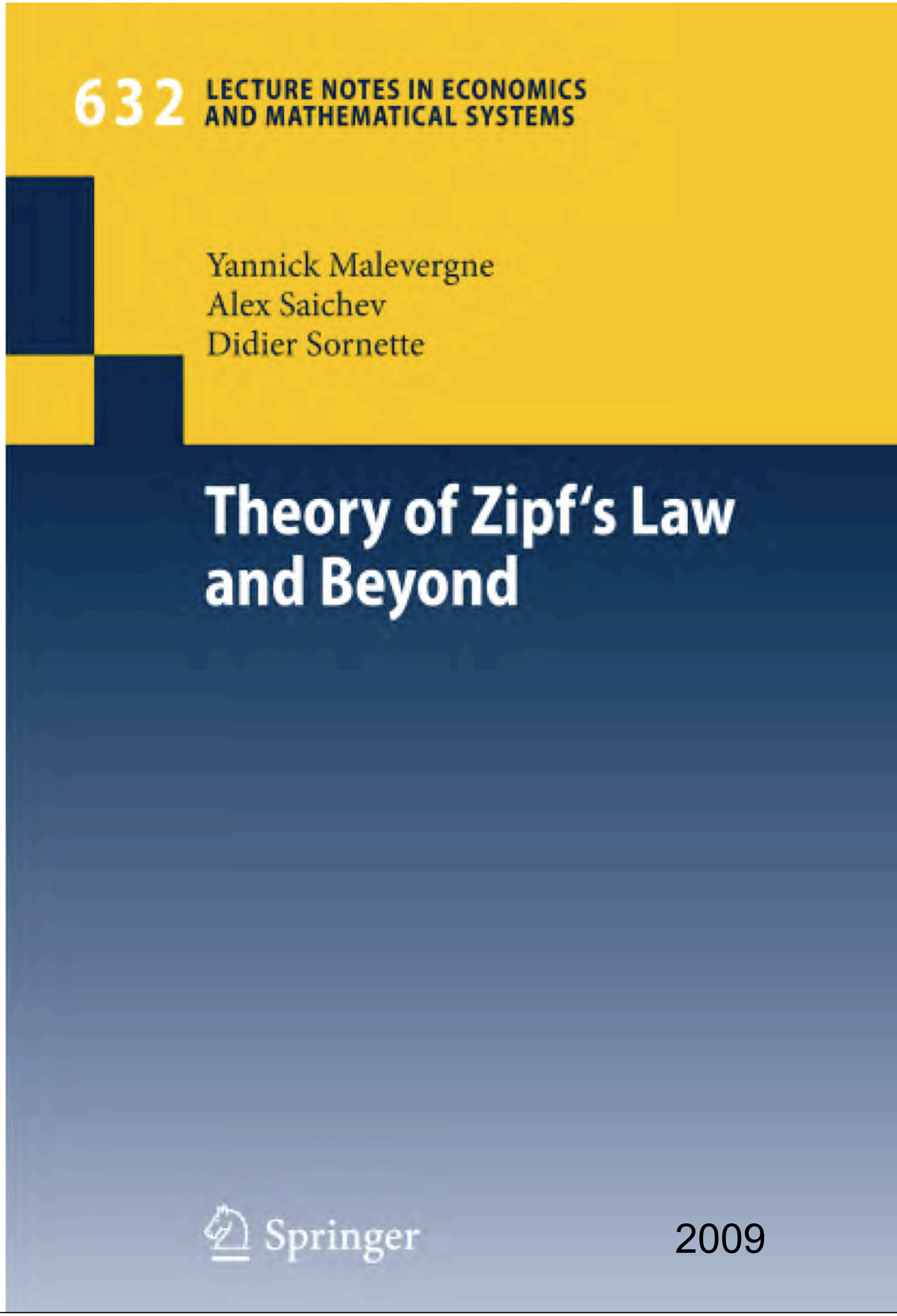
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Further Reading

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(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)

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