Endogenous versus Exogenous Origins of Crises

(book sales, volatility shocks, YouTube, cyber-risks, conflicts, epilepsy, earthquakes)

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A. Helmstetter (post-doc, now at CNRS Grenoble)
A. Johansen (Niels Bohr, Copenhagen, Denmark)
Y. Malevergne (Professor Univ, of Lyon, France)
T. Maillart (PhD, ETH Zurich)
J.F. Muzy (Research Fellow CNRS)
B. Roehner (Professor, Univ. Paris)

CRISES and EXTREME EVENTS

- dramatic and rapid change of a system which is the culmination of a complex preparatory stage.

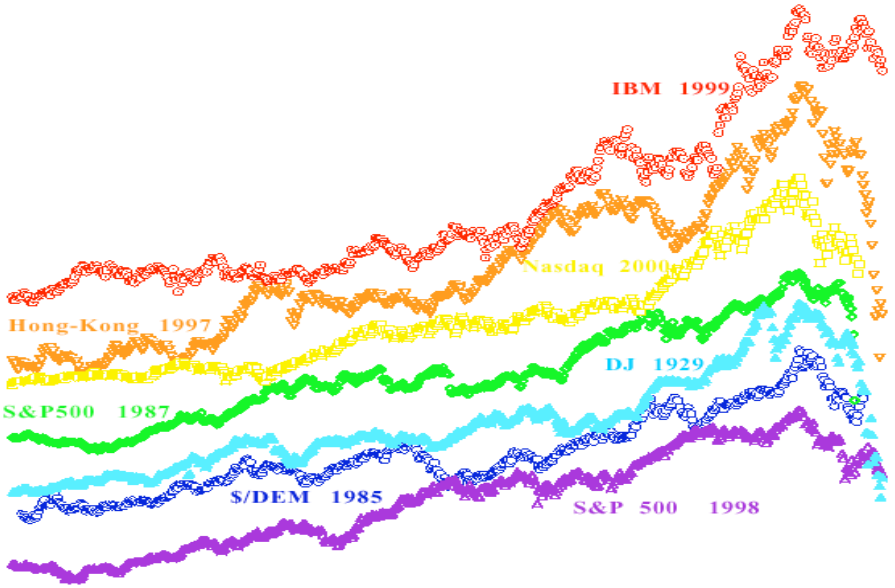
- fundamental societal impacts

- large natural catastrophes

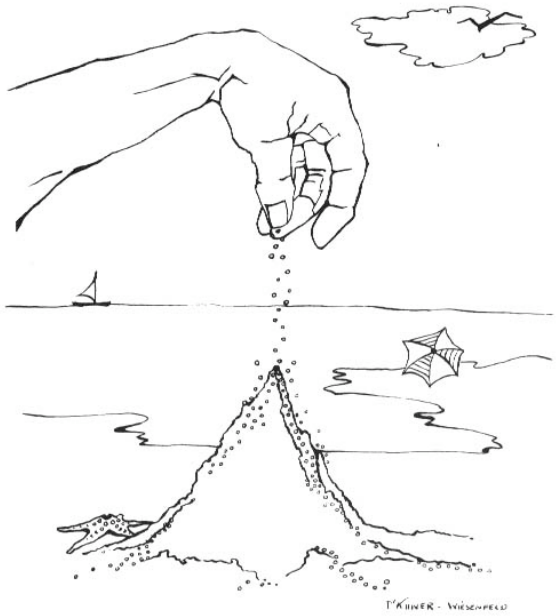
1. earthquakes,
2. volcanic eruptions,
3. hurricanes and tornadoes,
4. landslides, avalanches,
5. lightning strikes,
6. meteorite/asteroid impacts,
7. catastrophic events of environmental degradation,

EXTREME EVENTS in SOCIO-ECONOMIC SYSTEMS

- failure of engineering structures,
- crashes in the stock market,
- social unrest leading to large-scale strikes and upheaval,
- economic drawdowns on national and global scales,
- regional power blackouts,
- traffic gridlock,
- diseases and epidemics, etc.



- **Self-organization? Extreme events are just part of the tail of power law distribution due to "self-organized criticality"? (endogenous)**



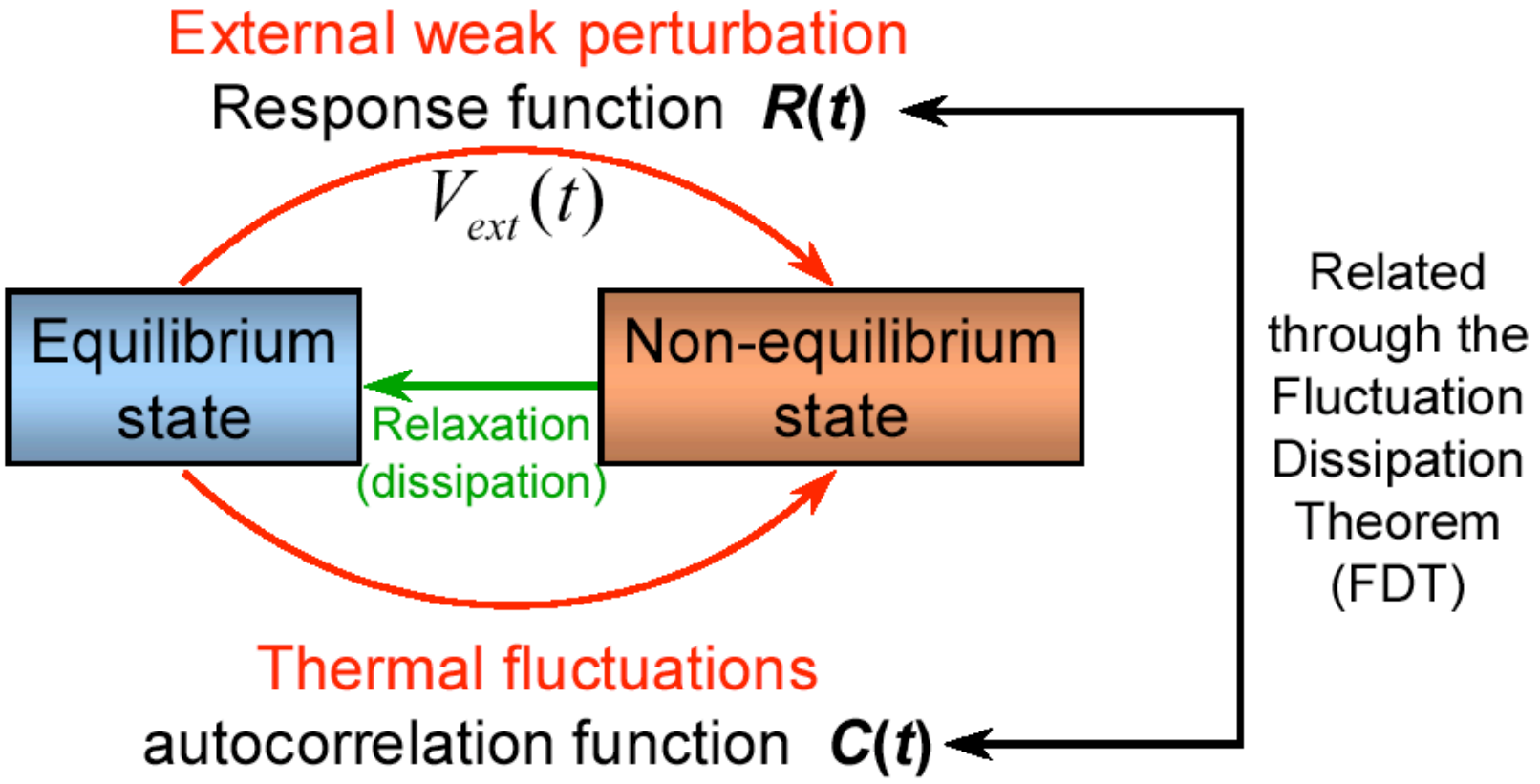
Artwork by Elaine Wiesenfeld
(from Bak, How Nature Works)

- **"Catastrophism": extreme events require extreme causes that lie outside the system (exogenous)**

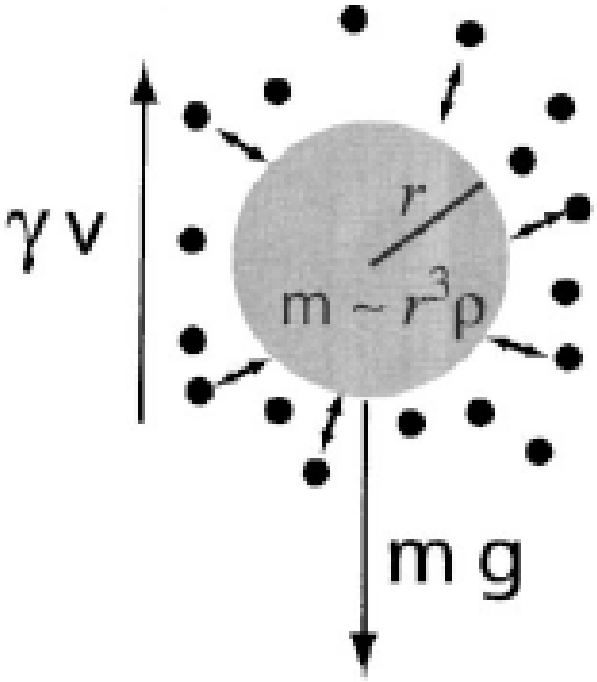
- **A mixture? How would it work?**

Guidelines from Physics: perturb and study the response

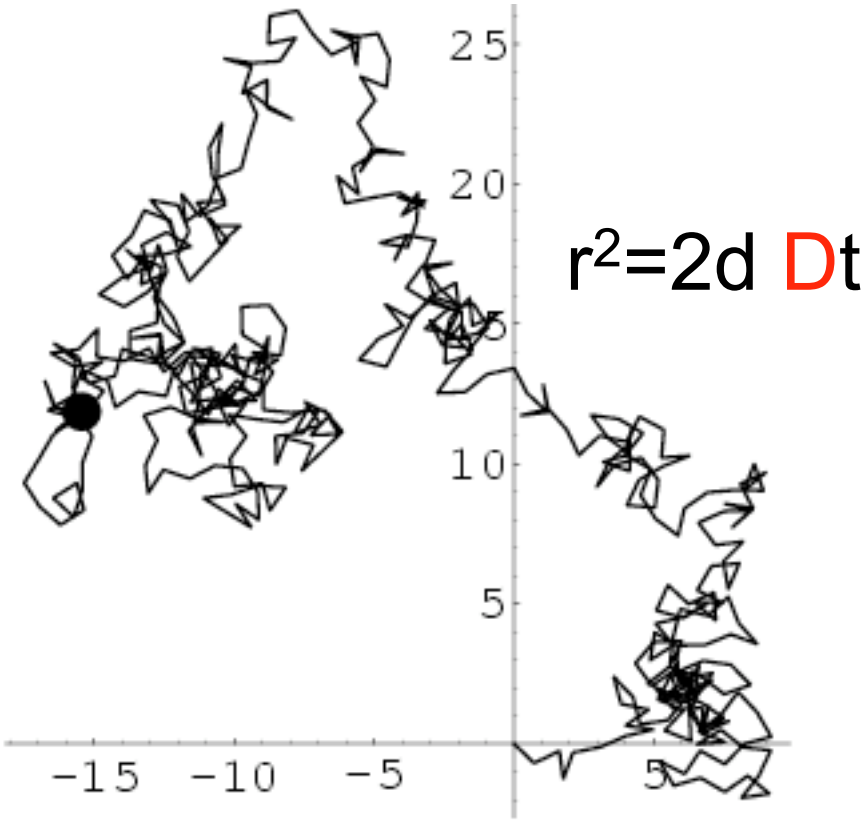
Linear Response Theory



EXO:Drag resistance under an external force



ENDO: Random walk



$r^2=2d\,Dt$

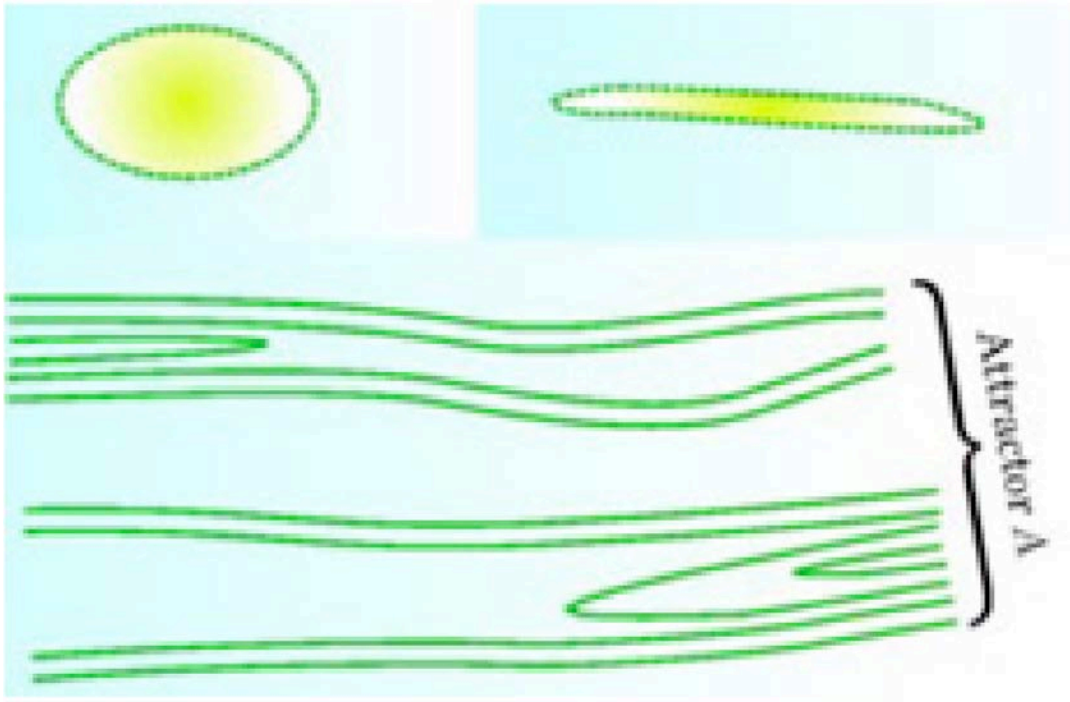
$$D=k_BT/\gamma$$

(Einstein, 1905)

Fluctuation-dissipation theorem far from equilibrium is not expected to hold

- Externally imposed perturbations may be different from spontaneous fluctuations (external fluctuations lie outside the complex attractor)

- Attractor of dynamics may exhibit bifurcations



D. Ruelle, Physics Today, May 2004

AMAZON BOOK SALES

- Amazon.com posts a "live" ranking of all its products
- Book ranks in the top 10,000 are updated every hour according to a secret weighting of recent sales and entire history

Top 100 Bestsellers
Updated Hourly

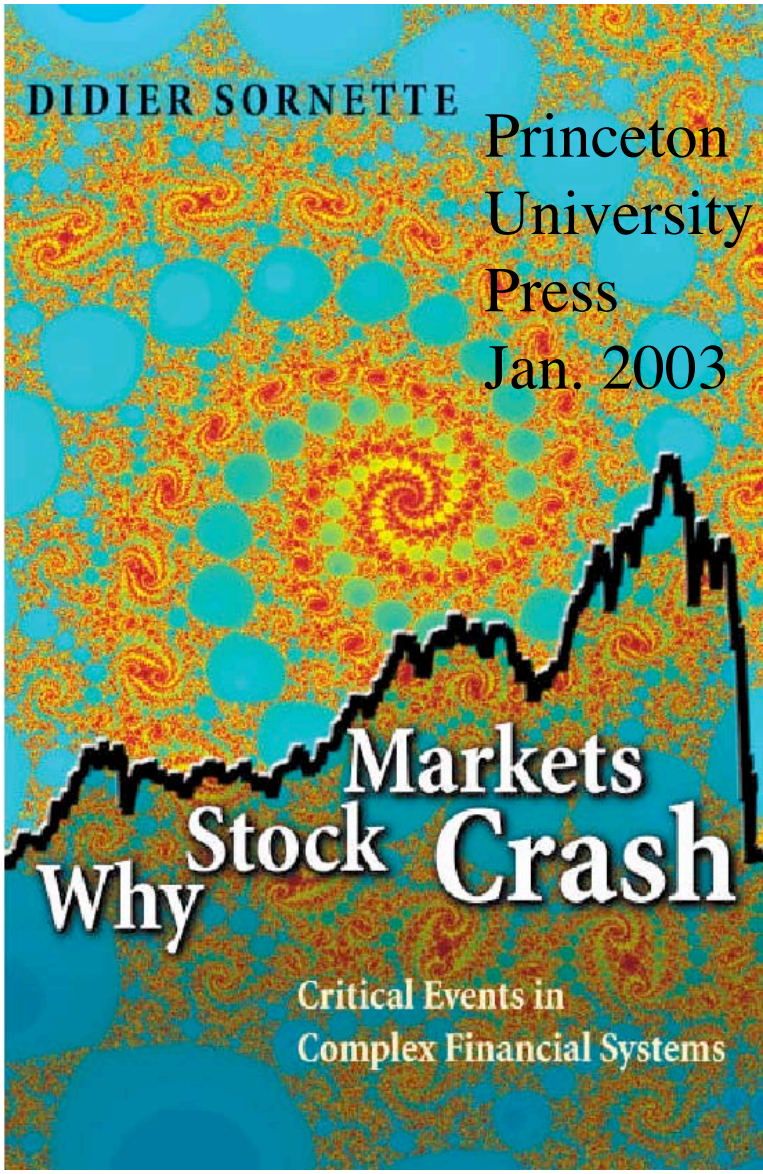
1. *The South Beach Diet*
by Arthur Agatston (Author)
Price: $14.97 You Save: $9.98 (40%) Used & new from $13.24

2. *The Da Vinci Code*
by Dan Brown (Author)
Price: $14.97 You Save: $9.98 (40%) Used & new from $10.80

3. *The Last Juror*
by John Grisham (Author)
Price: $19.57 You Save: $8.38 (30%)

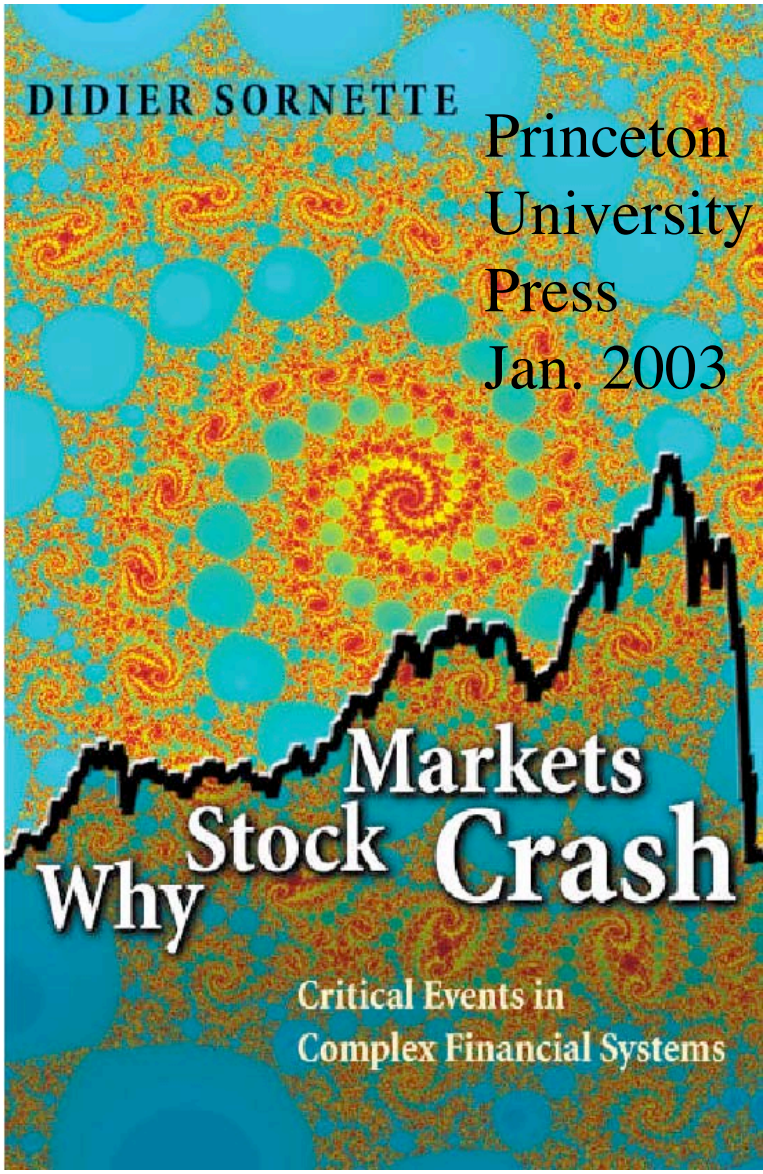
4. *South Beach Diet Good Fats/Good Carbs Guide*
by Arthur Agatston (Author)
Price: $7.99 Used & new from $7.80

The Original “Crisis”



The Original “Crisis”

- On Friday January 17, 2003, Sornette’s recent book jumped to rank # 5 on Amazon.com’s sales ranking (with Harry Potter as #1!!!)



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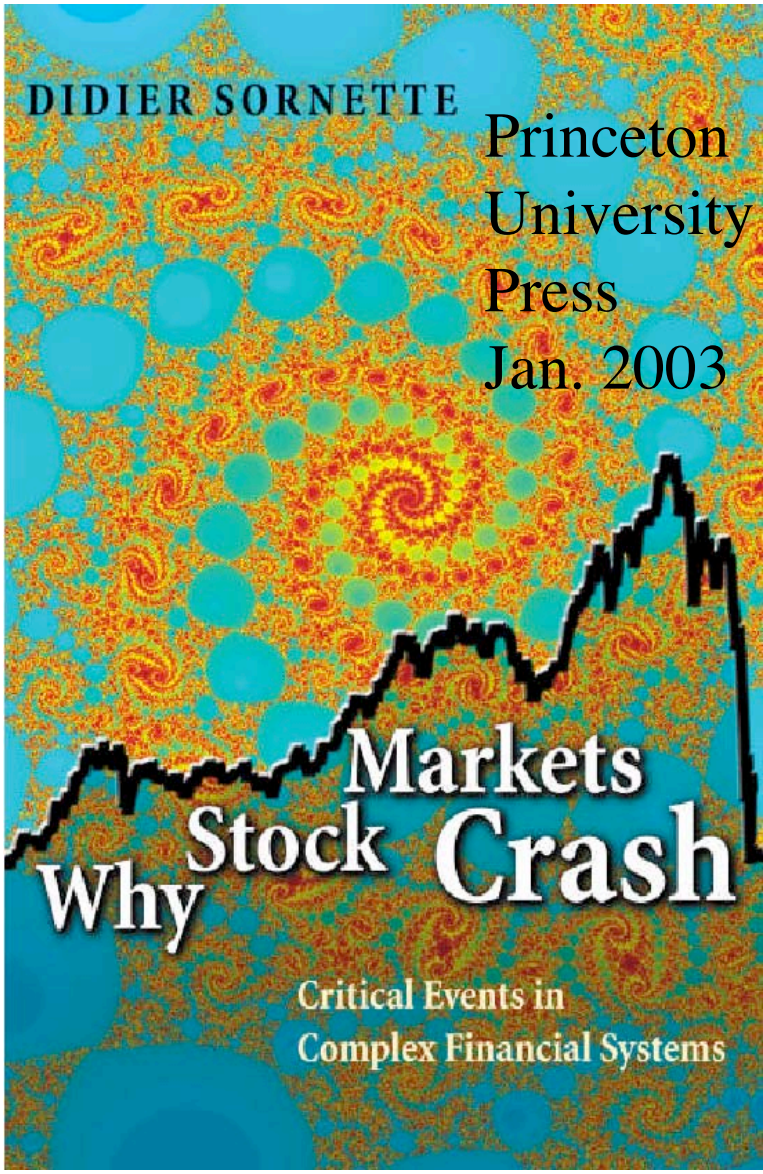
- Two days before: release of an interview on MSNBC’s MoneyCentral website



From Ranks to Sales

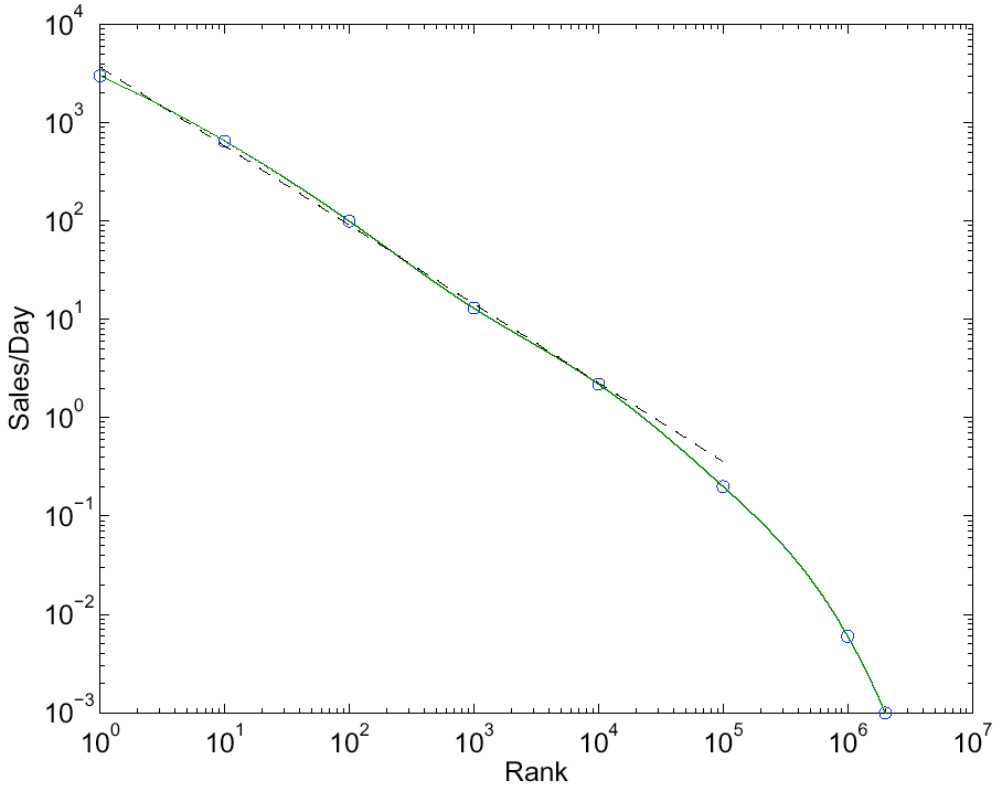
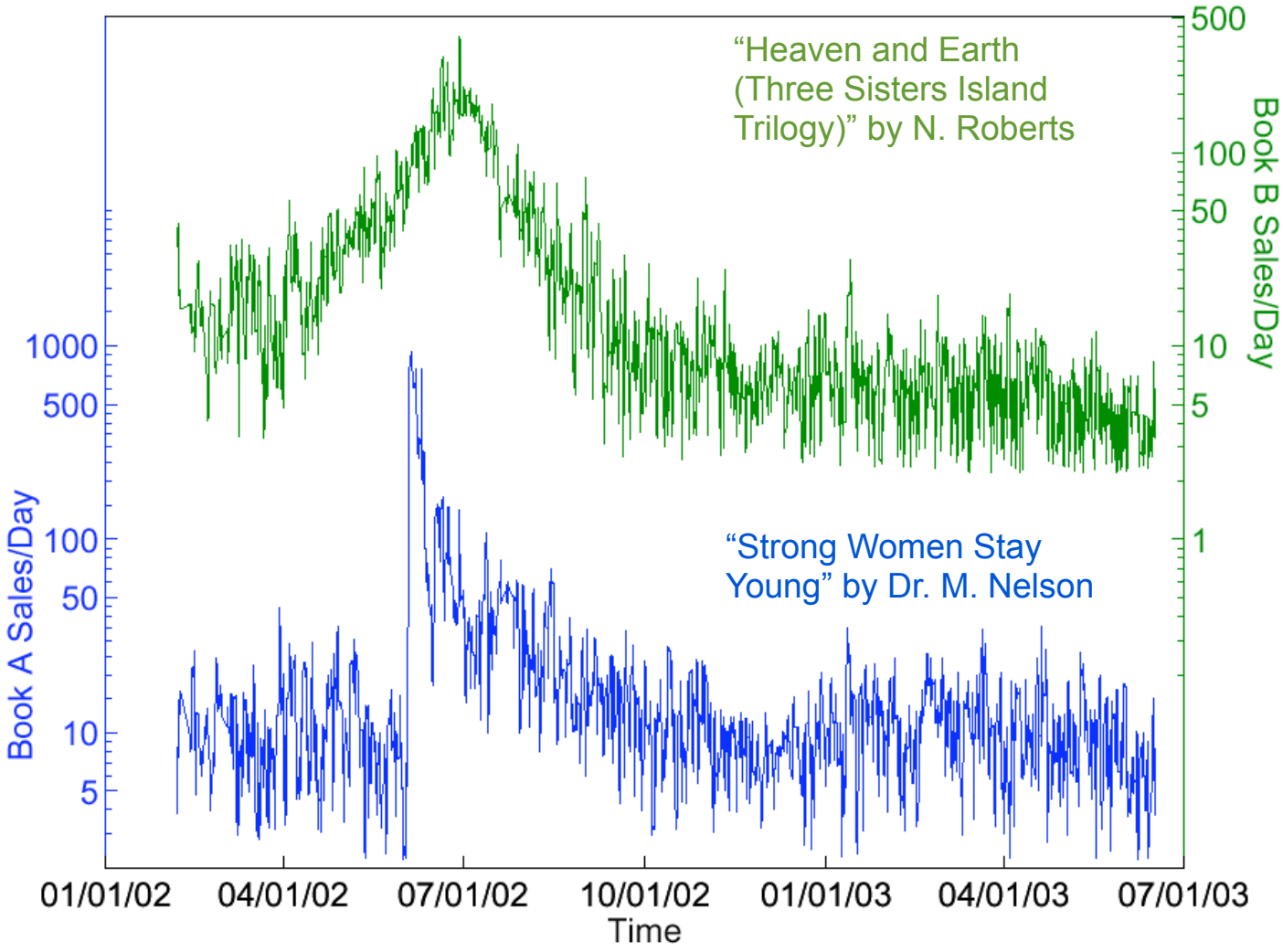


FIG. 1: Rank ordering plot of the sales per day, S, as a function of rank, r, for books that have sold at least one volume through Amazon.com. The dashed line shows the power law approximation $S(r) \sim 1/r^{\nu}$ with exponent $\nu = 0.8 \pm 0.1$.

- Need a stationary and relatively smooth time-series
- This curve was reconstructed via careful data and news analysis, interviews… by M. Rosenthal
- Our results are robust to the exact shape of this transformation

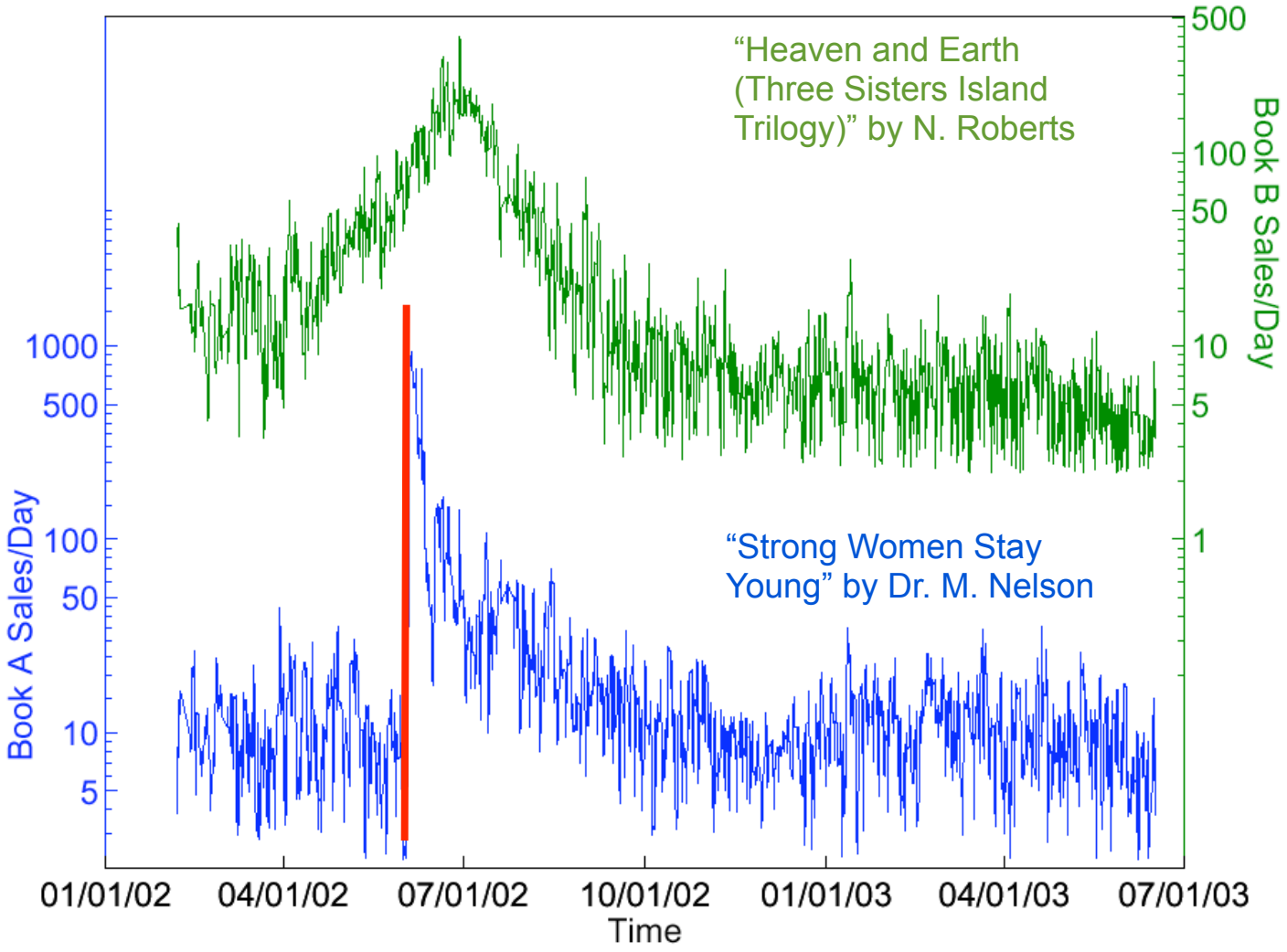
$$S(R) \sim 1/R^{1/\mu} \text{ with exponent } \mu = 2.0 \pm 0.1$$

Book sales dynamics



D. Sornette et al., Phys. Rev. Letts. 93 (22), 228701 (2004)

Book sales dynamics



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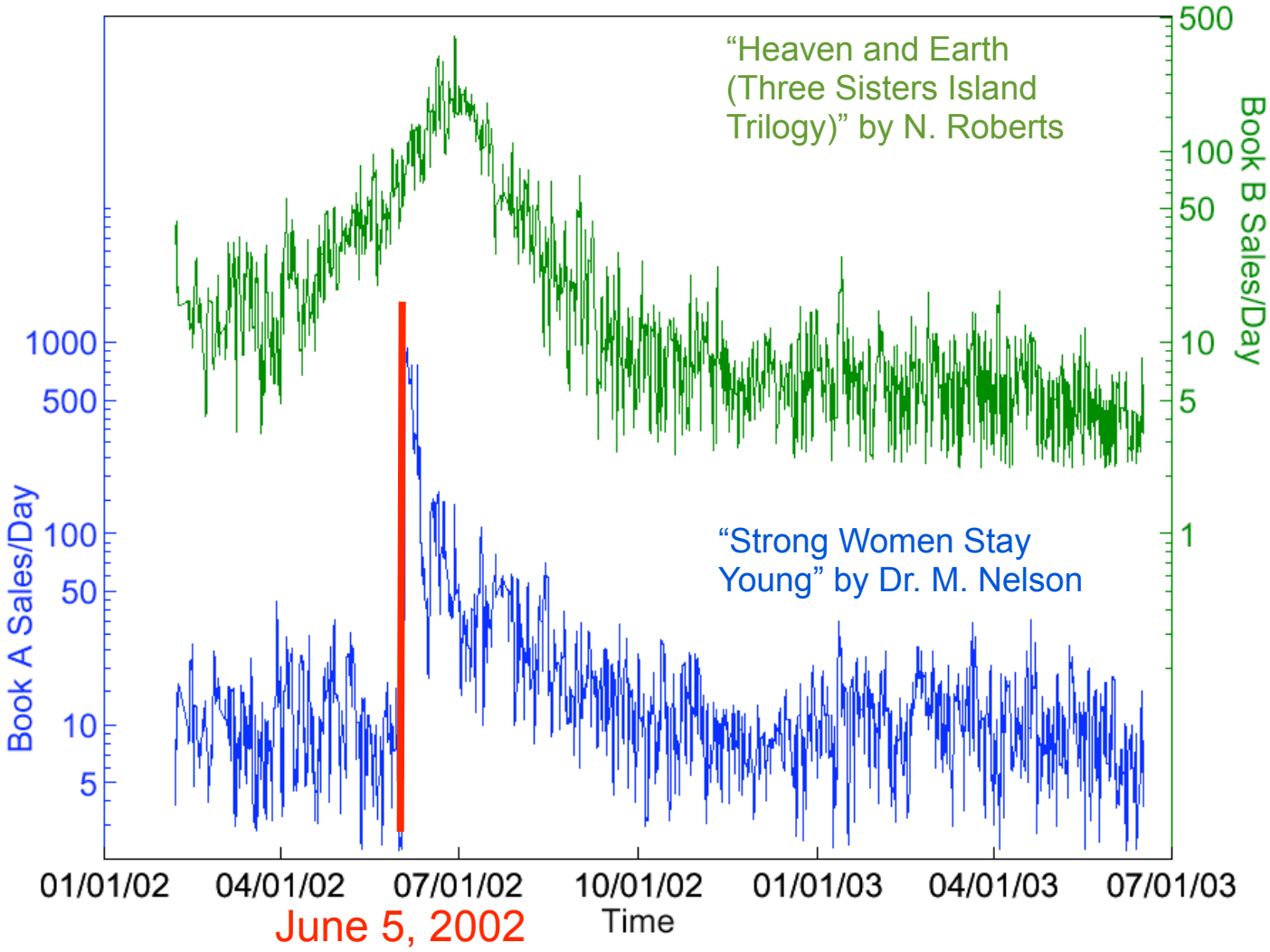

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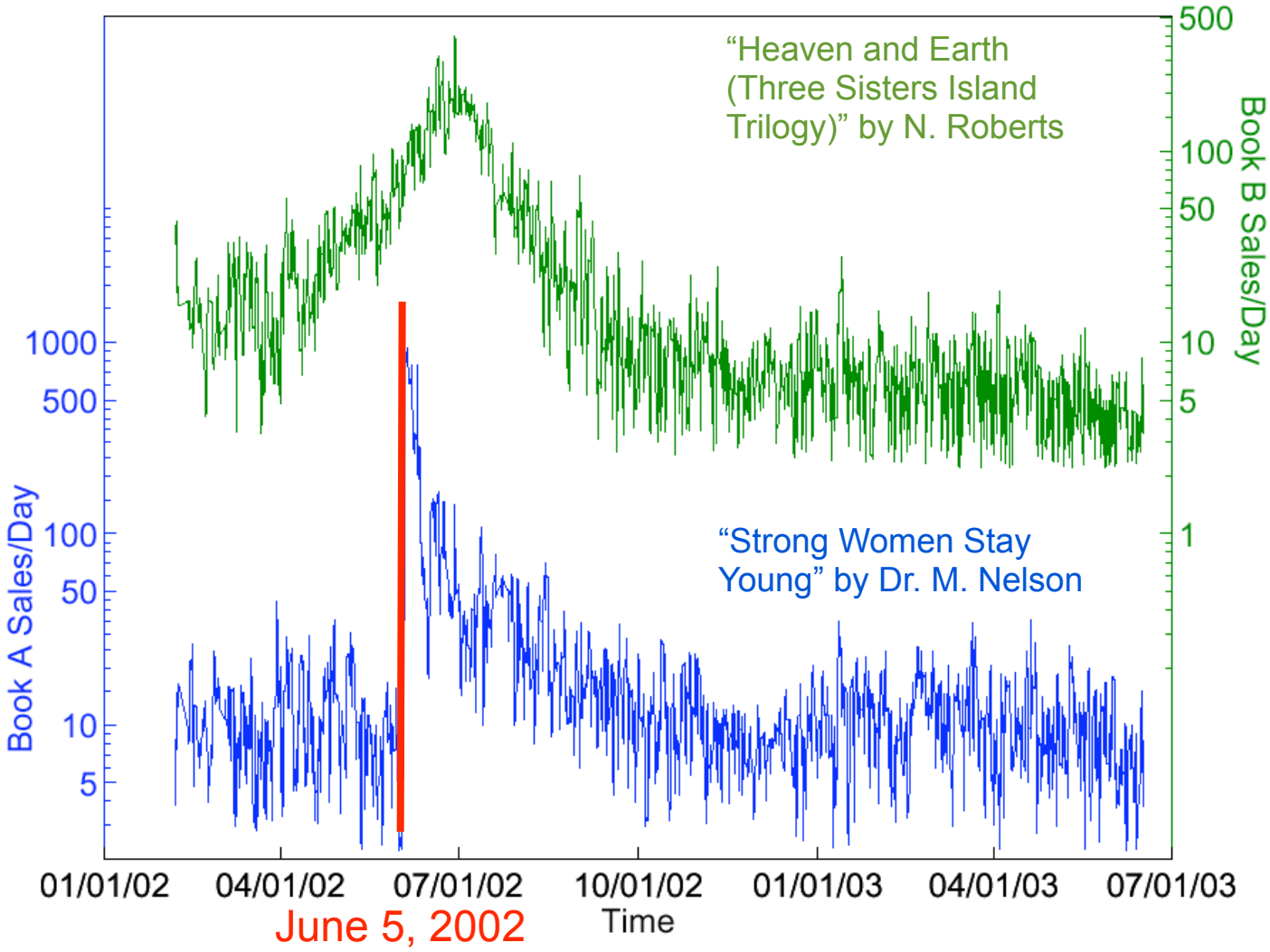

June 4, 2002:
New York Times article crediting the "groundbreaking research" of Dr. Nelson

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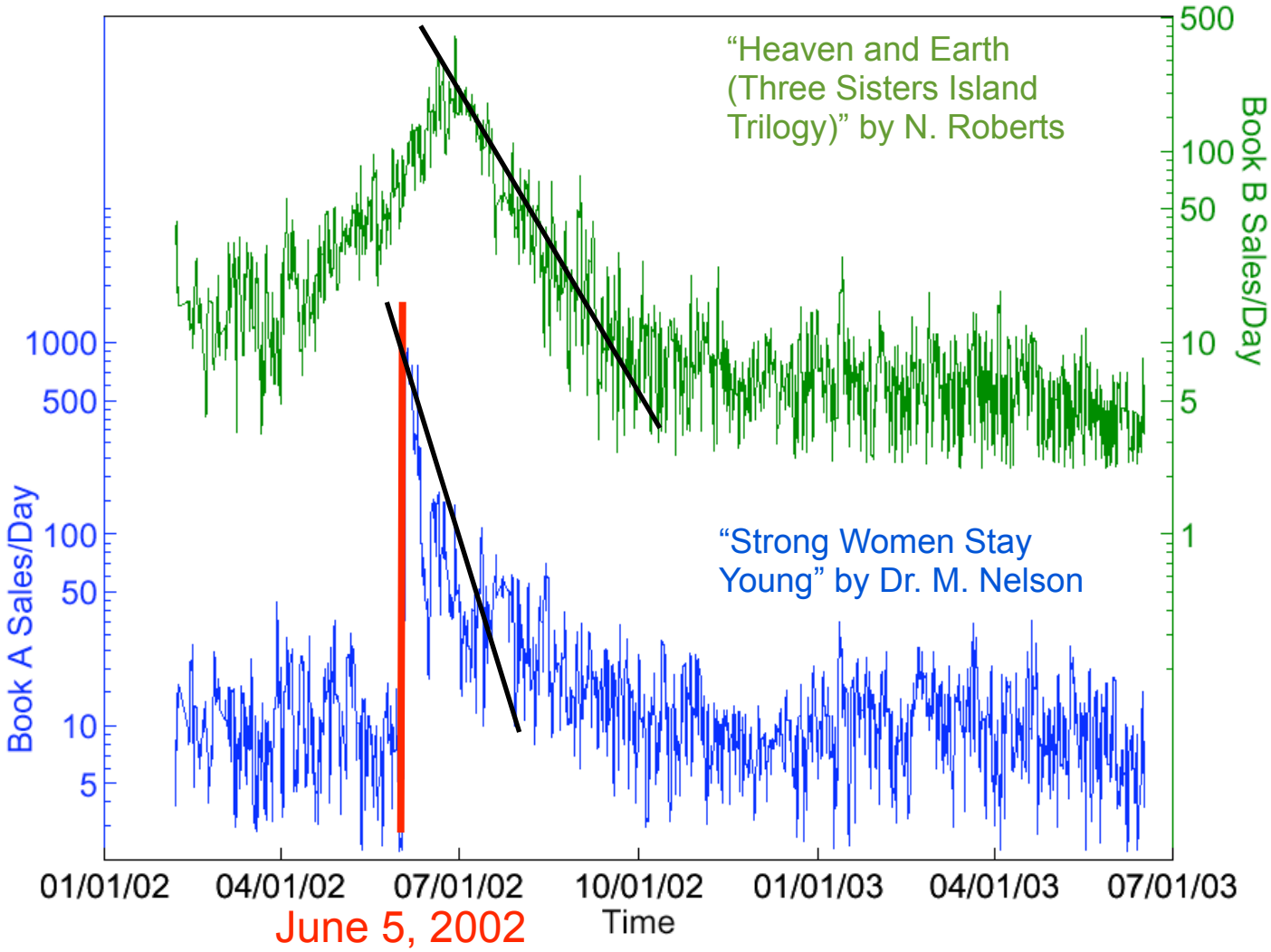

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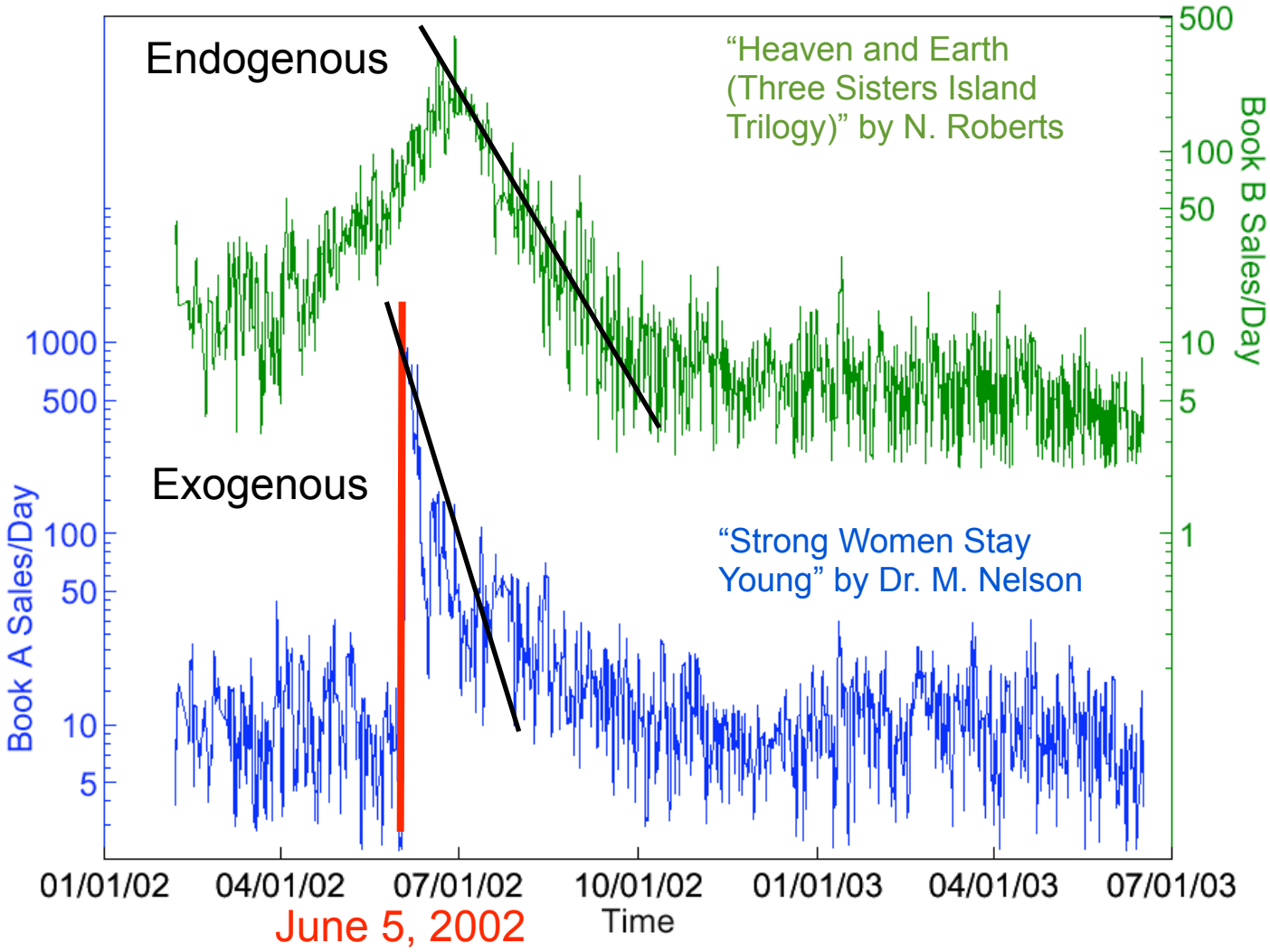

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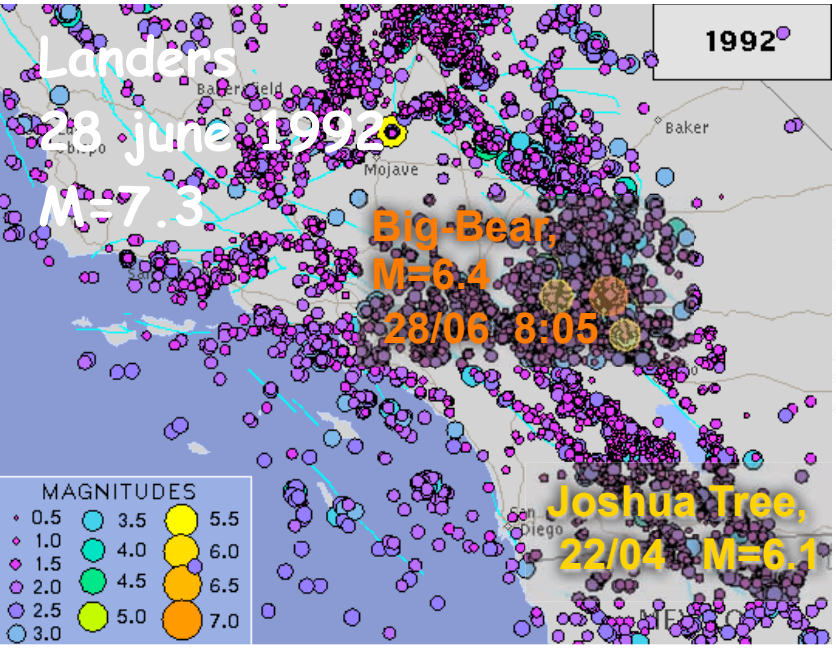
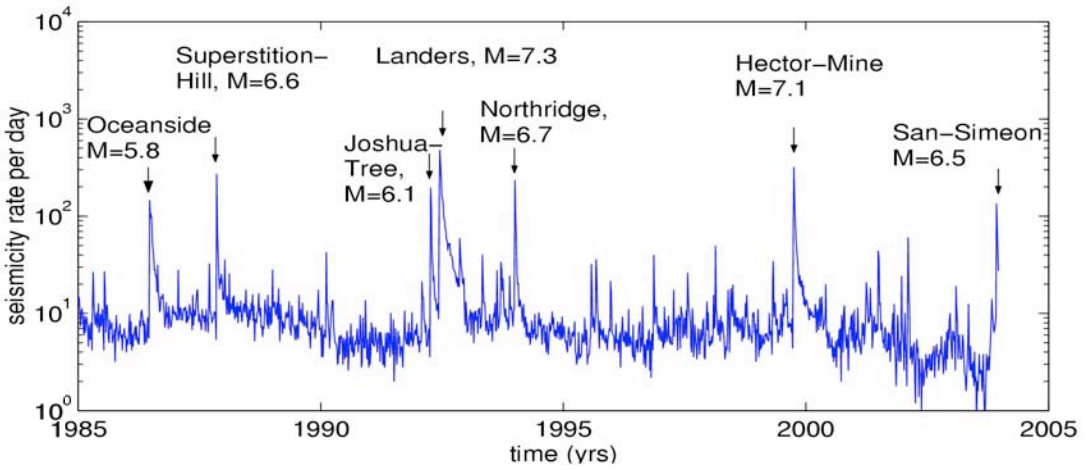
Analogy: Temporal decay of aftershocks





the seismicity rate after a mainshock at time t=0 follows the modified Omori law

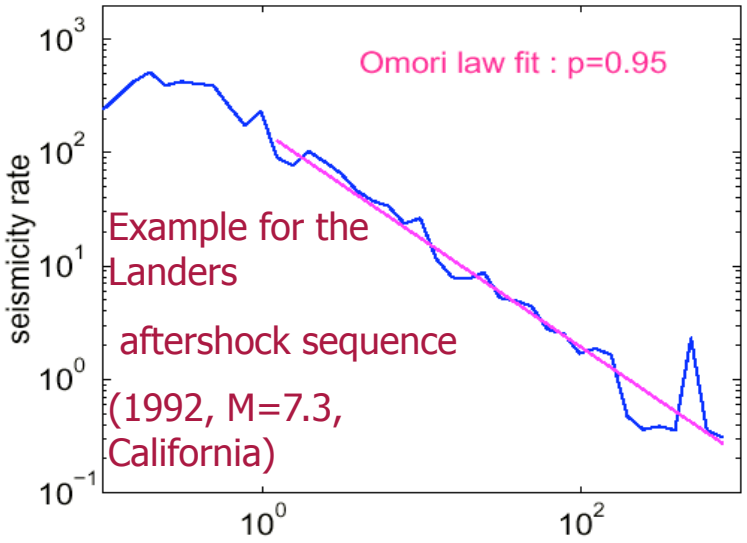
Temporal decay of the rate **N(t)** of aftershocks

after a mainshock at **t=0**

$$N(t) = K/(t+c)^p$$

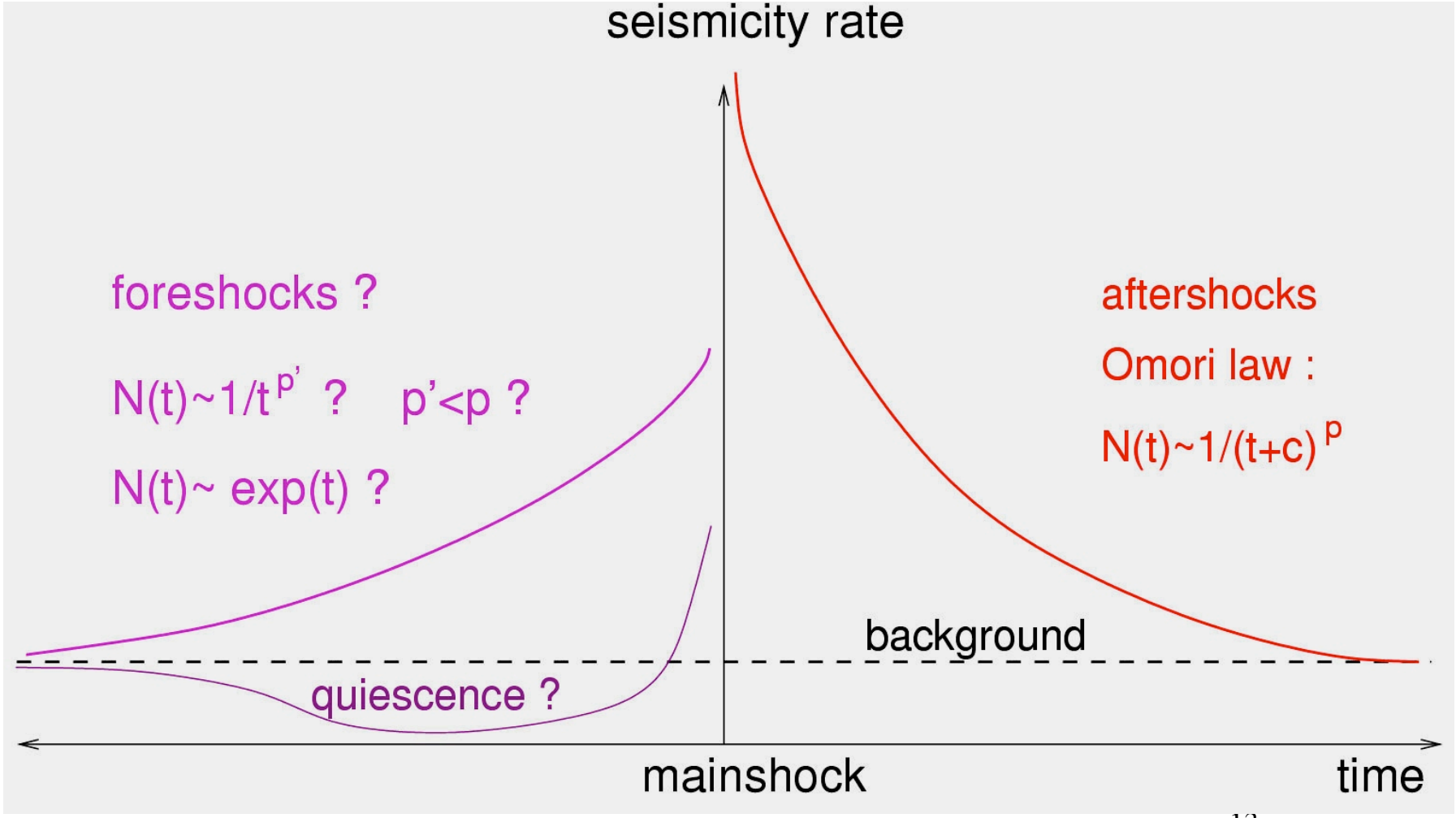
p is in the range [0.3, 2], often close to 1

[Omori, 1894; Utsu, 1960]



Temporal variation

Observations :



Epidemic processes by word-of-mouth

Theory: The Model

Theory: The Model

- Epidemic branching process
- The sales flux is made of:
  - External forces (news…): exogenous $\eta(t)$
  - Social influences (friends…): impact with delay described with a memory kernel $\Phi(t-t_i)$
- So the sum of all buys is modeled as a "self-excited" Hawkes conditional Poisson branching process with intensity:

$$\lambda(t) = \eta(t) + \sum_{i|t_i \le t} \mu_i \phi(t - t_i)$$

Theory: Aggregate and Exogenous Response

- Mean field treatment: ensemble averages, rather than individual behavior (where *n* is the branching ratio of the network):

$$S(t) \equiv \left\langle \lambda(t) \right\rangle = \eta(t) + n \int_{-\infty}^{t} \phi(t-\tau) S(\tau)\, d\tau$$

- One can then solve this equation for an exogenous shock $\eta(t) = \delta(t)$:
- For $\phi \sim 1/t^{1+\theta}$

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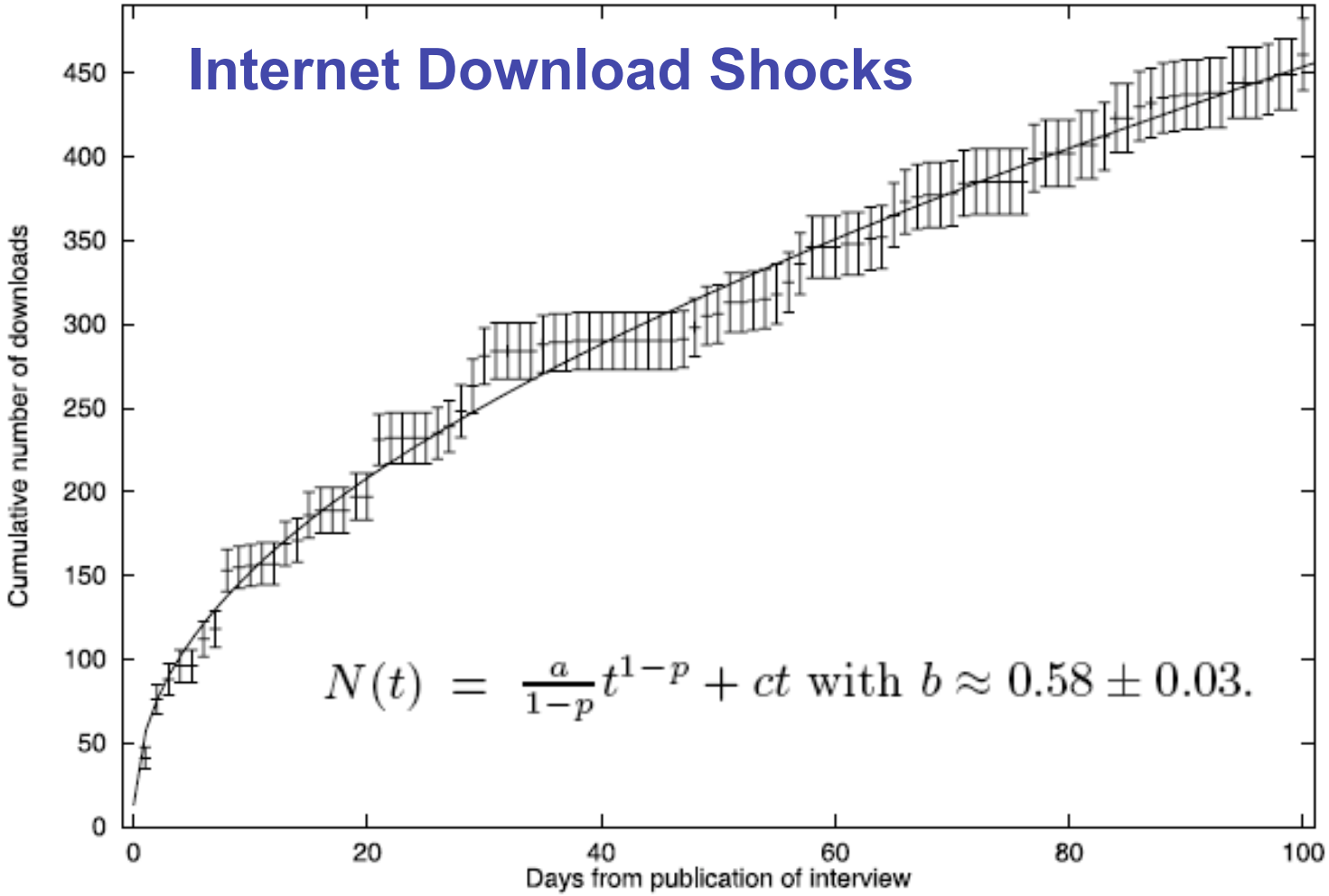
$$S_{exo}(t) \equiv K(t) : \frac{1}{(t-t_c)^{1-\theta}} \quad \text{with} \quad 0 < \theta < 1$$

Distribution of response times is power law for humans in a large variety of situations



Johansen, A. and D. Sornette, Download relaxation dynamics on the WWW following newspaper publication of URL, Physica A, 276 (1-2), 338–345 (2000)

Cumulative number of downloads N as a function of time t from the appearance of the interview on Wednesday 14th April 1999.

Dialog in e-Mail Traffic

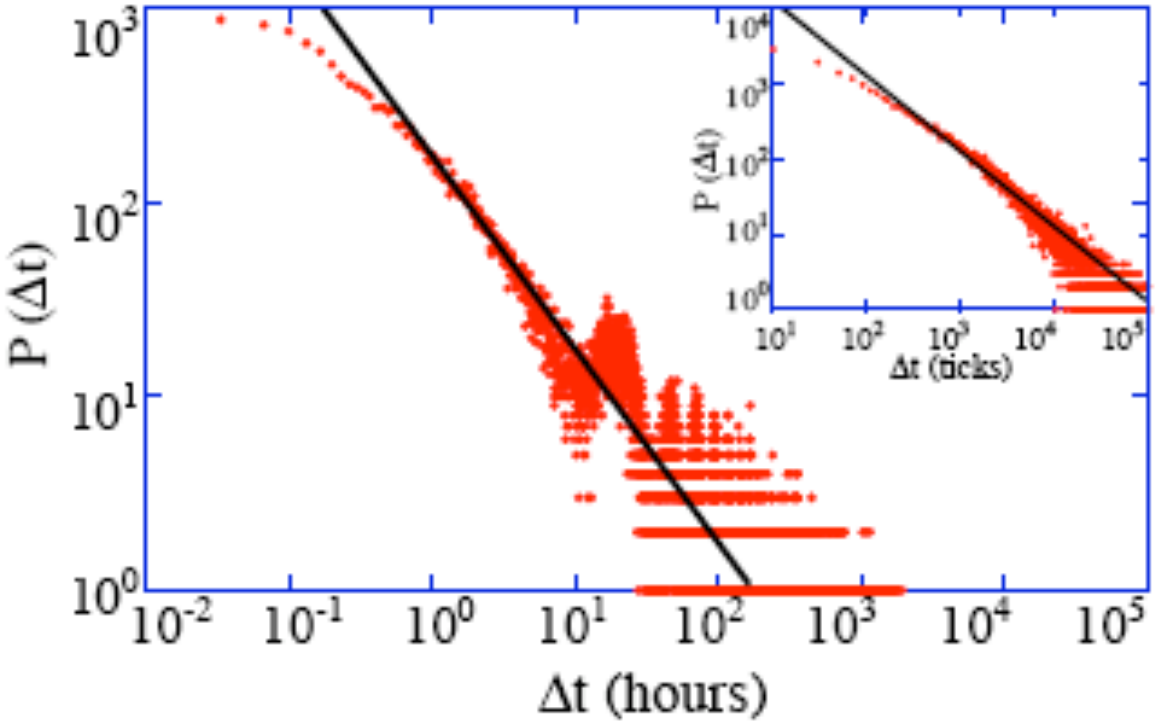


FIG. 1: The probability distribution of the response time till a message is 'answered' (see text for definitions). Inset: same but measured in 'ticks', i.e. units of messages sent in the system. Solid lines follow $\sim \Delta t^{-1}$ and are meant as a guide to the eye.

Eckmann et al. (2004)

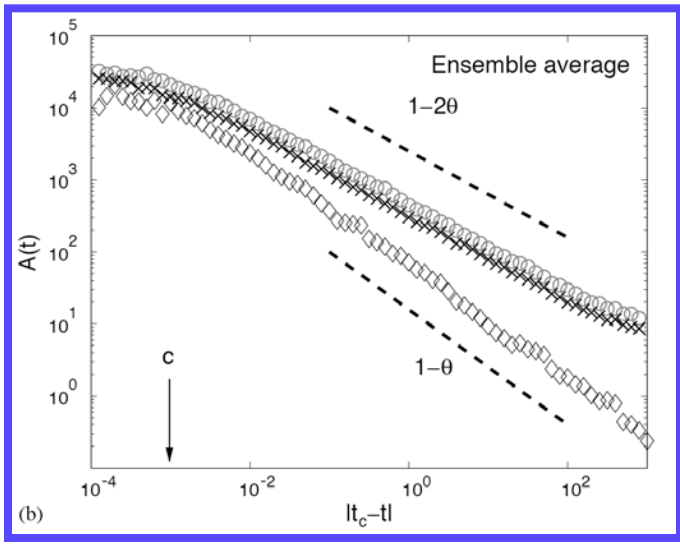
Mean field theory of Hawkes self-exciting conditional Poisson Process

$$A(t) = \int_{-\infty}^{t} d\tau\ \eta(\tau)\ K(t-\tau)$$

Exogeneous shock

$$\mathrm{E}_{\mathrm{exo}}[A(t)] = A_0\ K(t) + n\langle\eta\rangle$$

$$n = \int_0^{+\infty} \tau\ K(\tau)$$



Endogeneous shock

$$\mathrm{E}[X(t)|Y = A_0] - \mathrm{E}[X(t)] = (A_0 - \mathrm{E}[Y])\ \frac{\mathrm{Cov}(X(t), Y)}{\mathrm{E}[Y^2]}$$

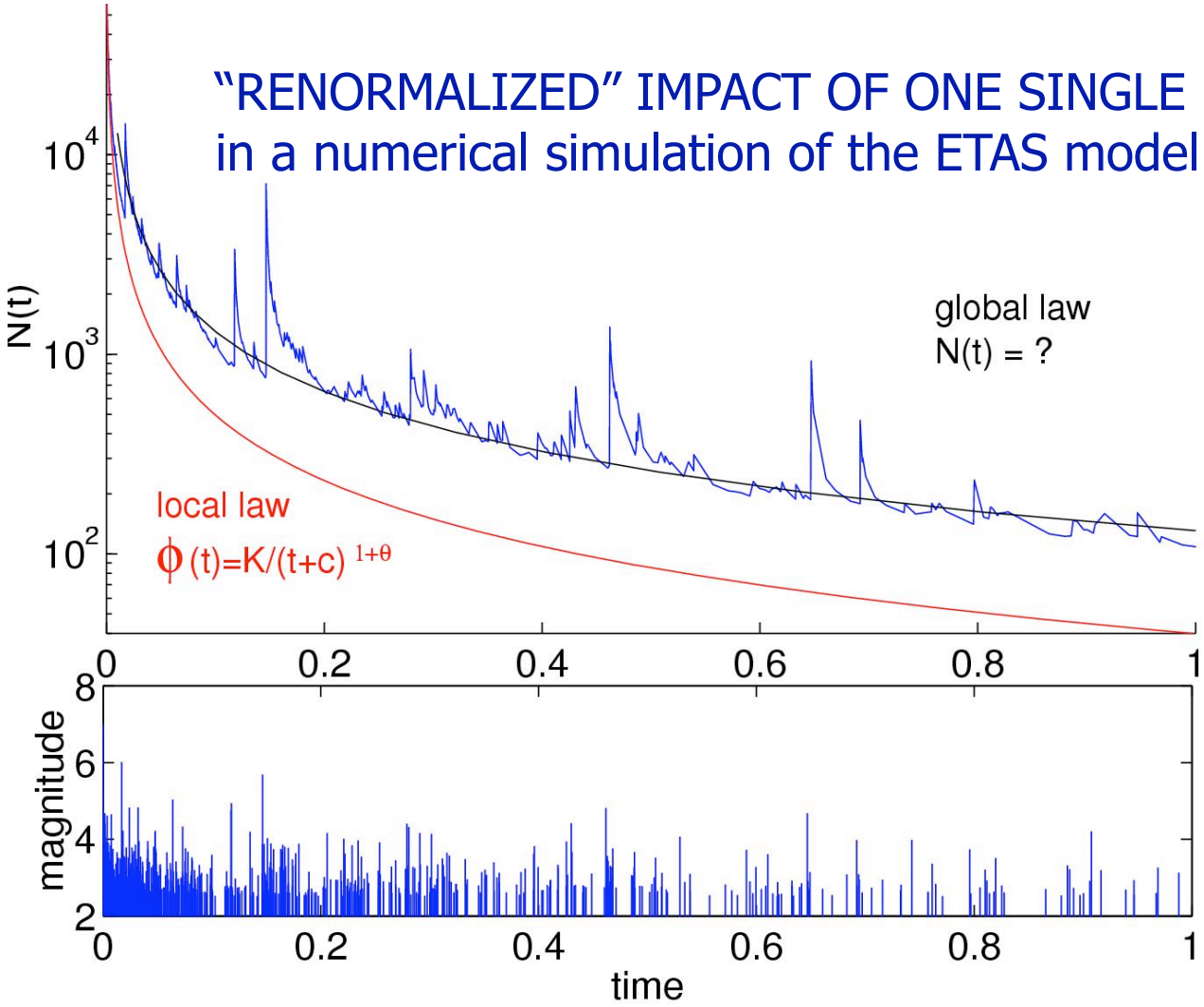
$$\mathrm{Cov}(A(t), A(0)) = \int_{-\infty}^{0} d\tau\ K(t-\tau)\ K(-\tau)$$

$$\mathrm{E}_{\mathrm{endo}}[A(t)|A(0) = A_0] \propto A_0 \int_0^{+\infty} du\ K(t+u)\ K(u)$$

Hawkes ETAS model and numerical simulations

The impact of cascades of generations

"RENORMALIZED" IMPACT OF ONE SINGLE PIECE OF INFORMATION in a numerical simulation of the ETAS model



For $\phi \sim 1/t^{1+\theta}$

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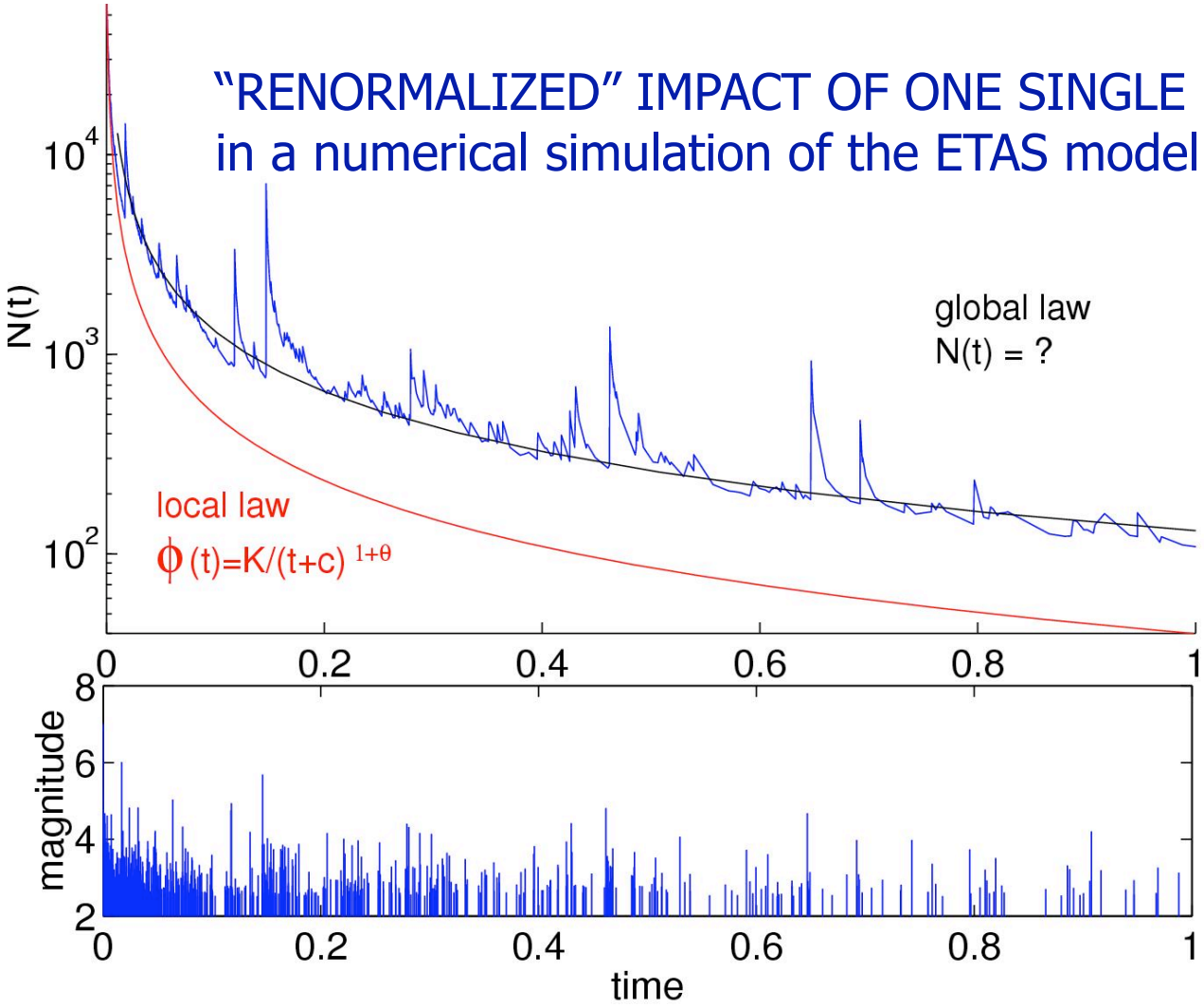


For $\phi \sim 1/t^{1+\theta}$ $\quad S_{exo}(t) \equiv K(t) : \dfrac{1}{(t-t_c)^{1-\theta}}$ with $\quad 0 < \theta < 1$

Theoretical predictions

- The tests are about the slopes of the response functions, conditional on the class of peak determined by the slope of the growth AT CRITICALITY n=1

	Endogenous	Exogenous
Foreshock (or growth)		
Aftershock (or decay)		

Non-critical:

+

Theoretical predictions

- The tests are about the slopes of the response functions, conditional on the class of peak determined by the slope of the growth AT CRITICALITY n=1

	Endogenous	Exogenous
Foreshock (or growth)	$S(t) \propto \frac{1}{\lvert t \rvert^{1-2\theta}}$	
Aftershock (or decay)	$S(t) \propto \frac{1}{t^{1-2\theta}}$	

Non-critical:

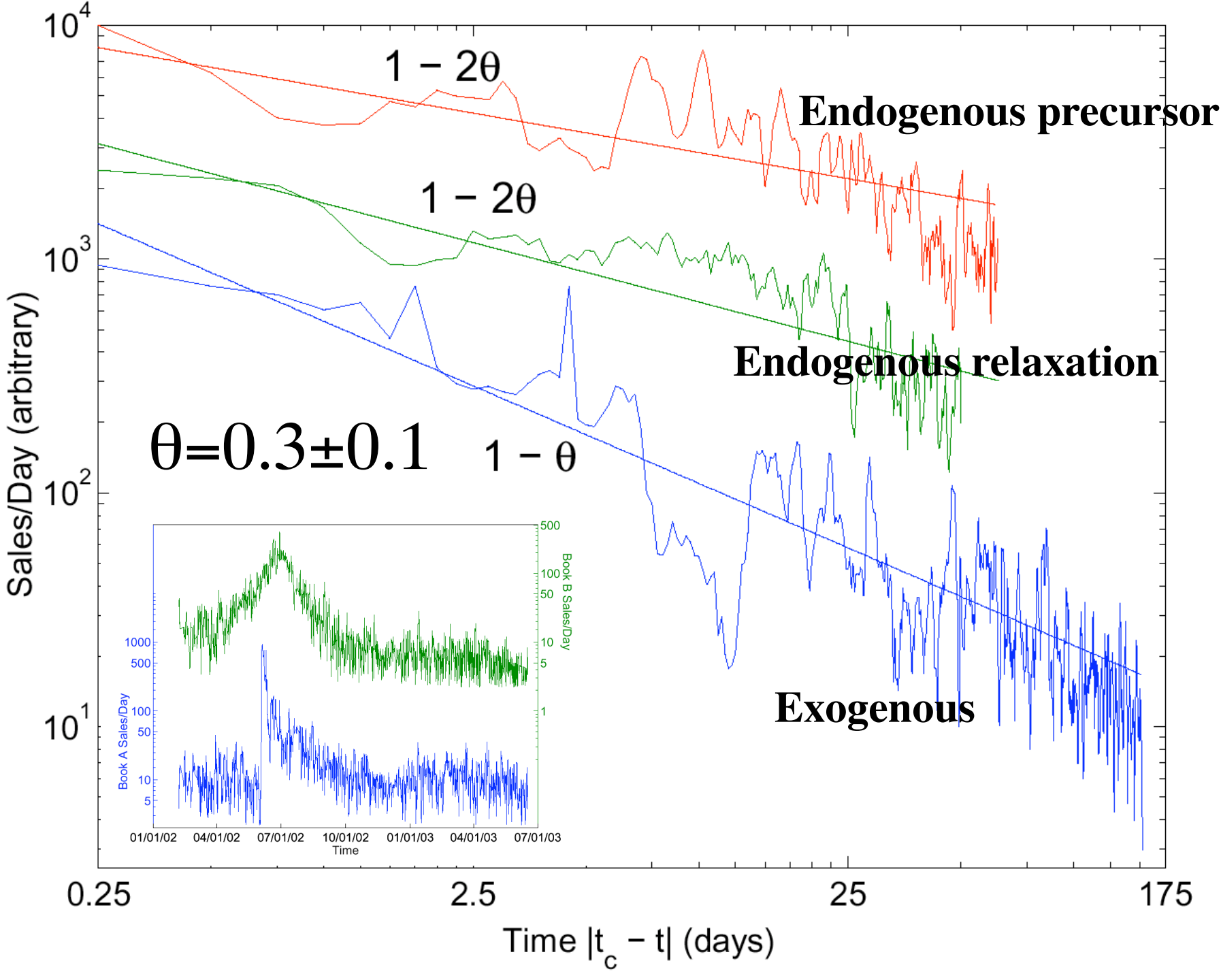
+

Theoretical predictions

- The tests are about the slopes of the response functions, conditional on the class of peak determined by the slope of the growth AT CRITICALITY n=1

	Endogenous	Exogenous
Foreshock (or growth)	$S(t) \propto \frac{1}{\lvert t \rvert^{1-2\theta}}$	Abrupt peak
Aftershock (or decay)	$S(t) \propto \frac{1}{t^{1-2\theta}}$	$S(t) \propto \frac{1}{t^{1-\theta}}$

Non-critical: $S(t) \propto \frac{1}{t^{1+\theta}}$


10^4
10^3
10^2
10^1
Sales/Day (arbitrary)
1 − 2θ
1 − 2θ
1 − θ
θ=0.3±0.1
Endogenous precursor
Endogenous relaxation
Exogenous
0.25
2.5
25
175
Time |t_c − t| (days)
Book A Sales/Day
Book B Sales/Day
01/01/02
04/01/02
07/01/02
10/01/02
01/01/03
04/01/03
07/01/03
Time

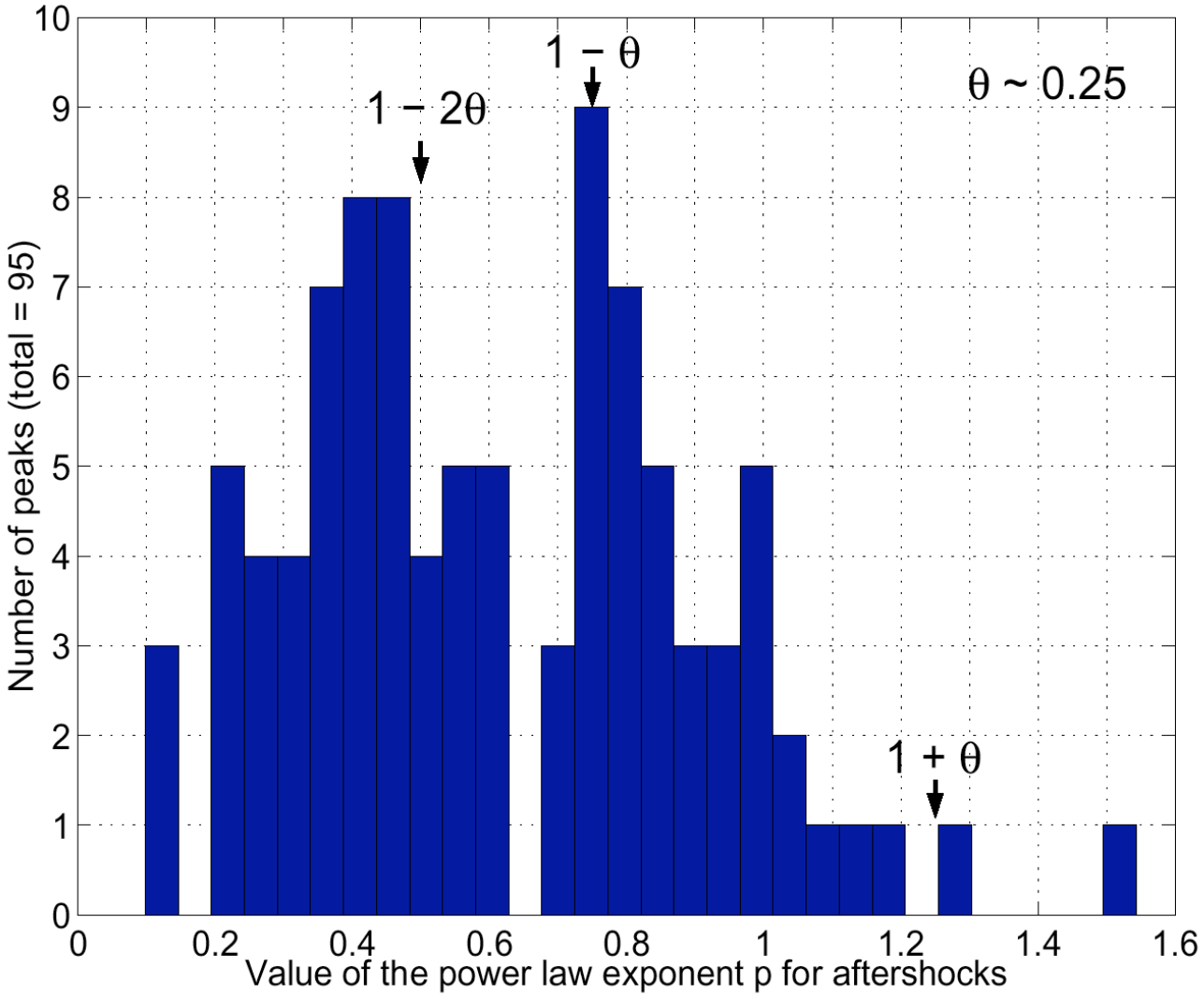
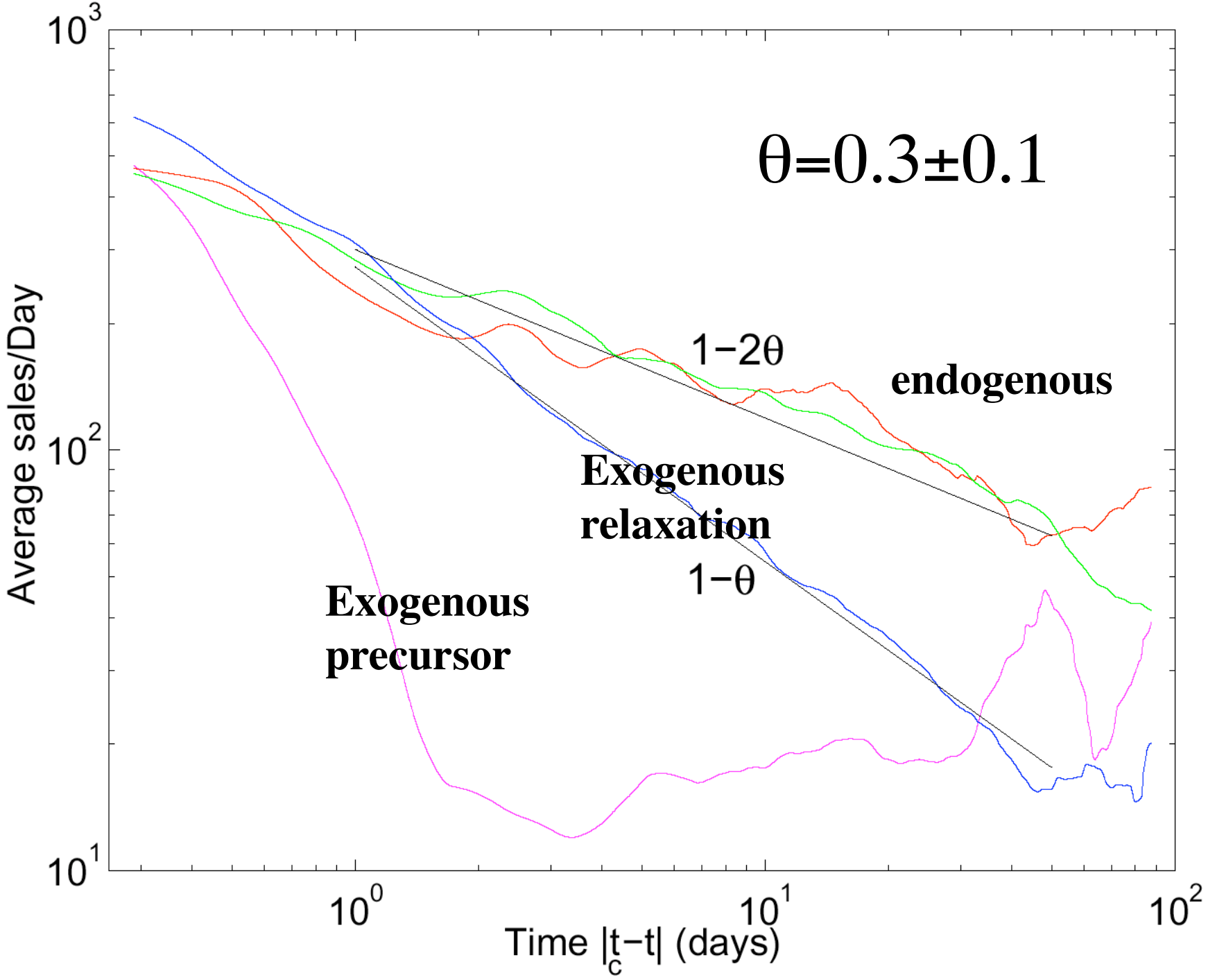


Figure 4: Histogram of the estimates of the power law exponents p of the relaxations of the sales of books following the largest peaks. The sample is obtained from 77 books, which yield 95 major peaks. One can clearly identify two classes of exponents: endogenous cluster for $1-2\theta$ close to 0.45 and exogenous cluster for $1-\theta$ close to 0.75, compatible with the estimation $\theta = 0.3 \pm 0.1$. The tail of the distribution of exponents extending up to at $1+\theta$ represents an exogenous crossover due to deviations from criticality (see text).


θ=0.3±0.1
1−2θ
endogenous
Exogenous
relaxation
1−θ
Exogenous
precursor
Average sales/Day
Time |t_c−t| (days)
10^3
10^2
10^1
10^0
10^1
10^2

Empirical Implications

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- If buys were mainly initiated via news and advertisements, the model predicts an exponent of $1+\theta$
- So the power-law exponents being smaller than 1 indicates:
  - Sales dynamics is dominated by cascades involving high-order generations
  - This implies that $n \sim 1$, i.e. the social network is close to critical

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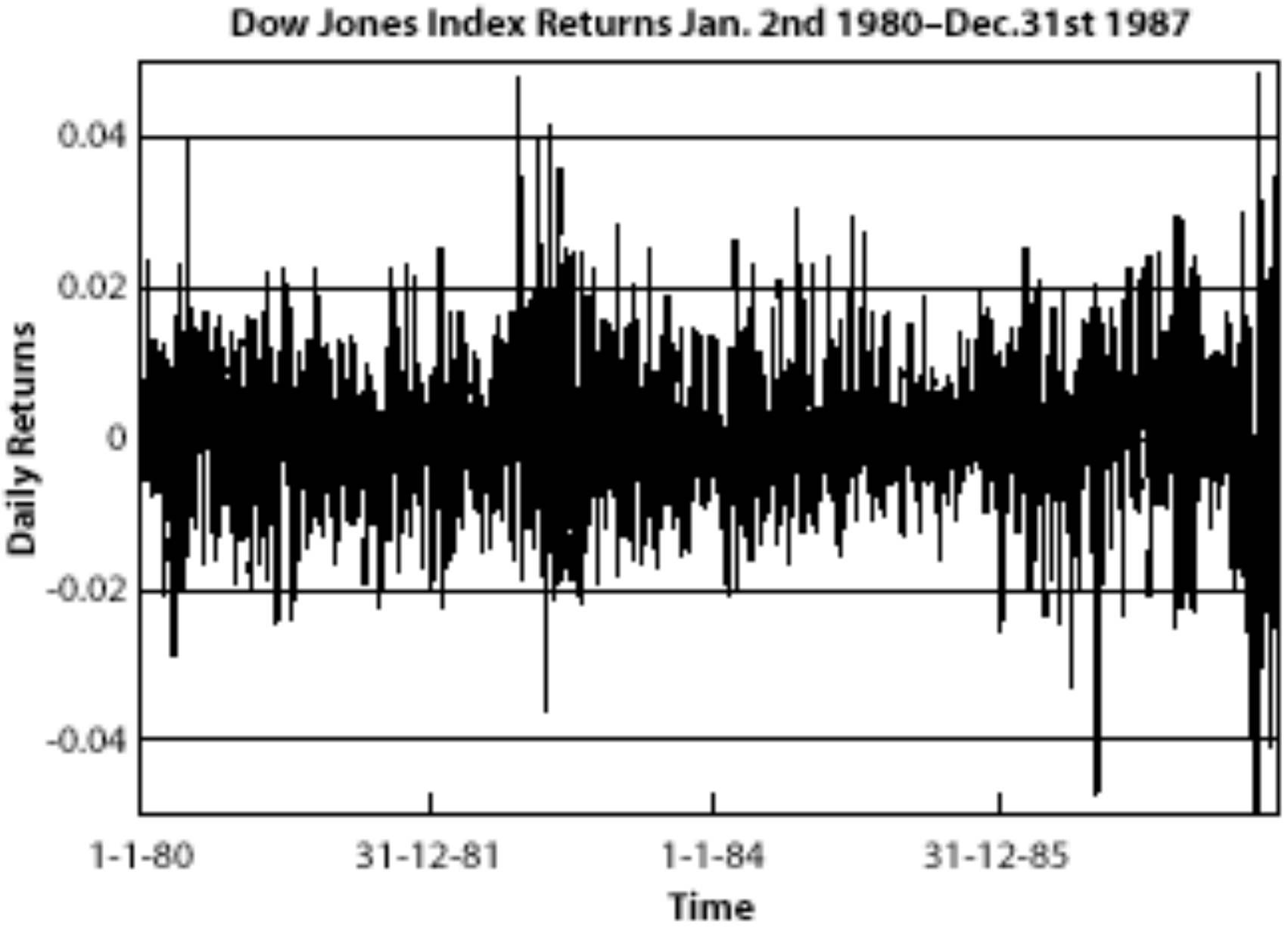
- So the power-law exponents being smaller than 1 indicates:
  - Sales dynamics is dominated by cascades involving high-order generations
  - This implies that $n \sim 1$, i.e. the social network is close to critical
- Identification of critical niches for optimal marketing strategy

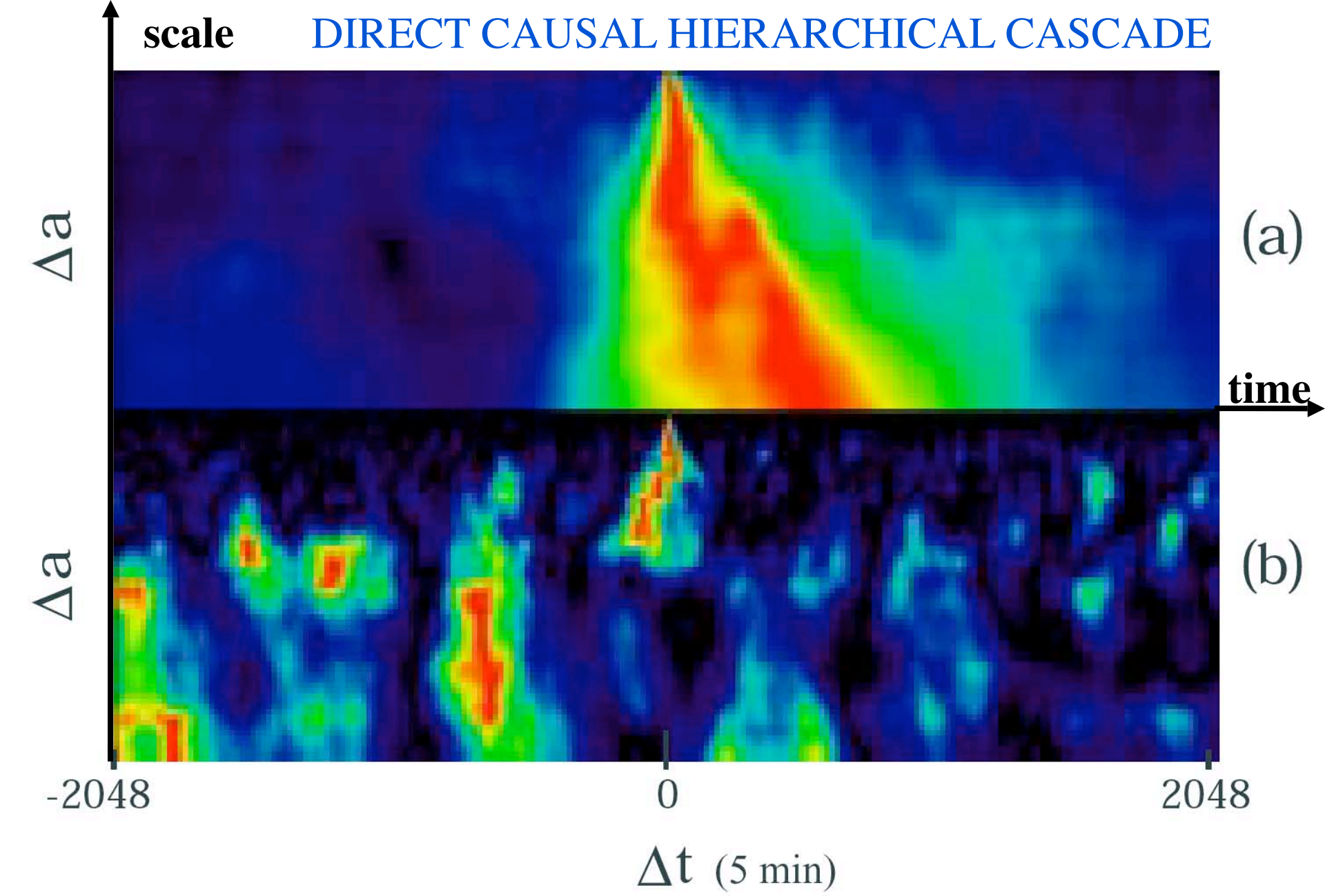
FINANCIAL SHOCKS

FIG. 1.8. Top panel: Time series of daily closes and volume of the Lucent Technology stock over a one-year period around the large drop of January 6, 2000. The time of the crash can be seen clearly as coinciding with the peak in volume (bottom panel). Taken from http://finance.yahoo.com/.

(Sornette, 2003)

Volatility


Dow Jones Index Returns Jan. 2nd 1980–Dec.31st 1987
0.04
0.02
0
-0.02
-0.04
Daily Returns
1-1-80
31-12-81
1-1-84
31-12-85
Time

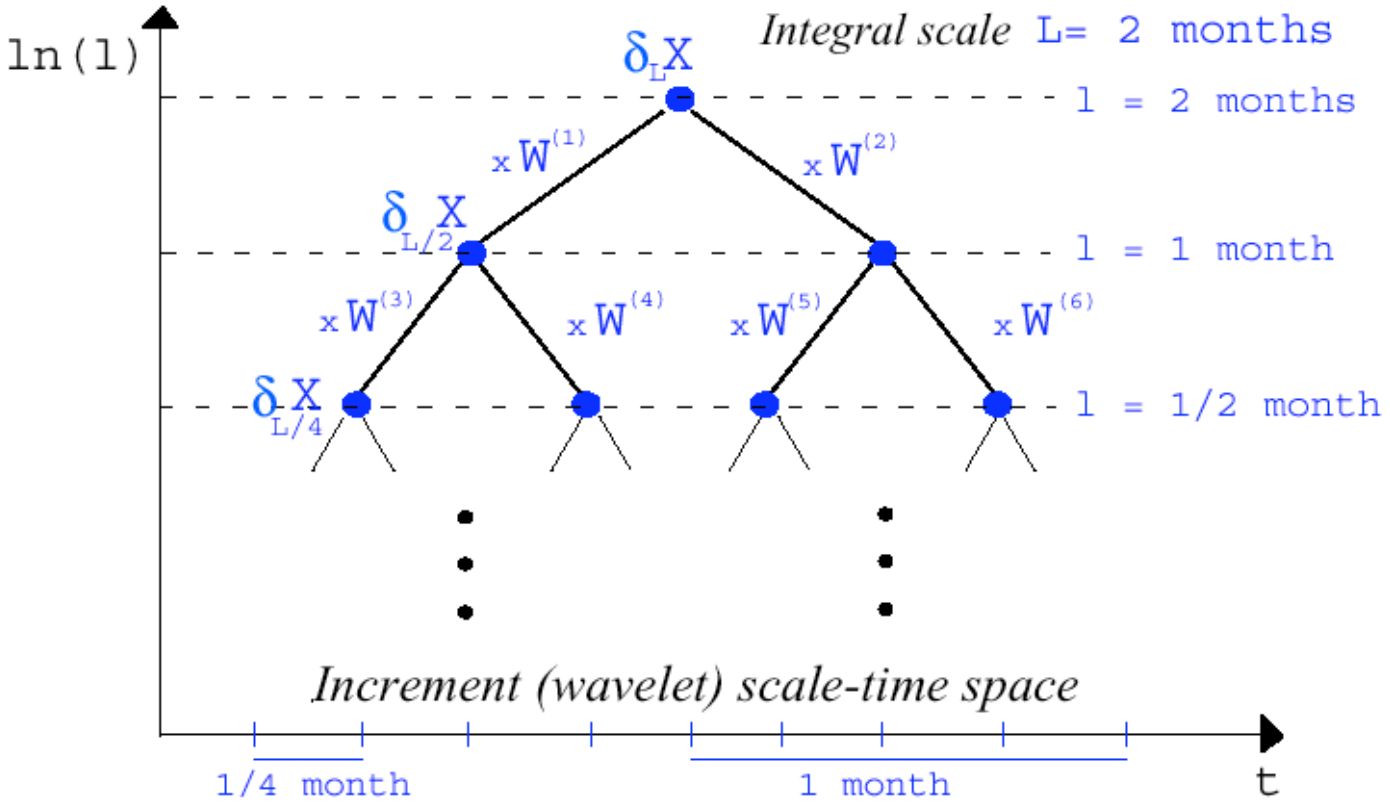


A. Arneodo, J.-F. Muzy and D. Sornette, Direct causal cascade in the stock market, European Physical Journal B 2, 277-282 (1998)

The multiplicative cascade paradigm

$$\delta_{\lambda l} X(\lambda t) = \lambda^H \delta_l X(t) = W_\lambda \delta_l X(t)$$

- $\mathcal{W}$-cascades (wavelet cascade)



The Multifractal Randow Walk (MRW) model

$$r_{\Delta t}(t) = \epsilon(t) \cdot \sigma_{\Delta t}(t) = \epsilon(t) \cdot e^{\omega_{\Delta t}(t)}$$

$$\mu_{\Delta t} = \frac{1}{2} \ln(\sigma^2 \Delta t) - C_{\Delta t}(0)$$

$$C_{\Delta t}(\tau) = \mathrm{Cov}[\omega_{\Delta t}(t), \omega_{\Delta t}(t+\tau)] = \lambda^2 \ln\left(\frac{T}{|\tau| + e^{-3/2}\Delta t}\right)$$

$$\omega_{\Delta t}(t) = \mu_{\Delta t} + \int_{-\infty}^{t} d\tau \; \eta(\tau) \; K_{\Delta t}(t-\tau)$$

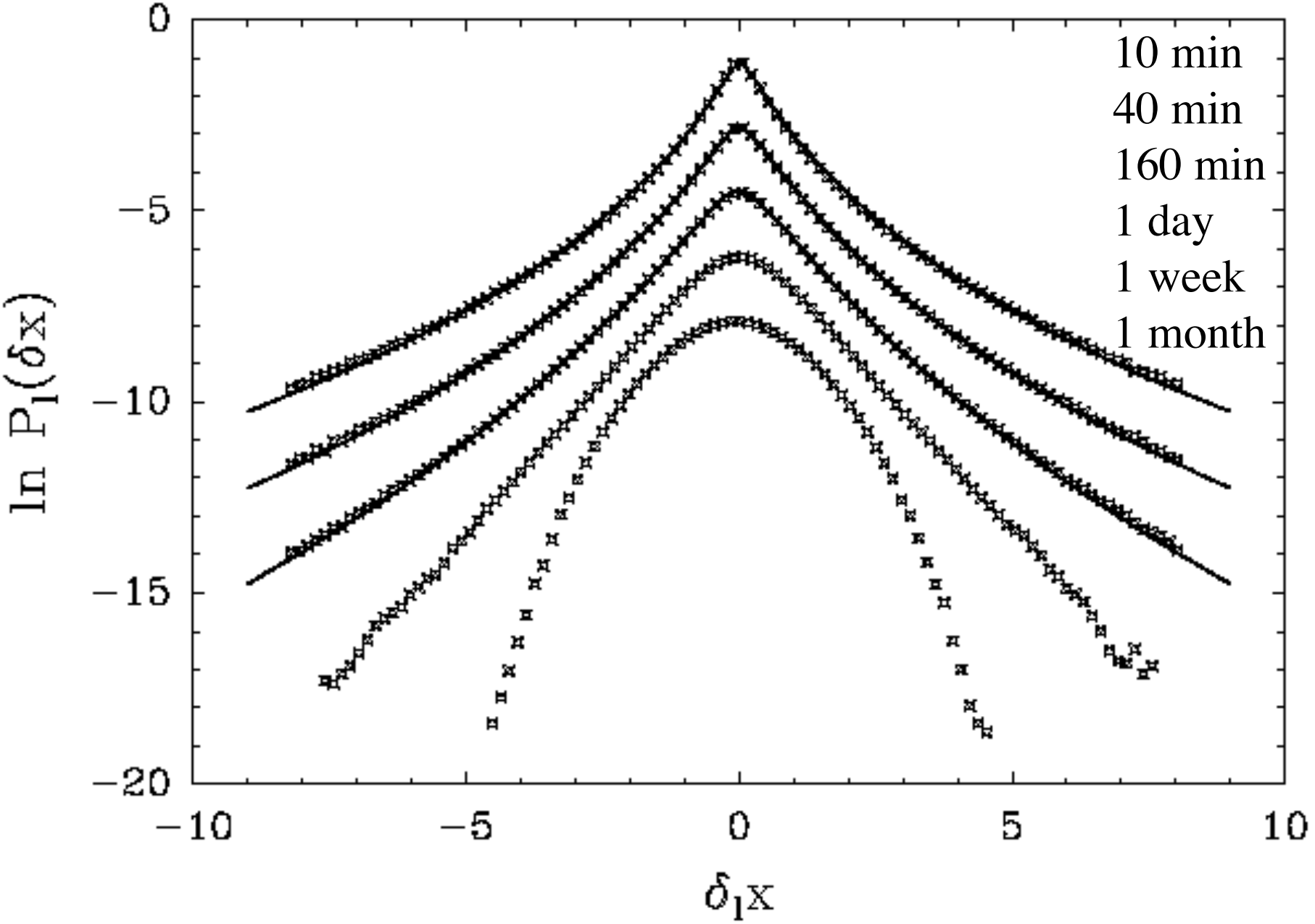
$\omega_{\Delta t}(t)$ is Gaussian with mean $\mu_{\Delta t}$ and variance $V_{\Delta t} = \int_0^\infty d\tau \; K_{\Delta t}^2(\tau) = \lambda^2 \ln\left(\frac{T e^{3/2}}{\Delta t}\right)$

$$C_{\Delta t}(\tau) = \int_0^\infty dt \; K_{\Delta t}(t) K_{\Delta t}(t + |\tau|)$$

$$\hat{K}_{\Delta t}(f)^2 = \hat{C}_{\Delta t}(f) = 2\lambda^2 \; f^{-1} \left[\int_0^{Tf} \frac{\sin(t)}{t} dt + O\left(f \Delta t \ln(f \Delta t)\right) \right]$$

$$K_{\Delta t}(\tau) \sim K_0 \sqrt{\frac{\lambda^2 T}{\tau}} \quad \text{for} \quad \Delta t << \tau << T$$

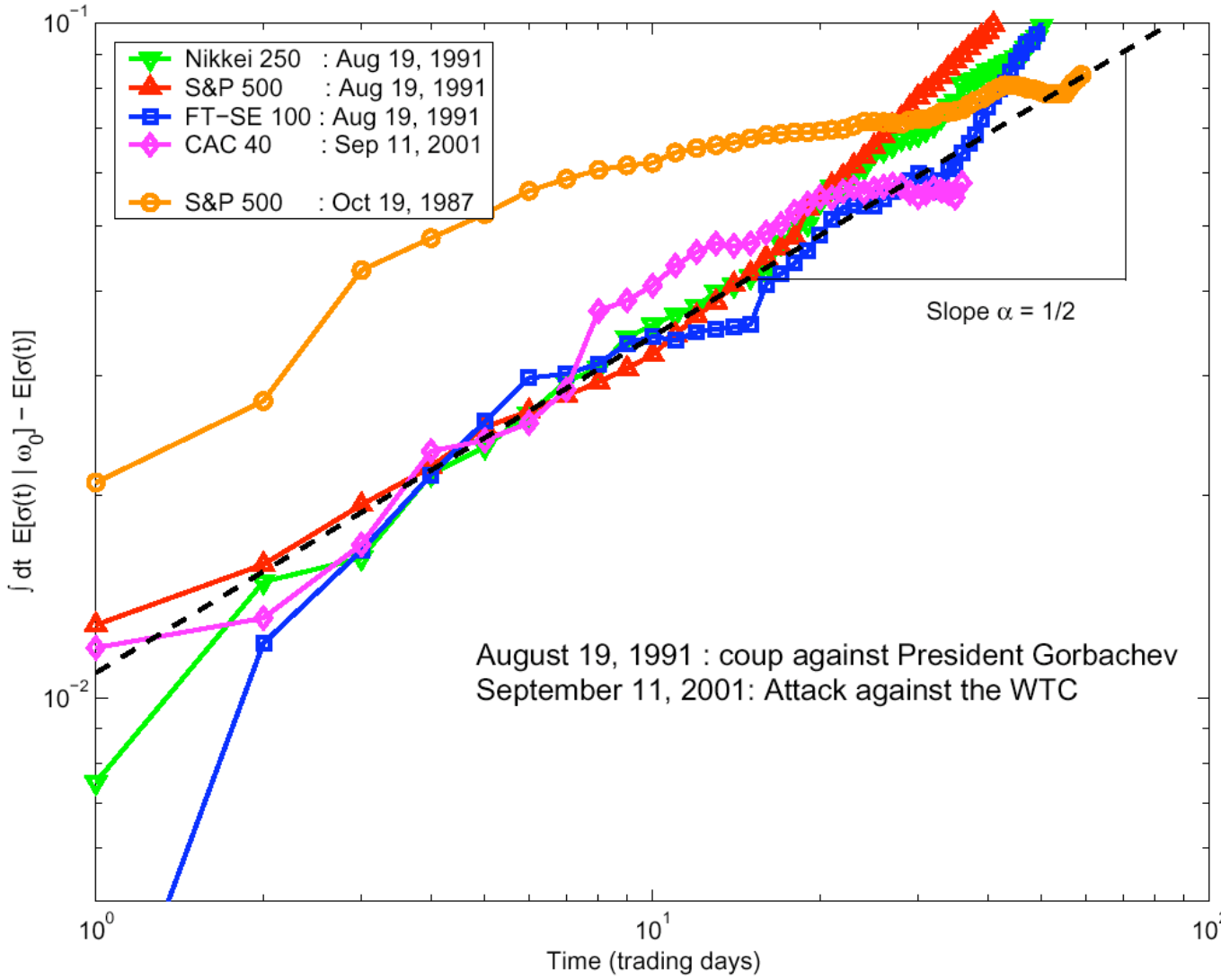
D. Sornette, Y. Malevergne and J.F. Muzy, Volatility fingerprints of large shocks: Endogeneous versus exogeneous, Risk 16 (2), 67-71 (2003)((http://arXiv.org/abs/cond-mat/0204626)


0
−5
−10
−15
−20
−10
−5
0
5
10
ln P1(δx)
δ1x
10 min
40 min
160 min
1 day
1 week
1 month

(a)

Linear response to an external shock

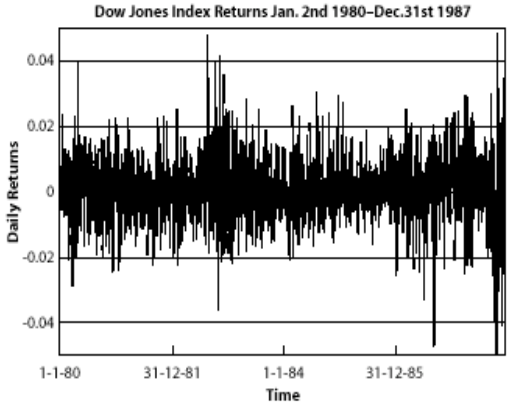
$$\mathrm{E}_{\mathrm{exo}}[\sigma^2(t) \mid \omega_0] - \overline{\sigma^2(t)} \propto e^{2K_0 t^{-1/2}} - 1 \approx \frac{2K_0}{\sqrt{t}}$$



D. Sornette, Y. Malevergne and J.F. Muzy
Volatility fingerprints of large shocks: Endogeneous versus exogeneous,
Risk Magazine
(http://arXiv.org/abs/cond-mat/0204626)

"Conditional response" to an endogeneous shock

$$\begin{aligned} \mathrm{E}_{\mathrm{endo}}[\sigma^2(t) \mid \omega_0] &= \overline{\sigma^2(t)} \exp\left[2(\omega_0 - \mu) \cdot \frac{C(t)}{C(0)} - 2\frac{C^2(t)}{C(0)}\right] \\ &= \overline{\sigma^2(t)} \left(\frac{T}{t}\right)^{\alpha(s)+\beta(t)} \end{aligned}$$



where

$$\alpha(s) = \frac{2s}{\ln\left(\frac{Te^{3/2}}{\Delta t}\right)},$$

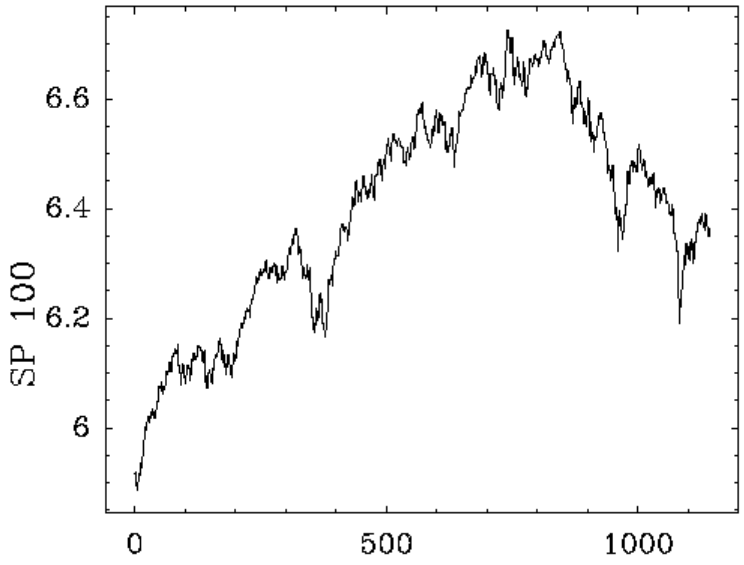
$$\beta(t) = 2\lambda^2 \frac{\ln(t/\Delta t)}{\ln(Te^{3/2}/\Delta t)}$$

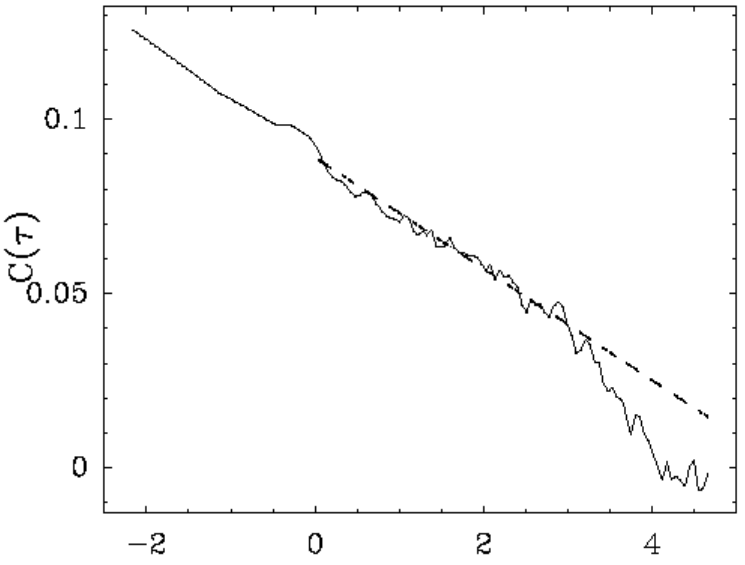
Interplay between
-long memory
-exponential

Within the range $\Delta t < t << \Delta t e^{\frac{|s|}{\lambda^2}}$, $\beta(t) << \alpha(s)$

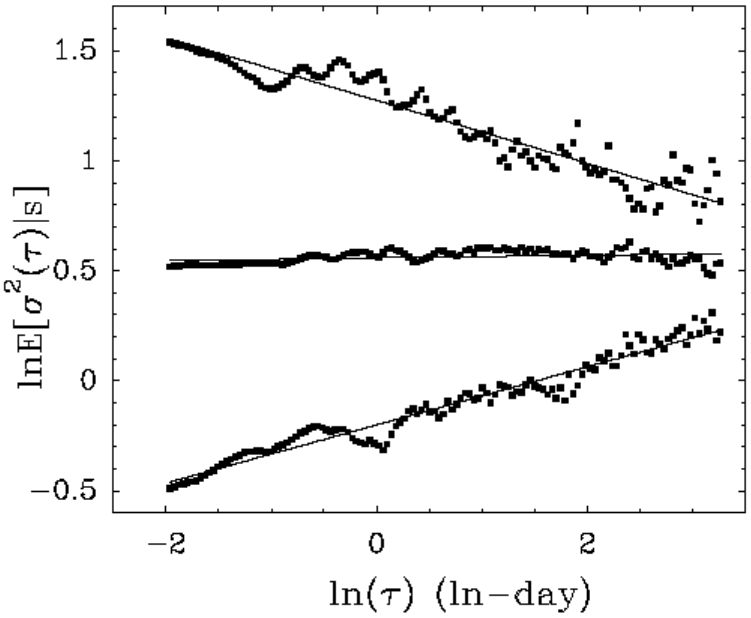
$$\mathrm{E}_{\mathrm{endo}}[\sigma^2(t) \mid \omega_0] \sim t^{-\alpha(s)}$$

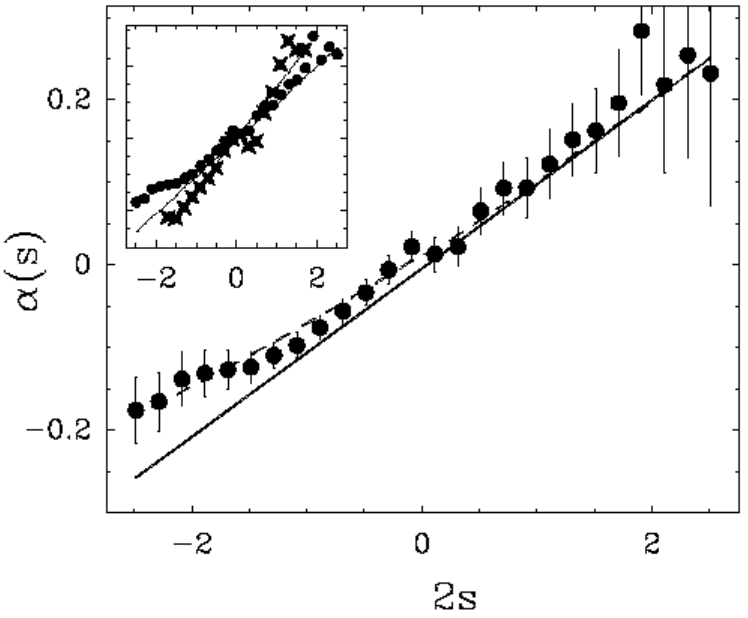
Real Data and Multifractal Random Walk model





$$\mathrm{E}_{\mathrm{endo}}[\sigma^2(t) \mid \omega_0] \sim t^{-\alpha(s)}$$





A Shocking Look At...

Riley Crane, Didier Sornette
ETH Zurich, D-MTEC
Chair of Entrepreneurial Risks

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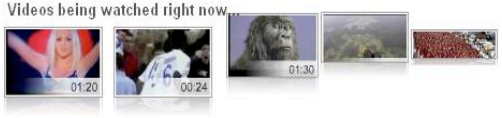

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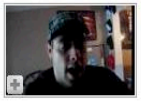
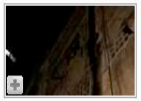


Final Words...Thank you YouTube!
This is it guys...
From: desiprince786
Views: 22,069
Time: 03:30
More in People & Blogs

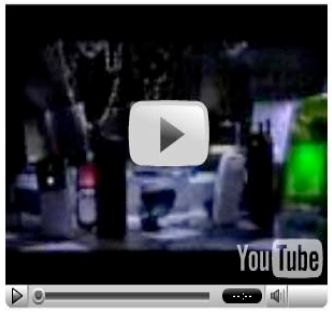
The Cacaman - Ain't Got Much of ...
The Cacaman's Music Video for "Ain't got much of a smile." Original music and Lyrics by The Cacaman. Check out more at: http:// (more)
From: CacamanMusic
Views: 143,521
Time: 03:42
More in Music



Rescue children living in povert...
I believe children, no matter where they are born, deserve to live free of danger, abuse and poverty. I Stir for a better world! (more)
From: WorldVisionStir
Views: 51,614
Time: 01:21
More in News & Politics

Ezekiel's Story
The Taylors shared their baby story, now go tell yours by visiting www.marchofdimes.com/everybaby Following the premature birth (more)
From: MarchofDimes
Views: 36,002
Time: 06:31
More in People & Blogs

Share Your Story at the 92nd Str...
Sharing Stories about the 92nd Street Y in New York City. To learn more about the 92nd Street Y, visit http://www.92Y.org
From: 92ndStreetY
Views: 18,122
Time: 03:08
More in People & Blogs



MOTORAZR2 ESSENCE OF SHARPER TRAILER
From: MOTORAZR2
Comments: 0

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Does your nonprofit organization have a great story to tell? Do you want to connect with supporters online but don't have the money for expensive outreach campaigns? Or are you just looking for way...

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Open Your Eyes - Sean Delaney
Sean Delaney is musician as well as a Direct Support Professional with the Special Needs Program in upstate New York. After spendi (more)
From: AutismSpeaksVids
Views: 52,531
Time: 03:48
More in Music

WOMEN OF DARFUR
IRC communications officer Emily Holland recently traveled to Darfur to document the lives of displaced Sudanese. In this video, (more)
From: theirc
Views: 84,468
Time: 01:22
More in News & Politics

Polar Bears
Two polar bears muse on the causes of global warming. An entry for our green film competition. http://www.foe.co.uk for info.
From: friendsoftheearth
Views: 235,760
Time: 01:00
More in Film & Animation

E-Waste: Dumping on the Poor ?? ?...
Asia Society's multimedia look at electronic waste shipped overseas and the toxic effect it has on places such as Guiyu, China--kn (more)
From: asiasociety
Views: 102,646
Time: 04:35
More in News & Politics

24 Hours for Darfur -- Numbers &...
This video montage highlights people's efforts to grapple with the scope and depth of violence and suffering wrought by the genoci (more)
From: 24hoursfordarfur
Views: 21,139
Time: 04:05
More in News & Politics

Kanye West: Education needs to b...
http://www.edin08.com - Join Kanye and ED in '08 ED in '08 is a campaign to make America's schools a top issue in the 2008 pres (more)
From: EDin08
Views: 241,230
Time: 00:29
More in News & Politics

Contest to End Youth Homelessness
A video explanation of the "Out Of The Shadows" Contest to end Youth Homelessness. Find out what you can do to address the problem (more)
From: YouthNoise
Views: 52,505
Time: 01:30
More in News & Politics

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From: MyDamnChannel
Views: 1642

American Eskimo puppies
From: invisioning
Views: 7495

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Overview

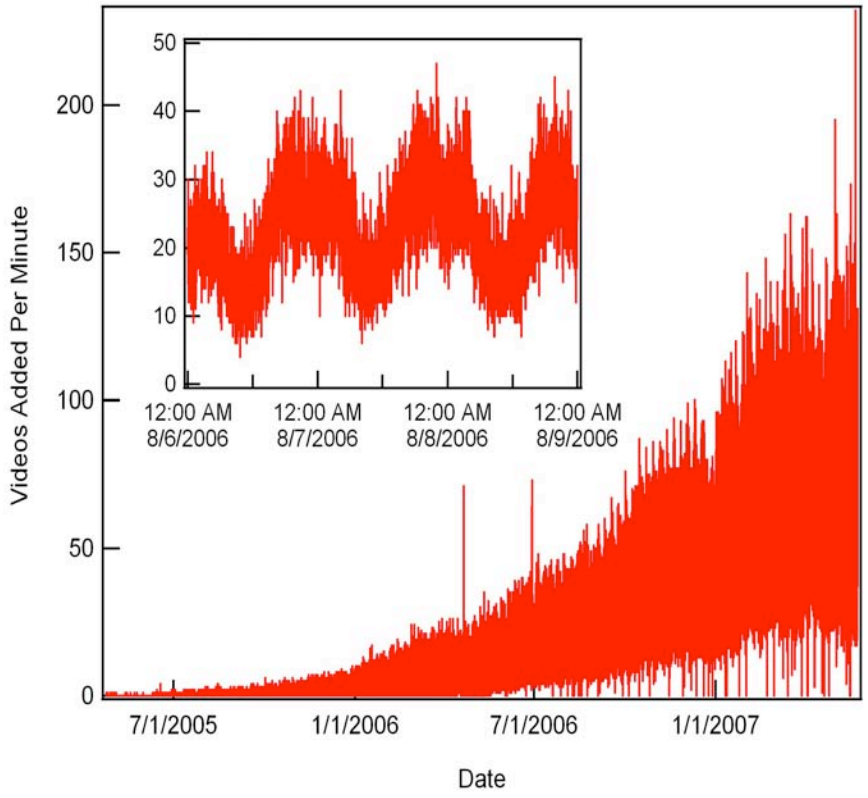
- Video Arrival and Site Growth
- Featuring – Endogenous/Exogenous Shocks
- Dynamical Relaxation Following Shocks

Perl script, via application programming interface (API) for the automated request of data. Stored in MySQL database

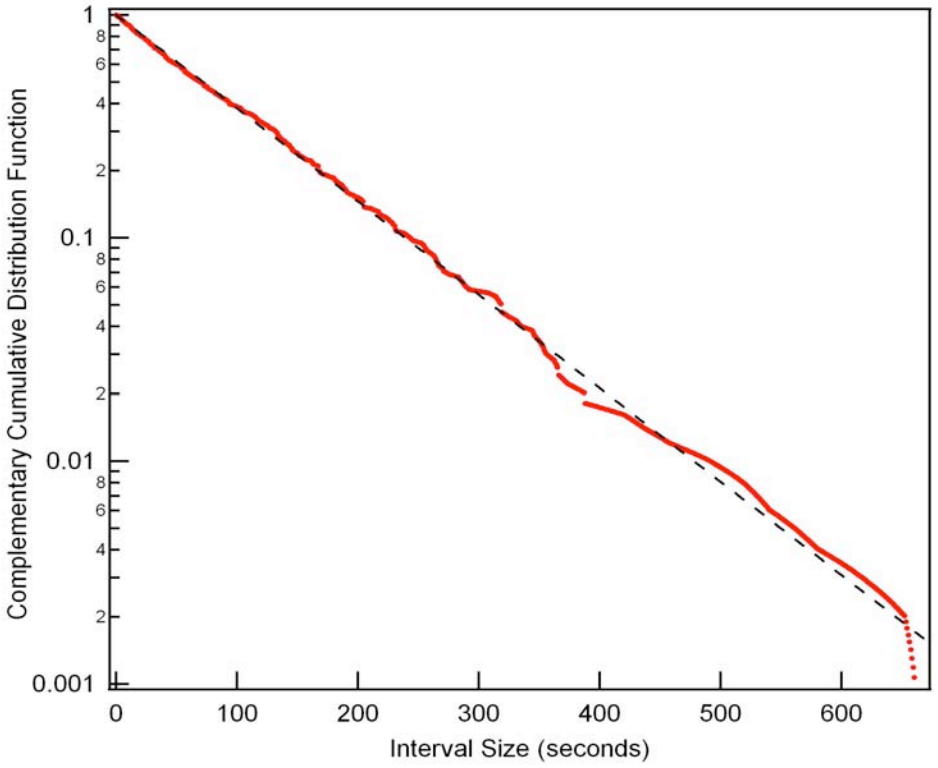
YouTube responds with a structured (XML) document containing information such as the cumulative number of times a video has been viewed (dynamic), along with descriptive information (static) concerning the user who posted the video, the title, tags, length, category, rating, comments, etc

Birth of a Video

Videos Added per Minute



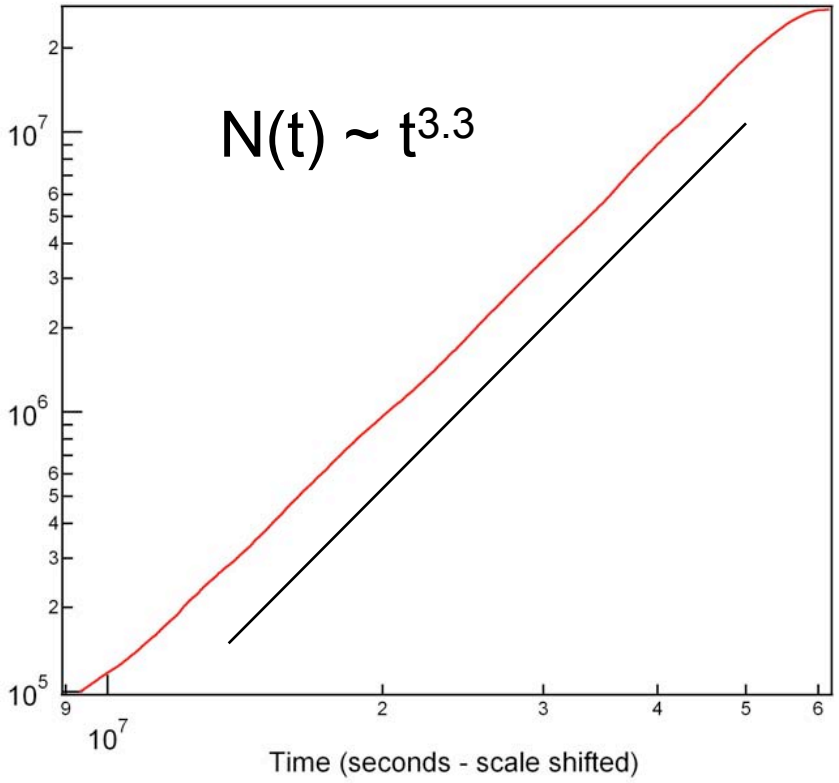
Locally - distribution of Waiting times is Exponential



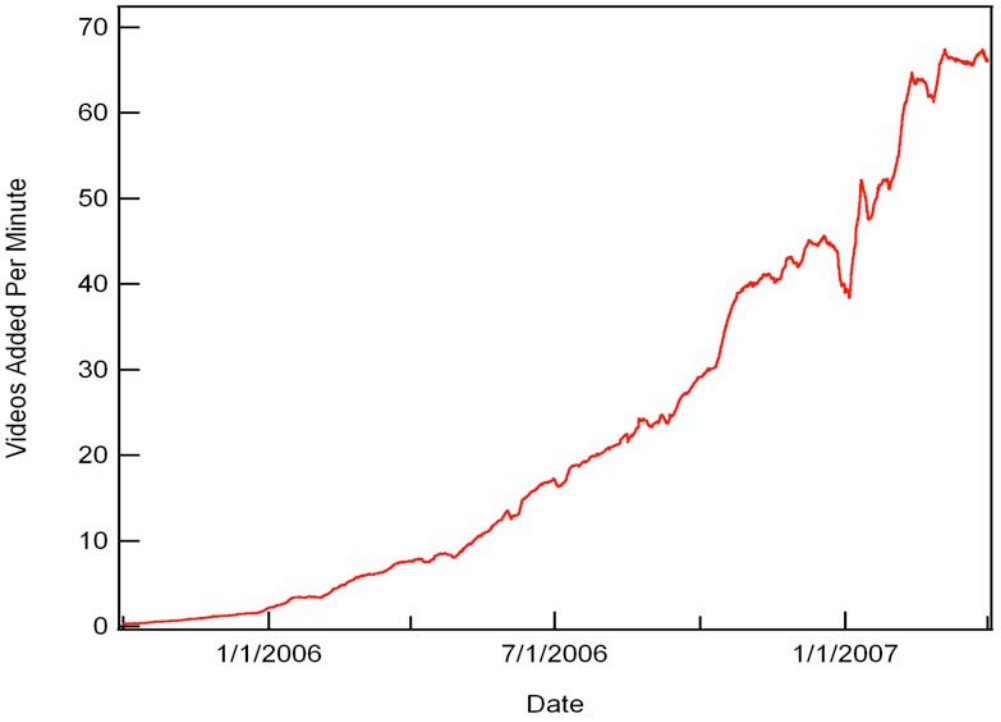
Non-Stationary Poisson Process

Exponent 3.3 reveals the average nb of "friends"

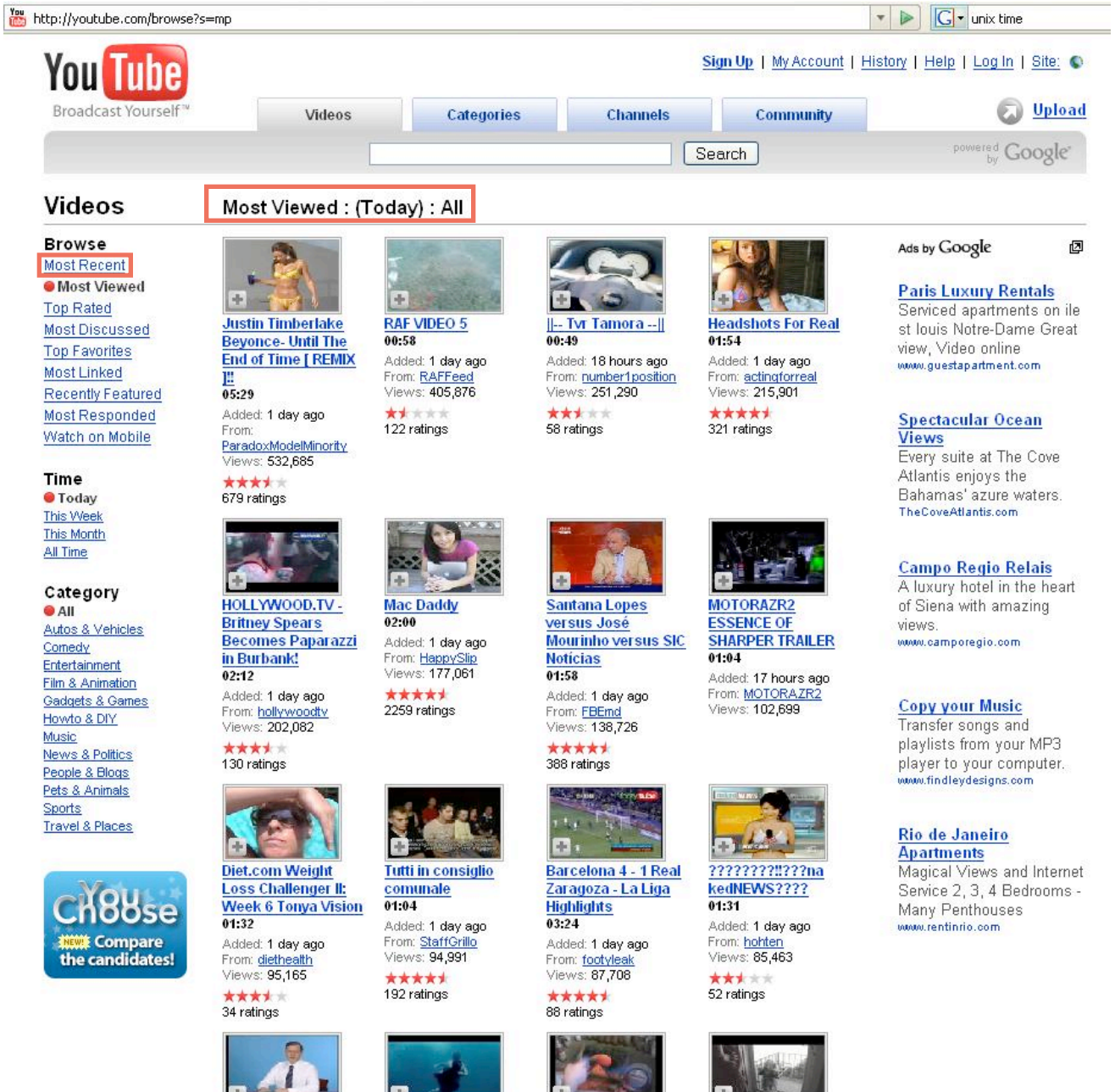
Cumulative Number of Videos



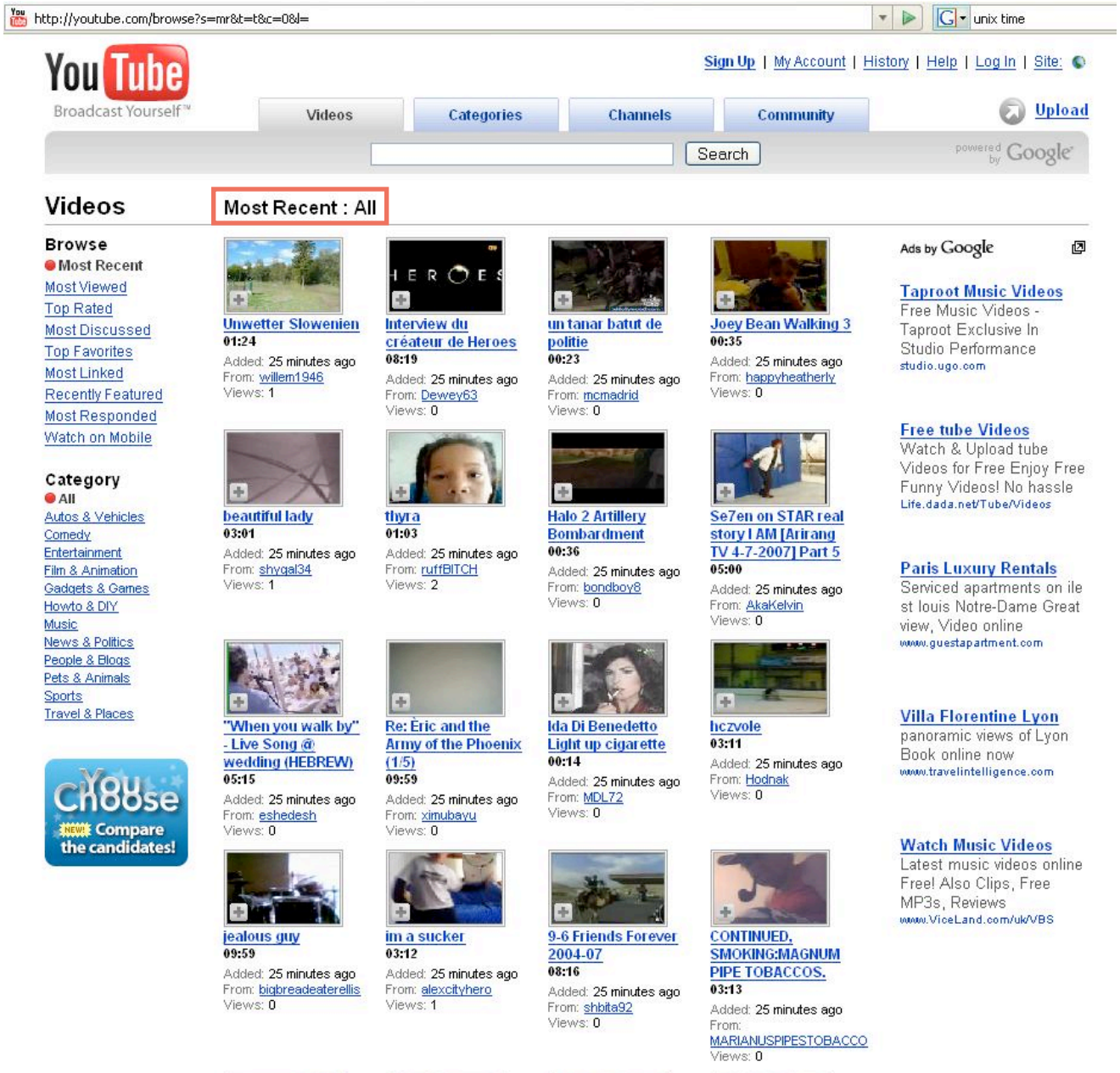
Non-Stationary Poisson Rate



Most Viewed Page

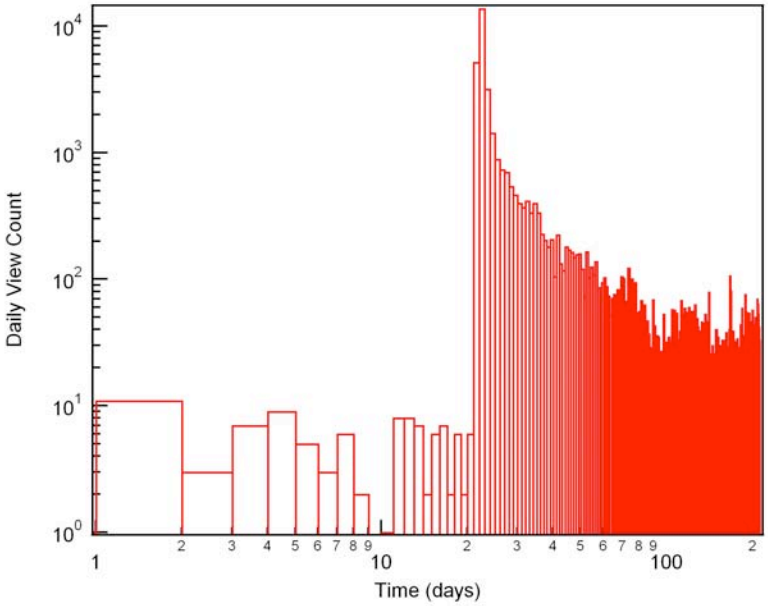


Most Recent Page

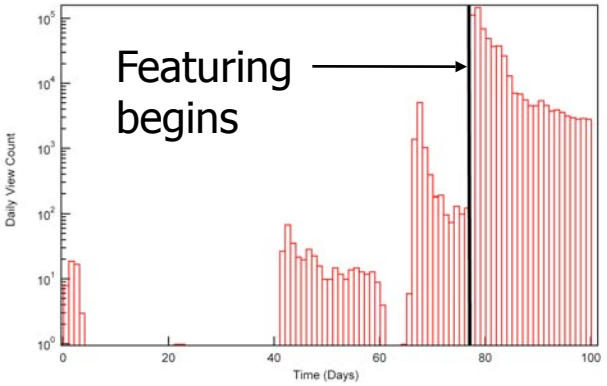


The Effect of Featuring

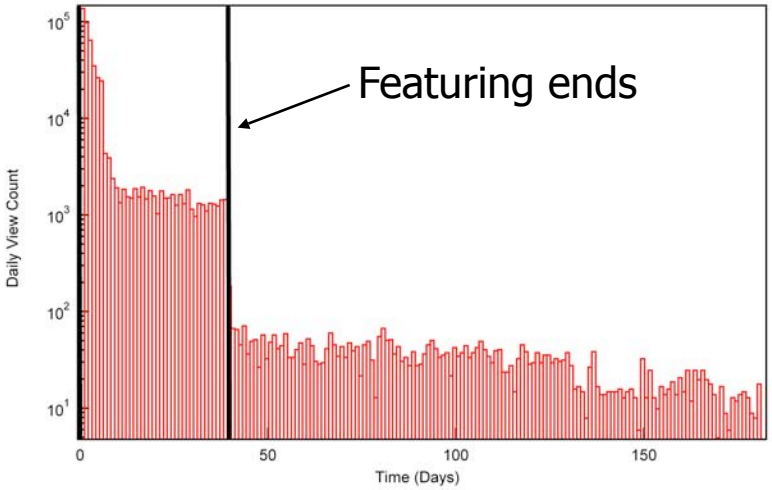
Editorial Featuring
(arbitrary and random)



Growth of a Video before being featured

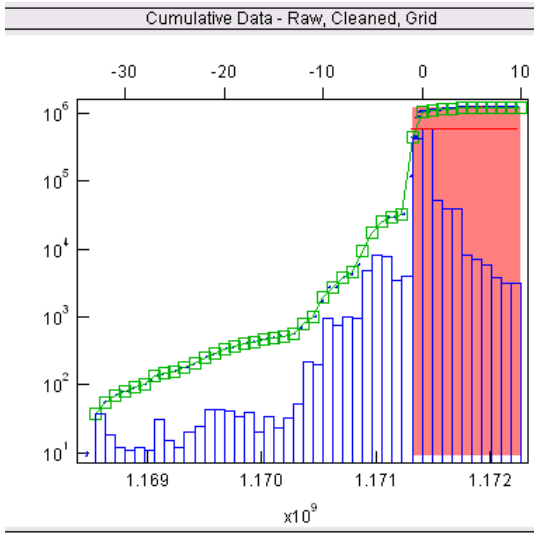


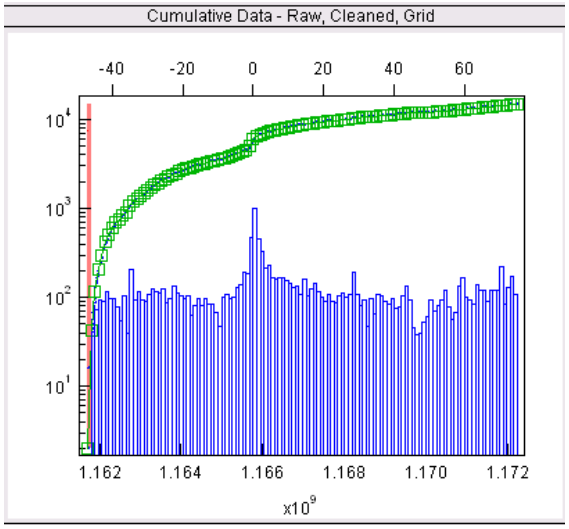
Decline of a video after being featured

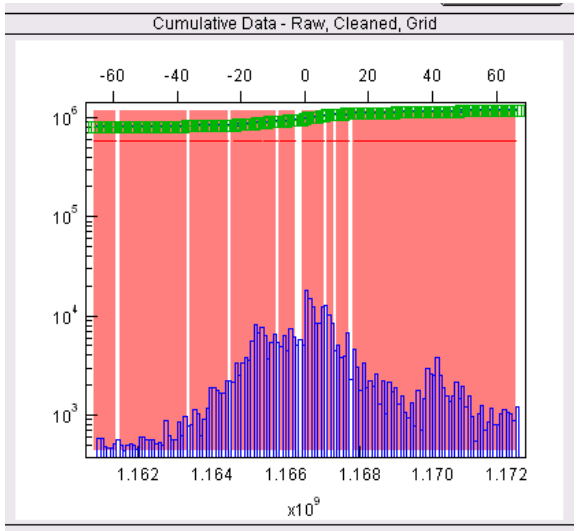


Shocks in YouTube

“Endogenous”

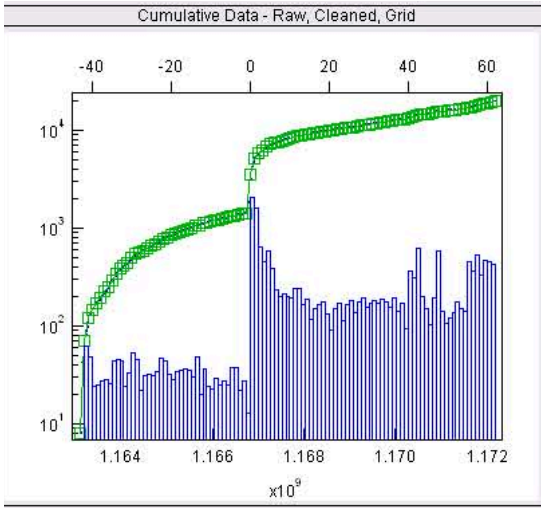


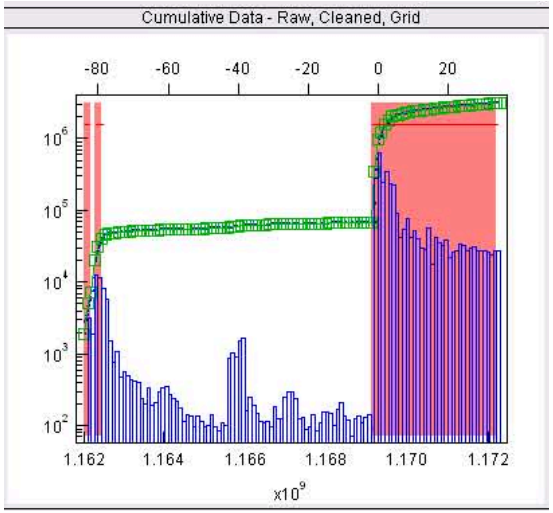


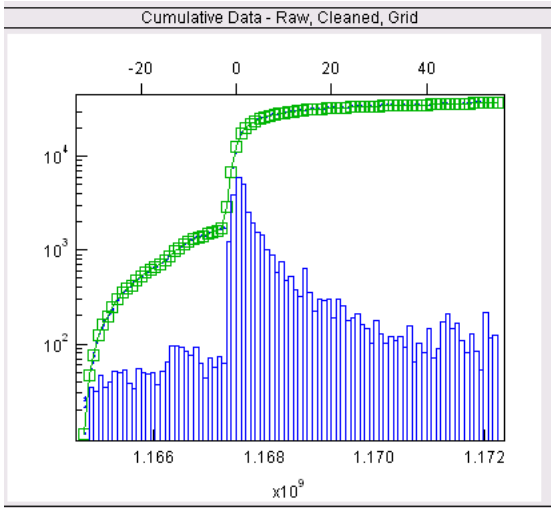


Shocks in YouTube

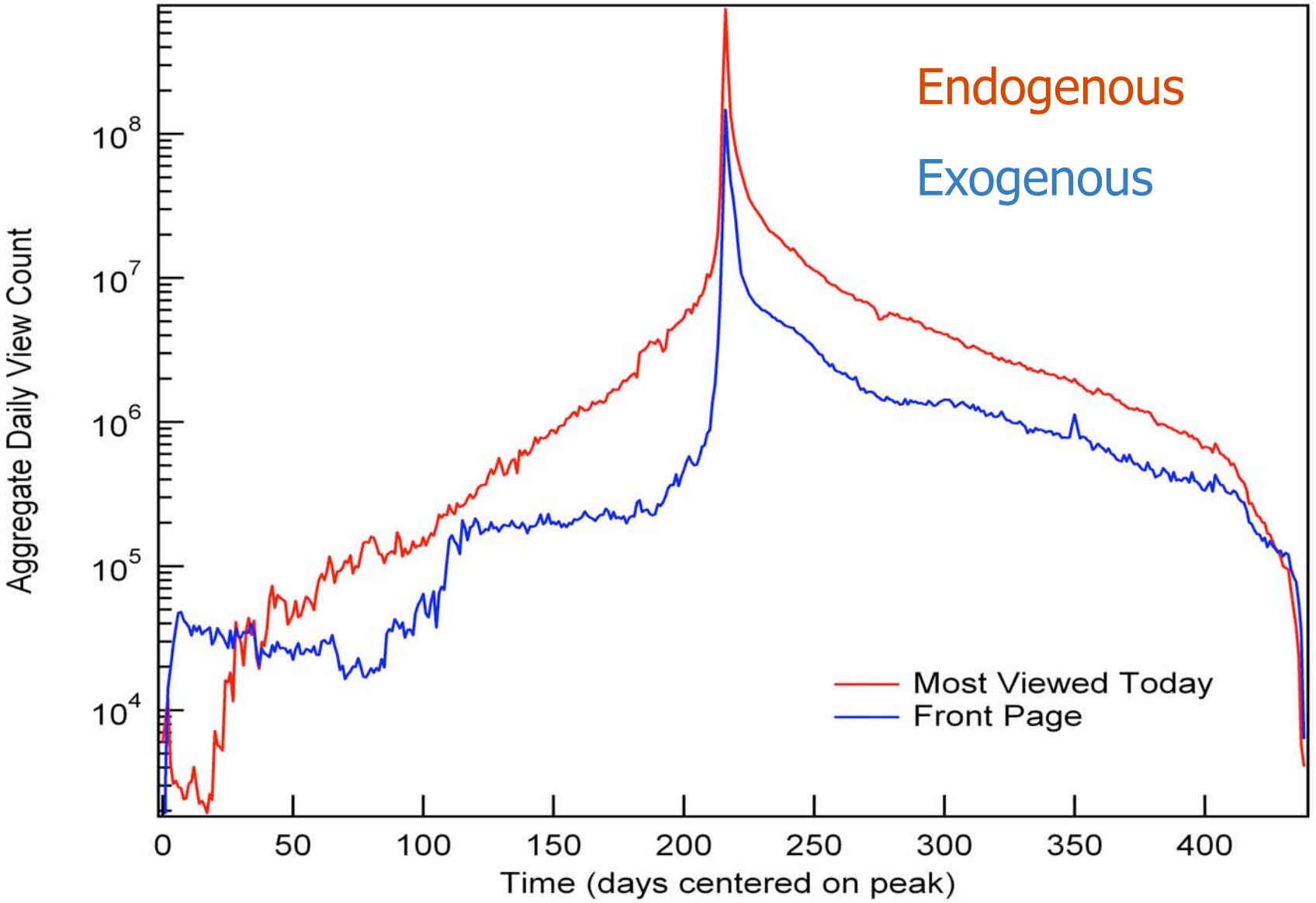
“Exogenous”





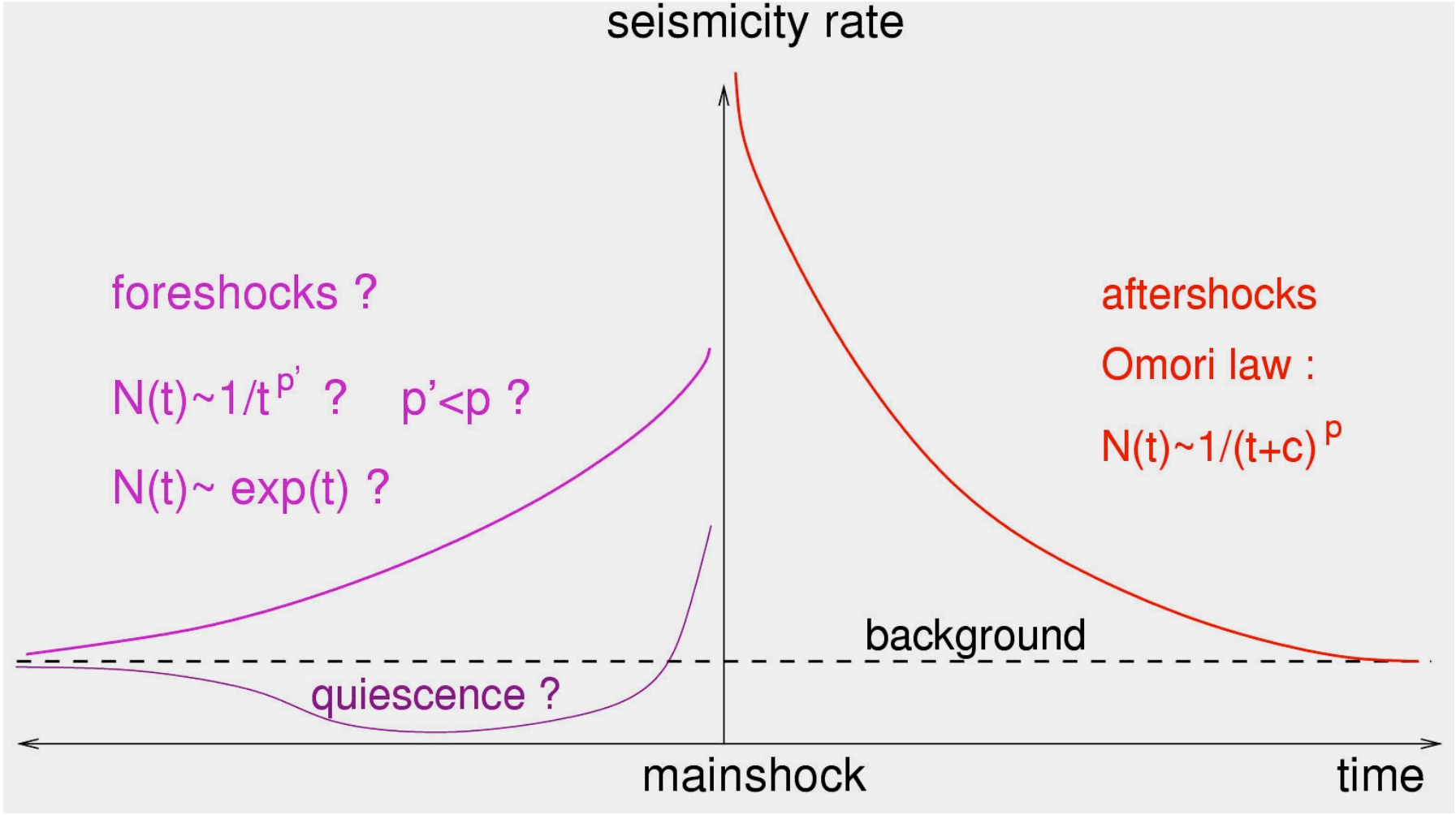


Non-Parametric Superposition

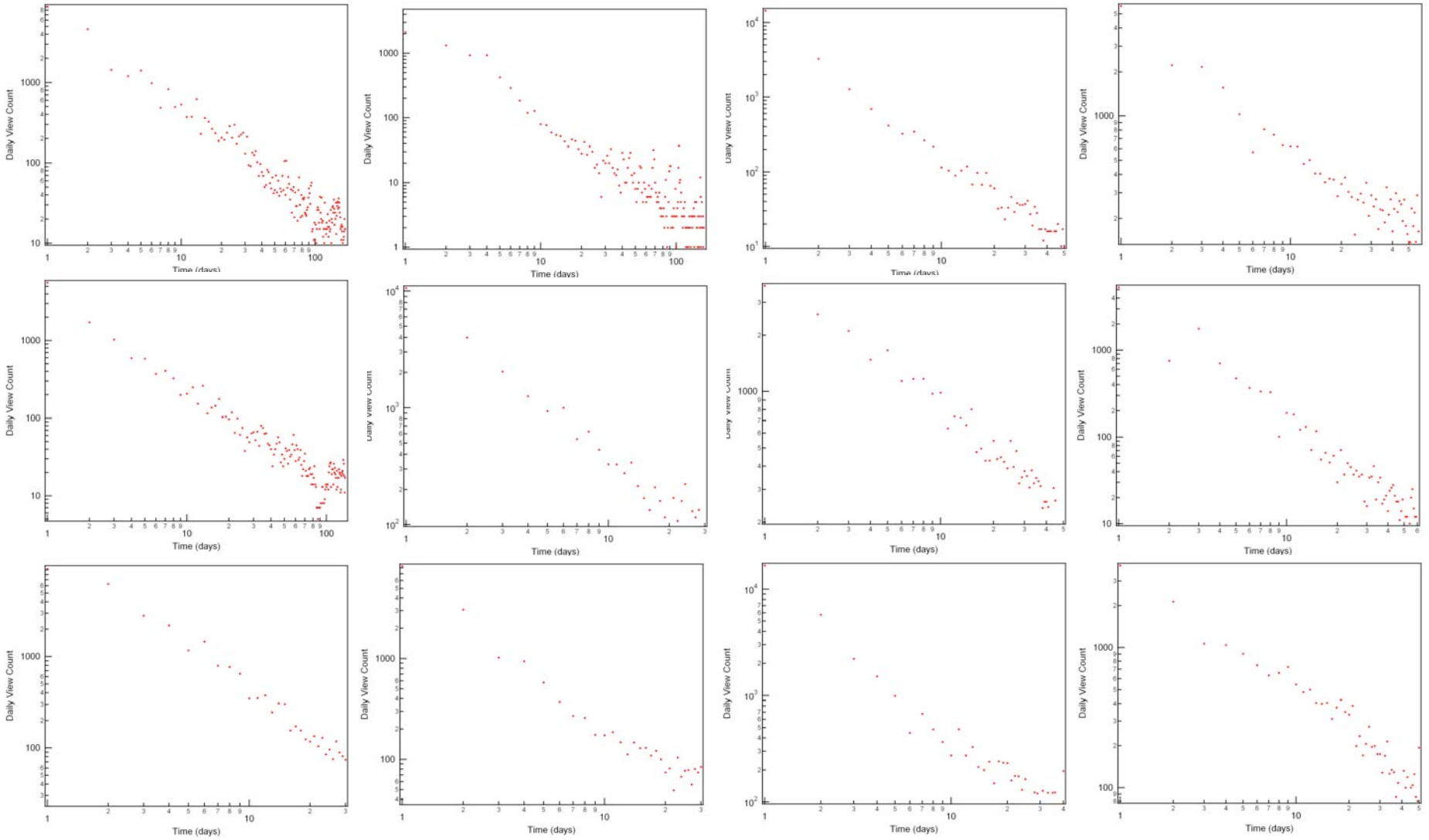


Temporal variation of seismicity

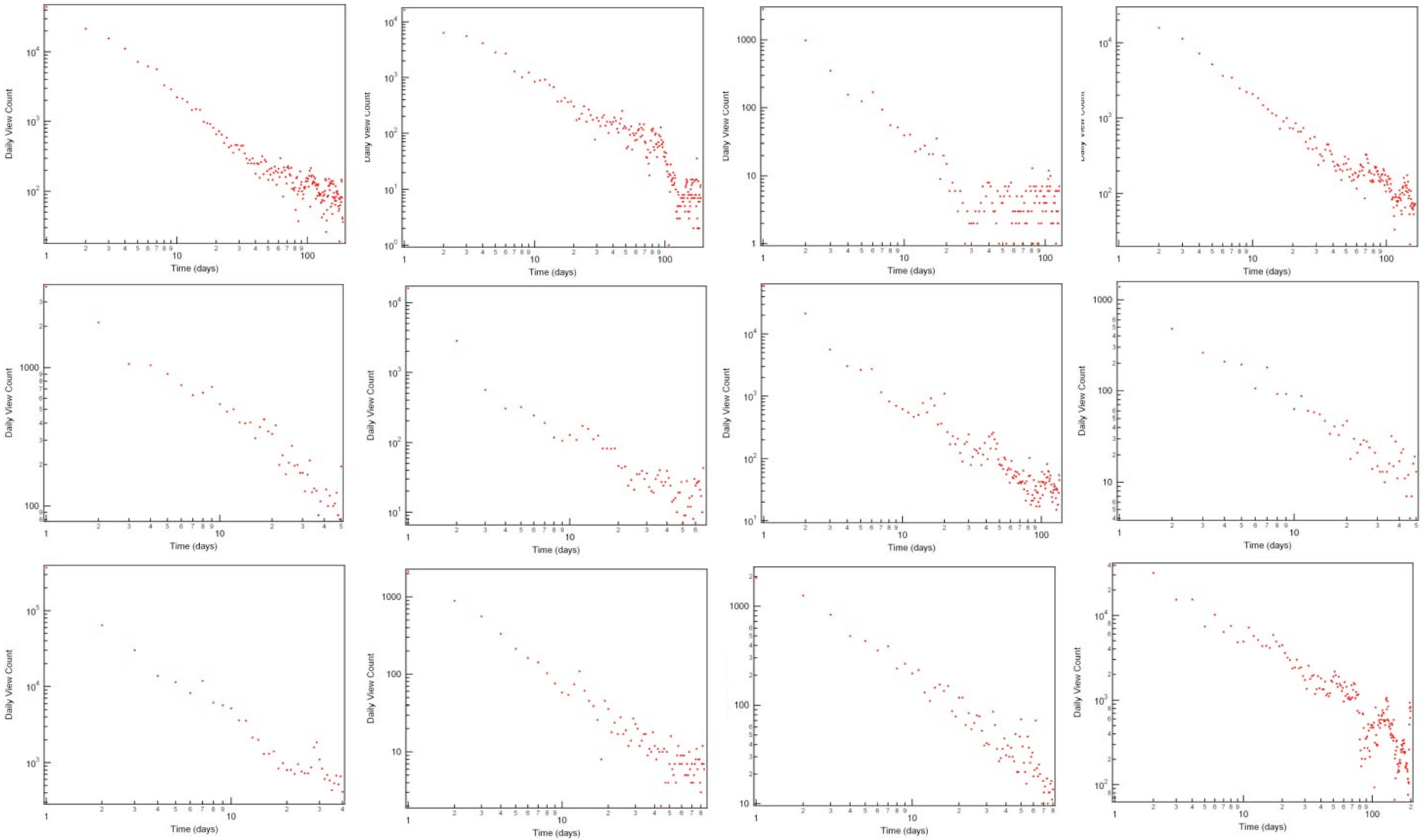
Observations :



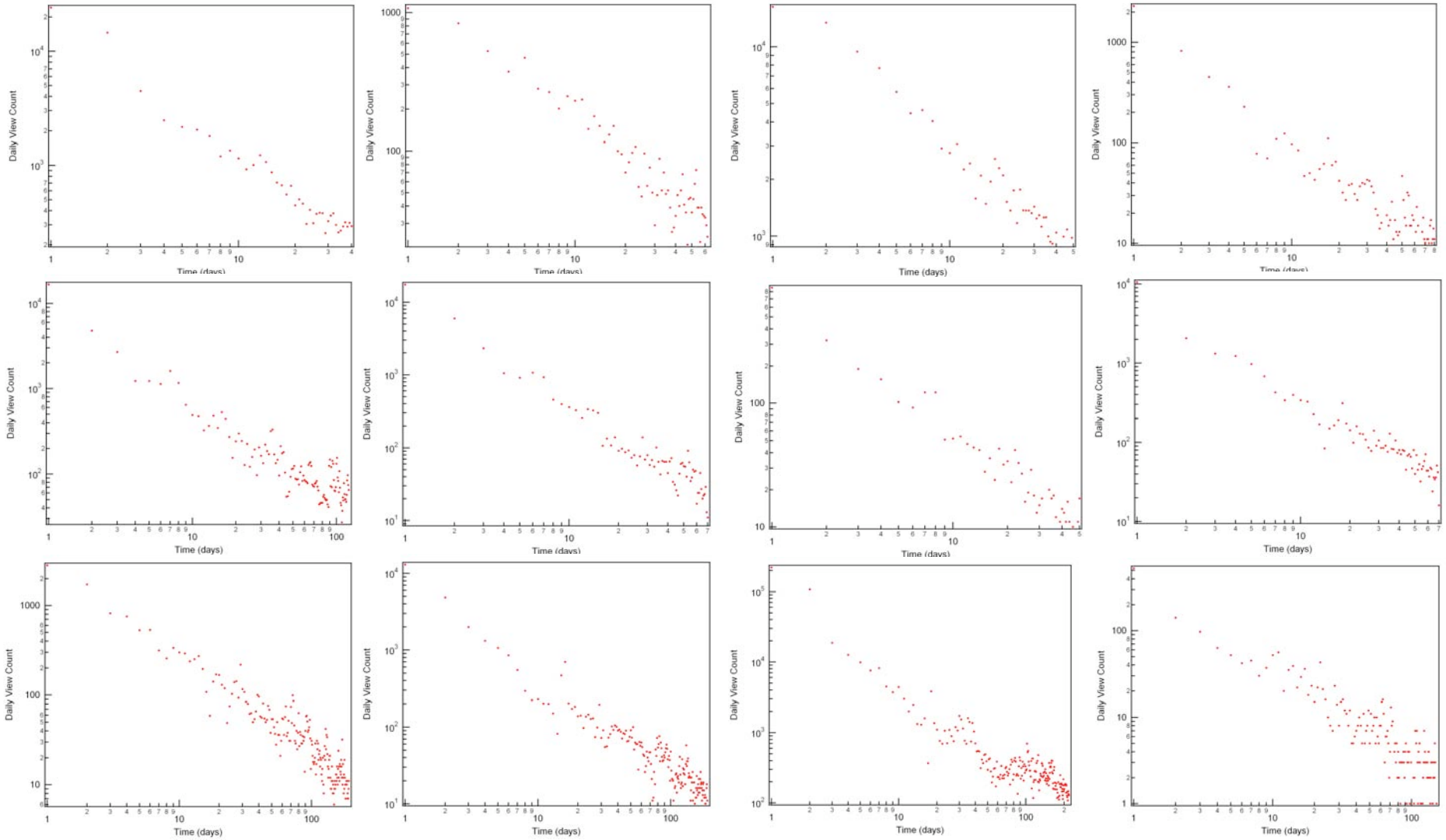
Typical Relaxation Following Peak



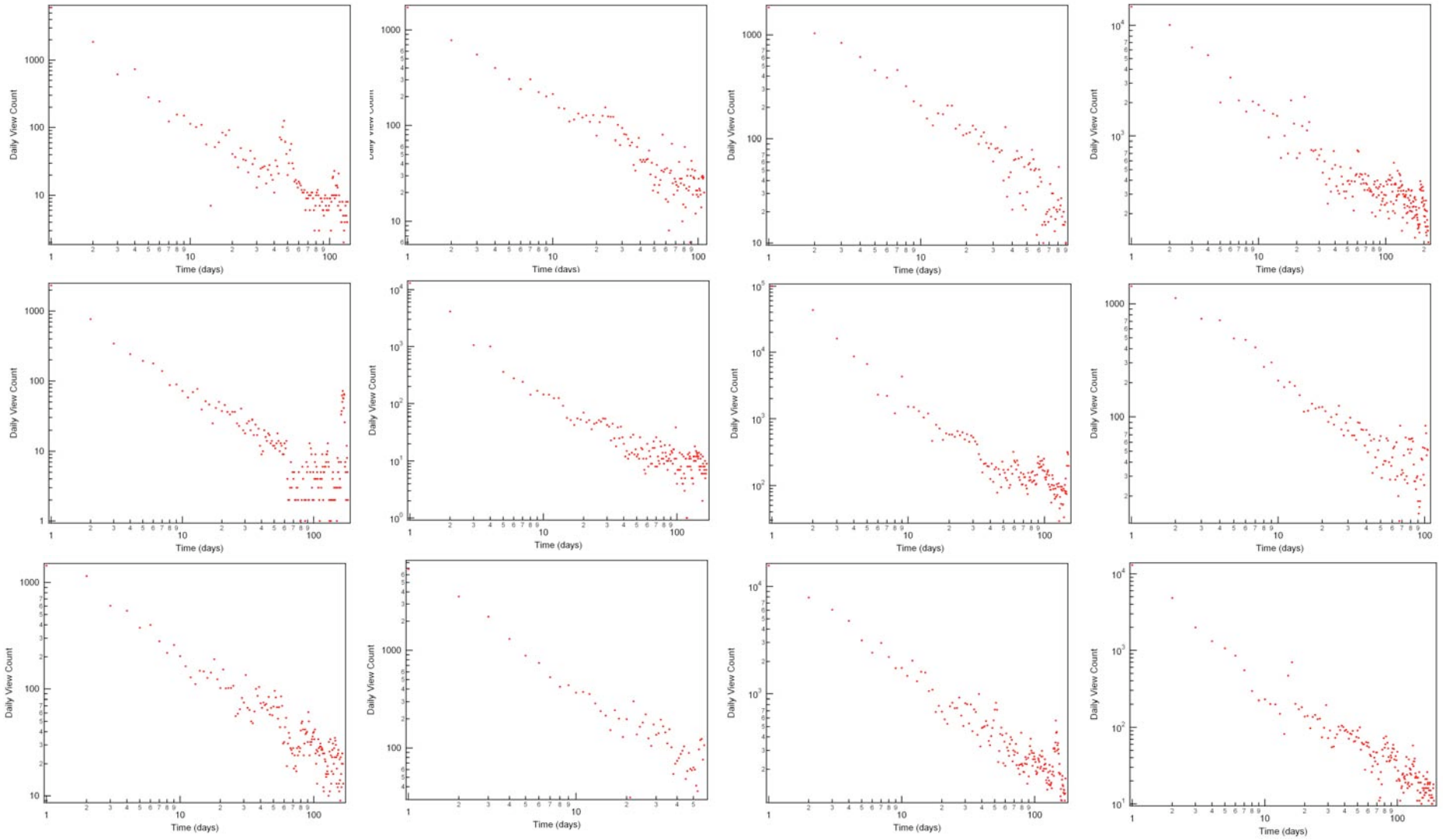
Typical Relaxation Following Peak



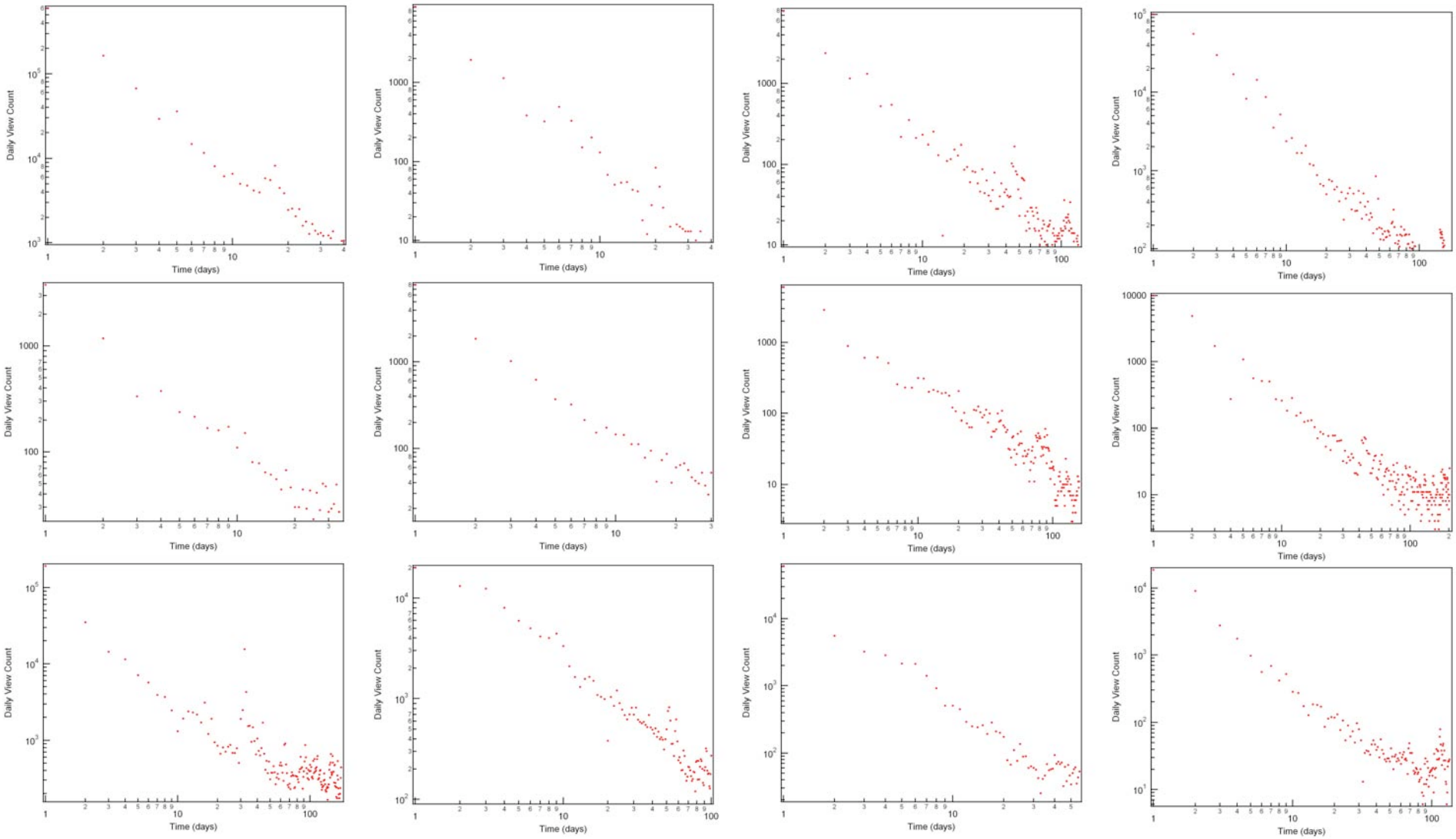
Typical Relaxation Following Peak



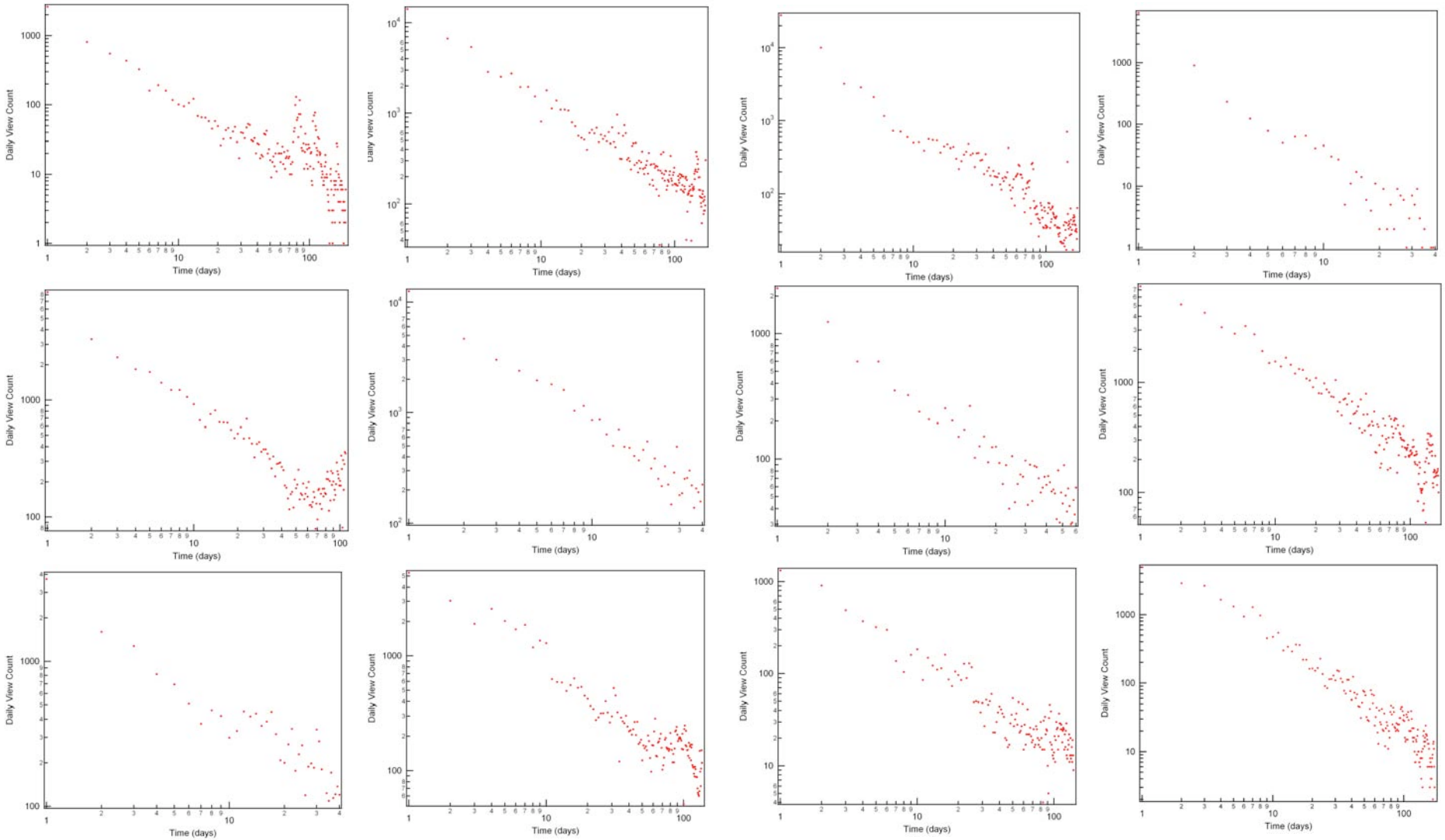
Typical Relaxation Following Peak



Typical Relaxation Following Peak

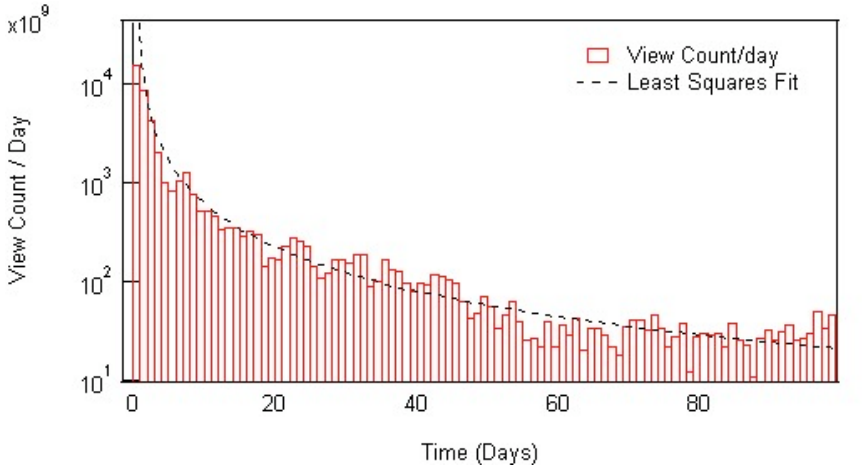


Typical Relaxation Following Peak



Typical Response

Shock: more than 100 views on a single day, and has at least 10 days following this peak. Of the 5 million videos we are tracking, 76% do not receive 100 views on any given day. Furthermore, 15% either don't have 10 days worth of data, or don't have 10 days following a qualified peak. This leaves us with roughly 9% (=421,487 videos).

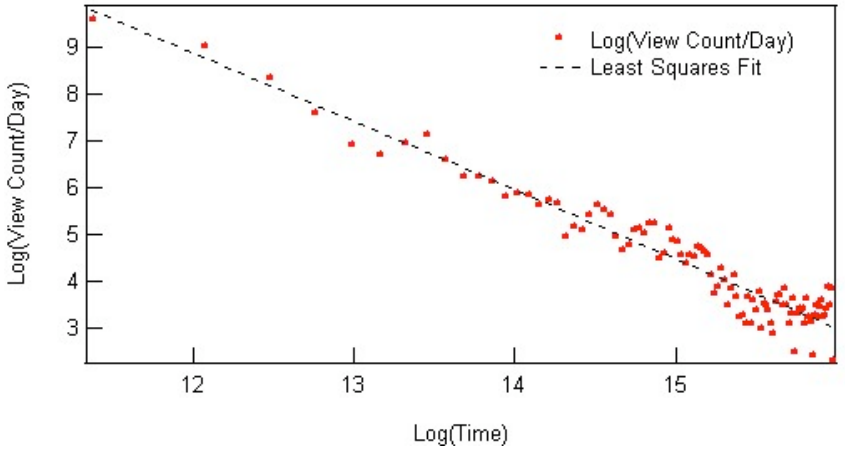


$$\text{View Count per Day} = A(t - t_c)^p$$

A = Amplitude

p = exponent governing decay

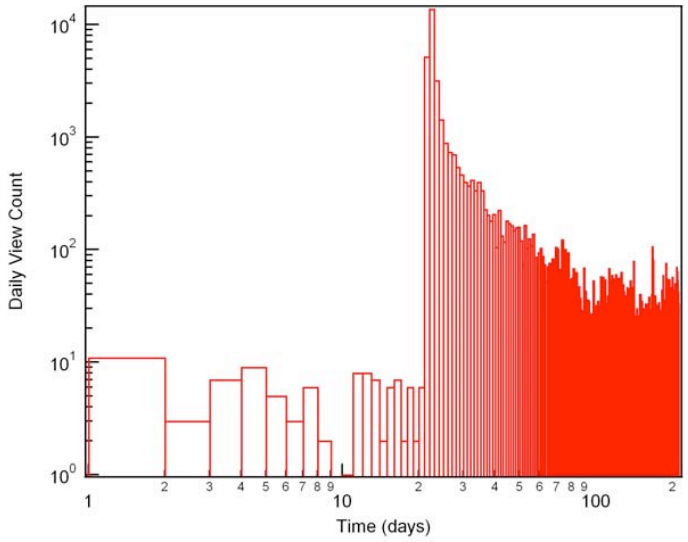
- A Least-Squares Fit is performed on the log-log data over the largest possible range.
- The exponent "p" is extracted



Sorting Out the data: Peak Height Fraction

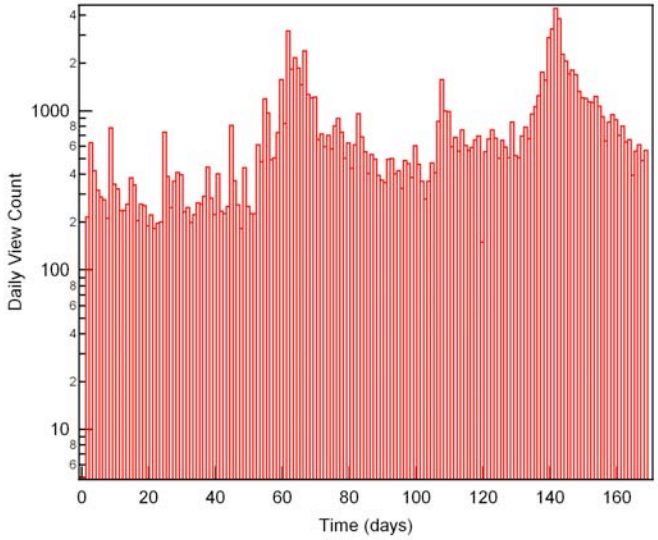
"Not Critical/Exo"

Fraction ~ 40%

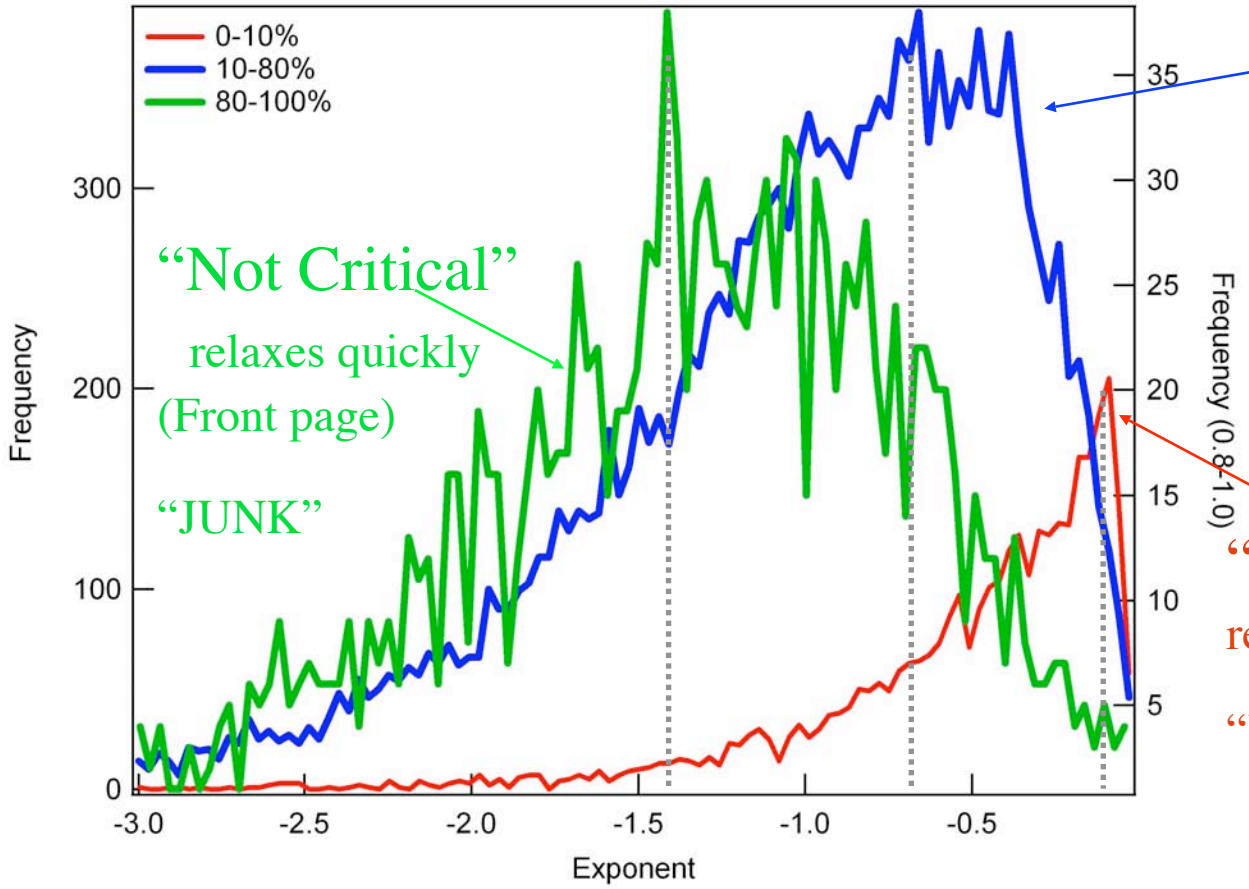


"Critical/Endo"

Fraction ~ 1%



Exponent – Shock as Fraction of Total Peak Height



"Critical"
relaxes slowly
(most viewed)

"QUALITY VIDEOS"

"Not Critical"
relaxes quickly
(Front page)

"JUNK"

"Endogenous"
relaxes more slowly

"VIRAL VIDEOS"

	Endogenous	Exogenous
Foreshock (or growth)	$S(t) \propto \frac{1}{\lvert t \rvert^{1-2\theta}}$	Abrupt peak
Aftershock (or decay)	$S(t) \propto \frac{1}{t^{1-2\theta}}$	$S(t) \propto \frac{1}{t^{1-\theta}}$

Non-critical: $S(t) \propto \frac{1}{t^{1+\theta}}$

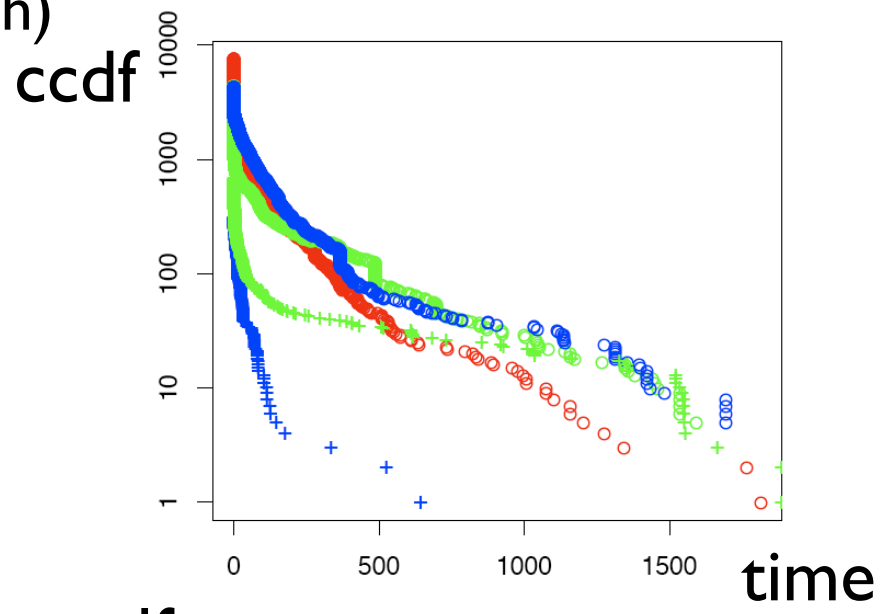
Software vulnerability dynamics

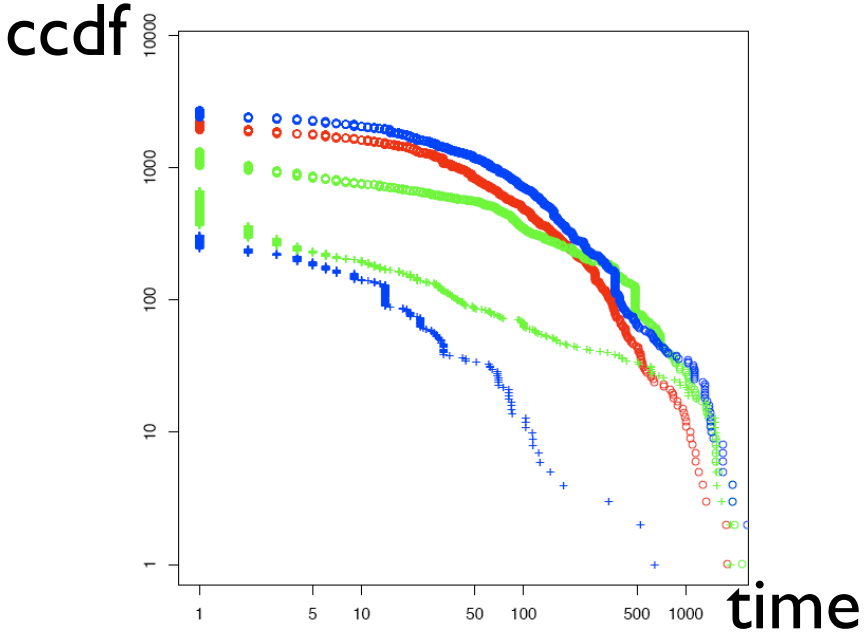
with S. Frei and T. Maillart (ETH Zurich)

- vulnerability process is a good proxy of software resilience to bugs
- we identify 4 steps in vulnerability process:

  1. discovery (red)
  2. exploit (green)
  3. public disclosure (time reference)
  4. patch release (blue)

- exploits and patch can appear before disclosure (crosses) or after (circles)
- once again, response distribution in this process is heavily tailed
- very characteristic is the distribution of exploits (before disclosure, green crosses) which shows some patterns of power-law with phase transition, in lower tail





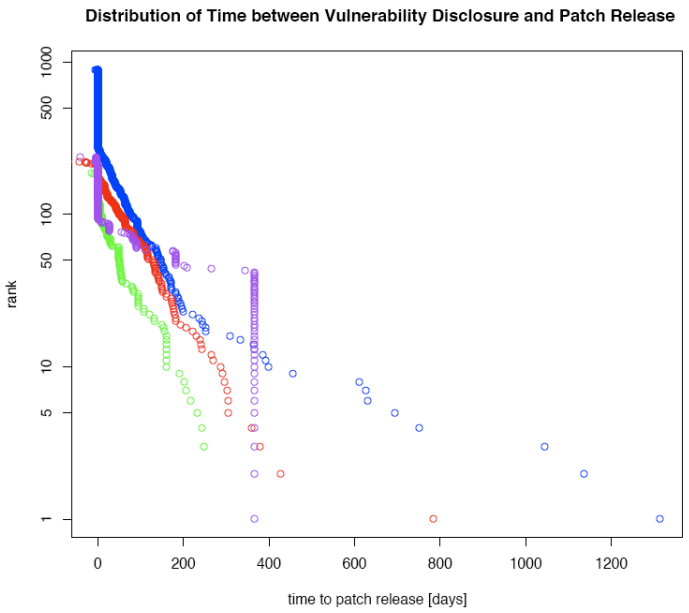
Software vulnerability dynamics

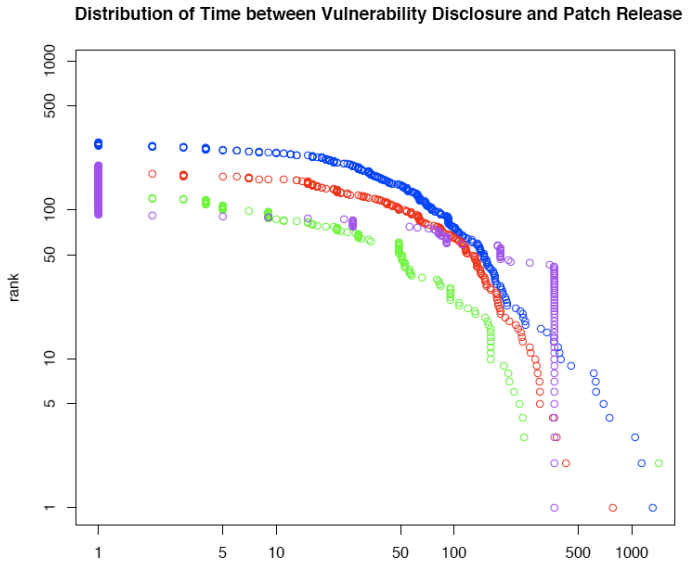
- Here we show comparison between types of softwares:

  - Microsoft (blue)
  - Linux (red)
  - Oracle (purple)
  - Mozilla (green)

- We can see that time to patch distribution is also heavily tailed.

- While it varies differently according to considered software the allure remains somehow the similar, especially when we consider Microsoft (blue) and Linux (red).





Application to conflict early warning

with P. Meier (Tufts Univ., Boston) and R. Woodard (BAS, Cambridge, UK)

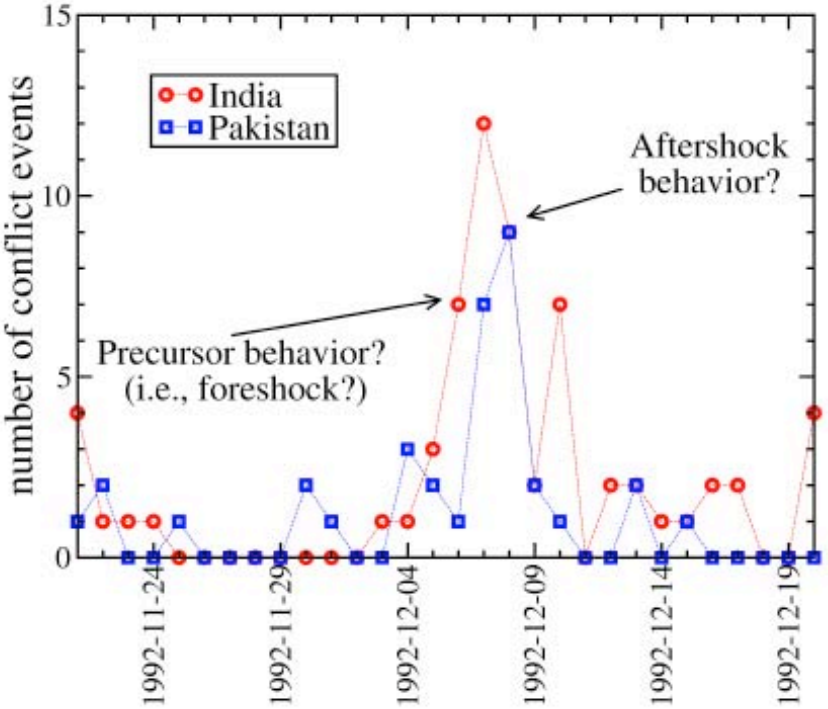
- Data extracted using Virtual Research Associates, Inc. (VRA) Reader `http://www.vranet.com`
- Software parses Reuters Business Briefing newswire
- Database of *source* and *target* actors, *type of event*
- 157 event types, 'all' countries, aggregated into *conflict* and *cooperation* time series, 1990-2005

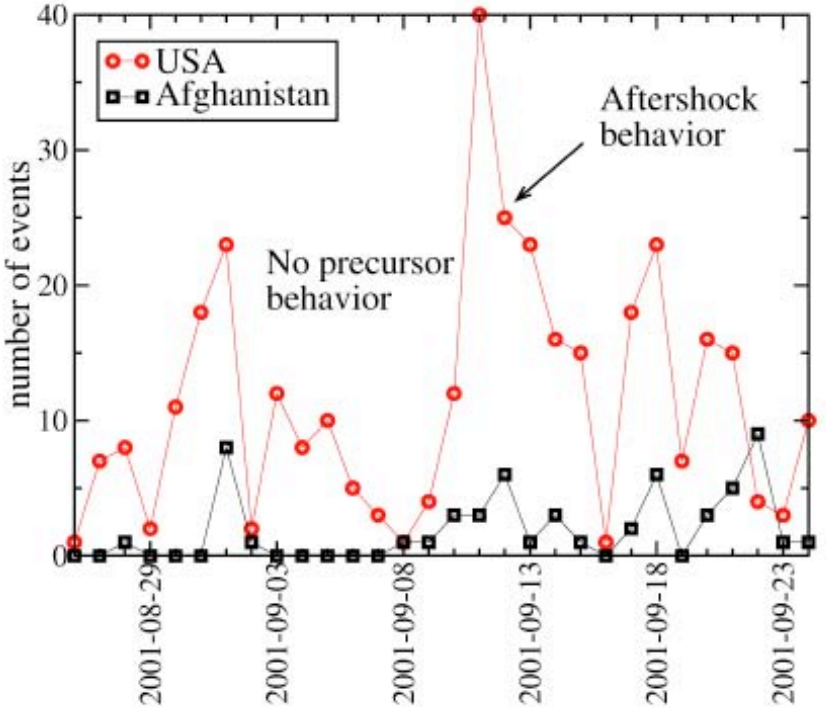
24 conflict event types

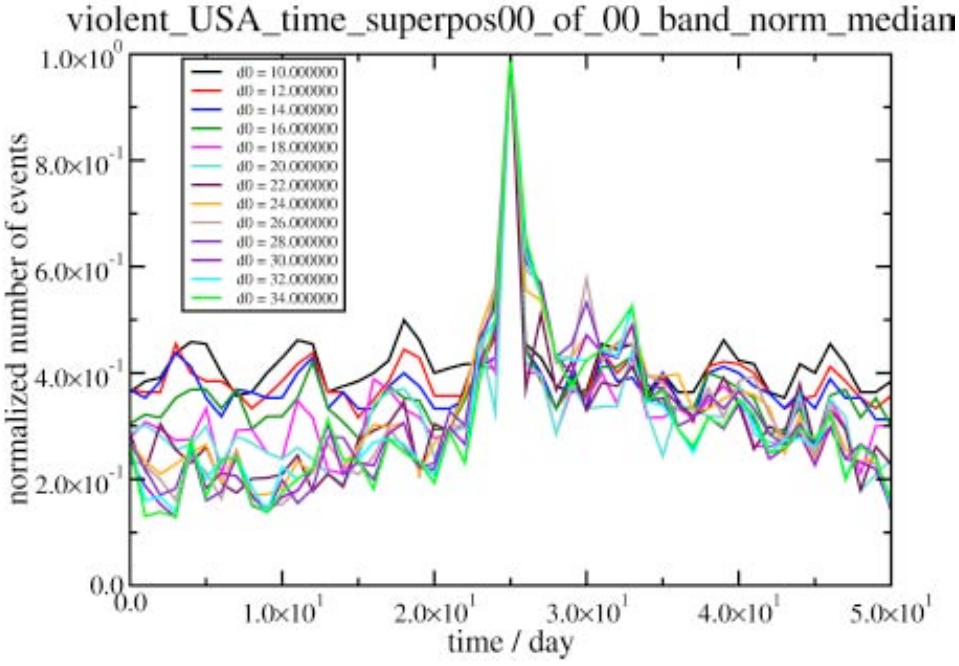
Abduction	Armed actions
Armed battle	Arrest and detention
Artillery attack	Assassination
Beatings	Bodily punishment
Coups and mutinies	Criminal arrests
Crowd control	Force use
Hijacking	Hostage and kidnapping
Mine explosion	Missile attack
Physical assault	Political arrests
Riot	Sexual assault
Small arms attack	Suicide bombing
Torture	Vehicle bombing

27 cooperation event types.

Acknow. respons.	Agree to mediation
Agree to negotiate	Agree to peacekeeping
Agree to settlement	Apologize
Collaborate	Demobilize armed forces
Ease sanctions	Empathize
Engage in negotiation	Evacuate victims
Forgive	Grant asylum
Host a meeting	Improve relations
Mediate talks	Observe truce
Offer peace proposal	Offer to Negotiate
Offer to mediate	Promise to mediate
Provide shelter	Relax curfew
Request mediation	Request withdrawal or ceasefire
Travel to meet	

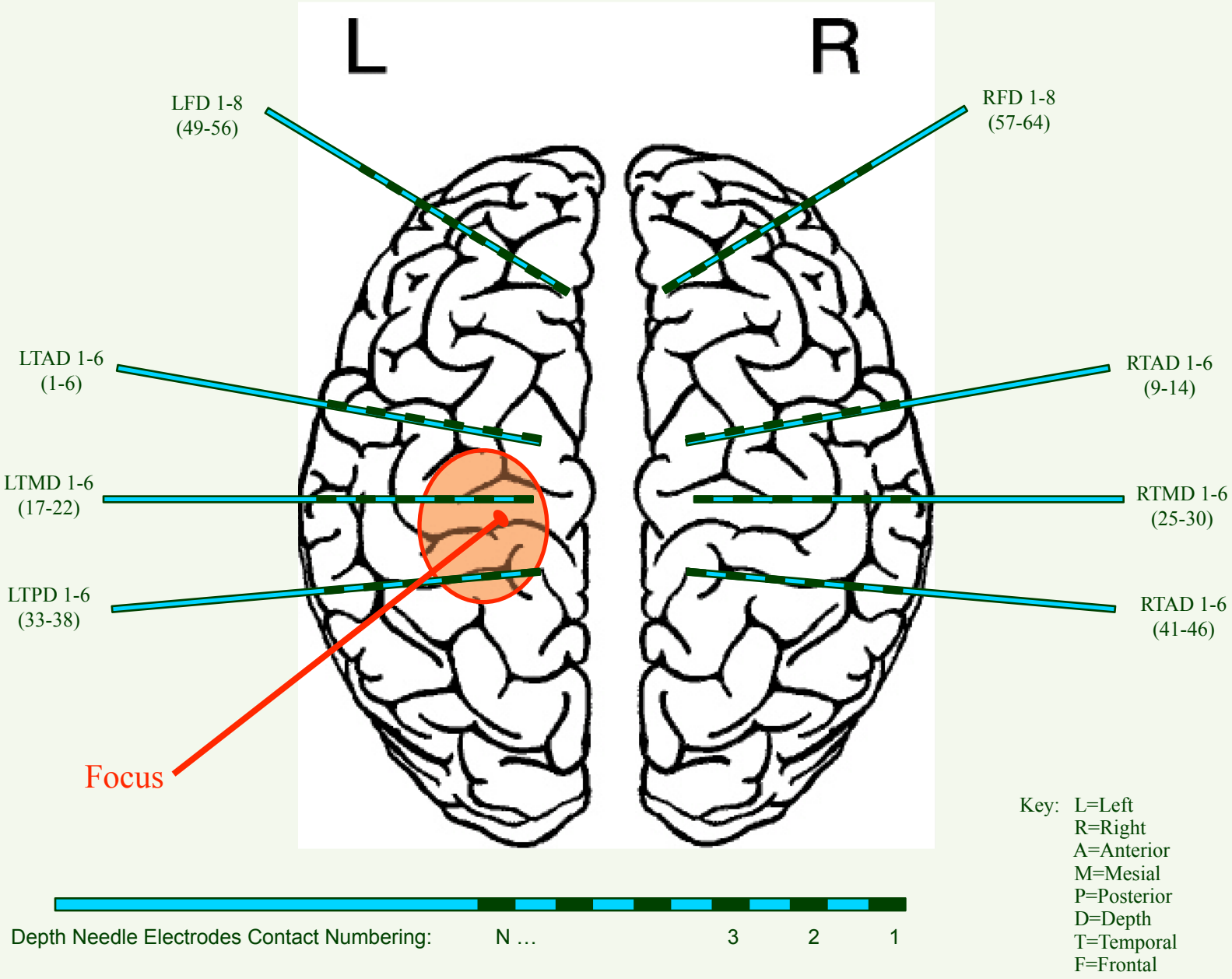

India
Pakistan
Aftershock behavior?
Precursor behavior? (i.e., foreshock?)
number of conflict events
0
5
10
15
1992-11-24
1992-11-29
1992-12-04
1992-12-09
1992-12-14
1992-12-19


USA
Afghanistan
Aftershock behavior
No precursor behavior
number of events
0
10
20
30
40
2001-08-29
2001-09-03
2001-09-08
2001-09-13
2001-09-18
2001-09-23

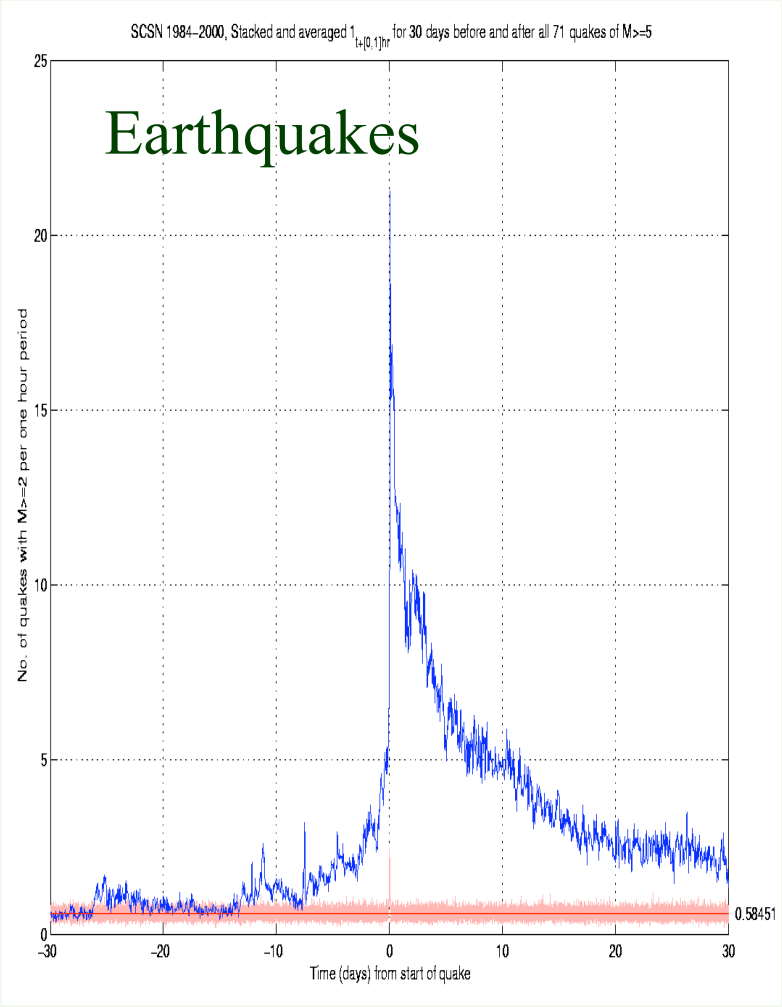

violent_USA_time_superpos00_of_00_band_norm_median
d0 = 10.000000
d0 = 12.000000
d0 = 14.000000
d0 = 16.000000
d0 = 18.000000
d0 = 20.000000
d0 = 22.000000
d0 = 24.000000
d0 = 26.000000
d0 = 28.000000
d0 = 30.000000
d0 = 32.000000
d0 = 34.000000
normalized number of events
0.0
2.0×10^-1
4.0×10^-1
6.0×10^-1
8.0×10^-1
1.0×10^0
0.0
1.0×10^1
2.0×10^1
3.0×10^1
4.0×10^1
5.0×10^1
time / day

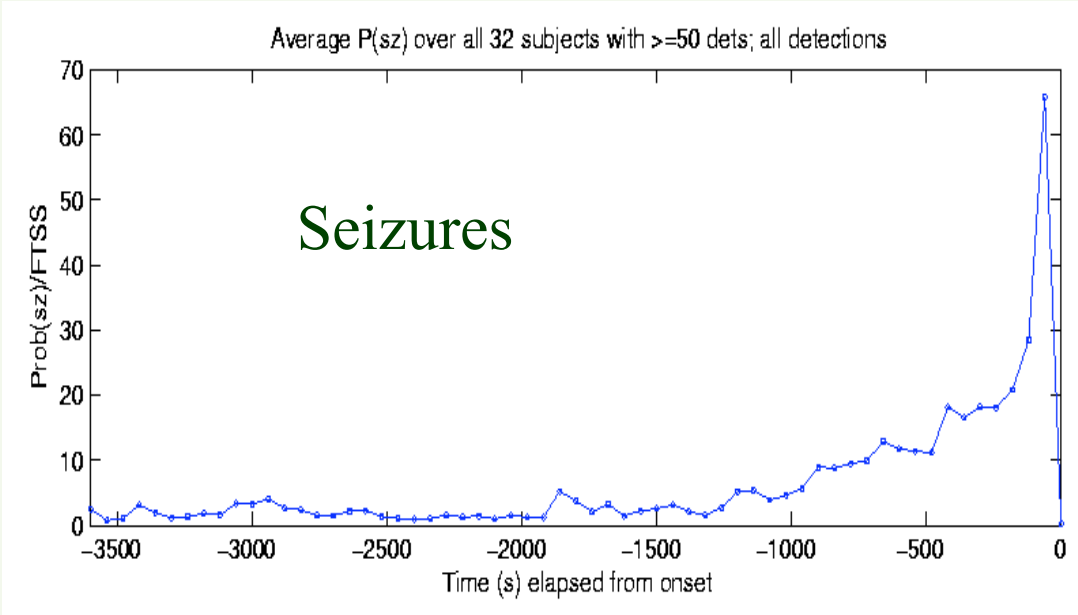
Seizures – Quakes of the Brain?

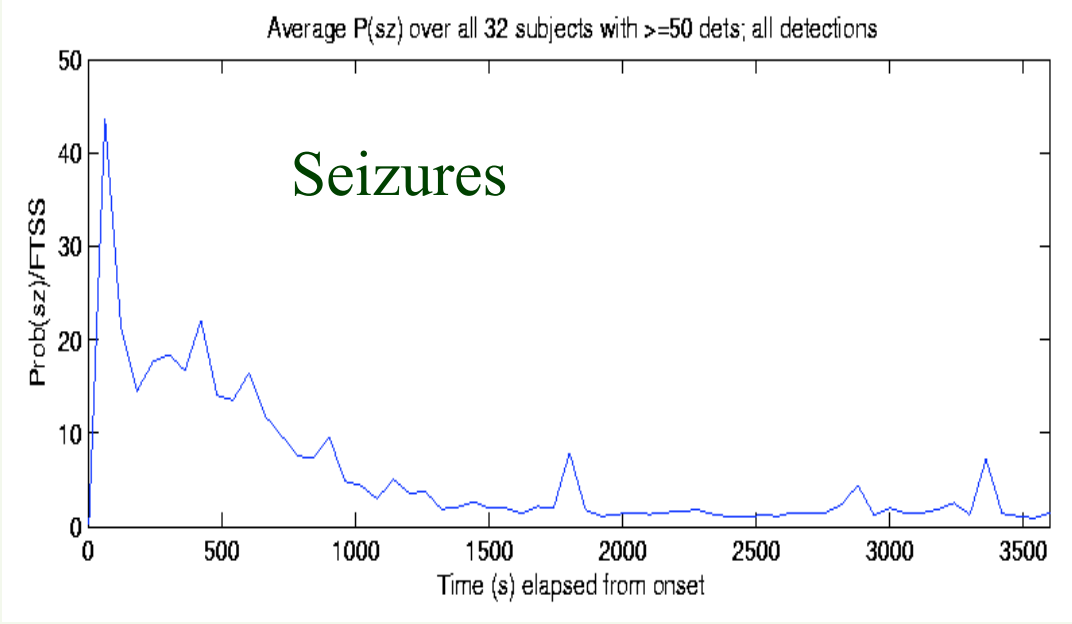
with Ivan Osorio – KUMC & FHS
Mark G. Frei - FHS

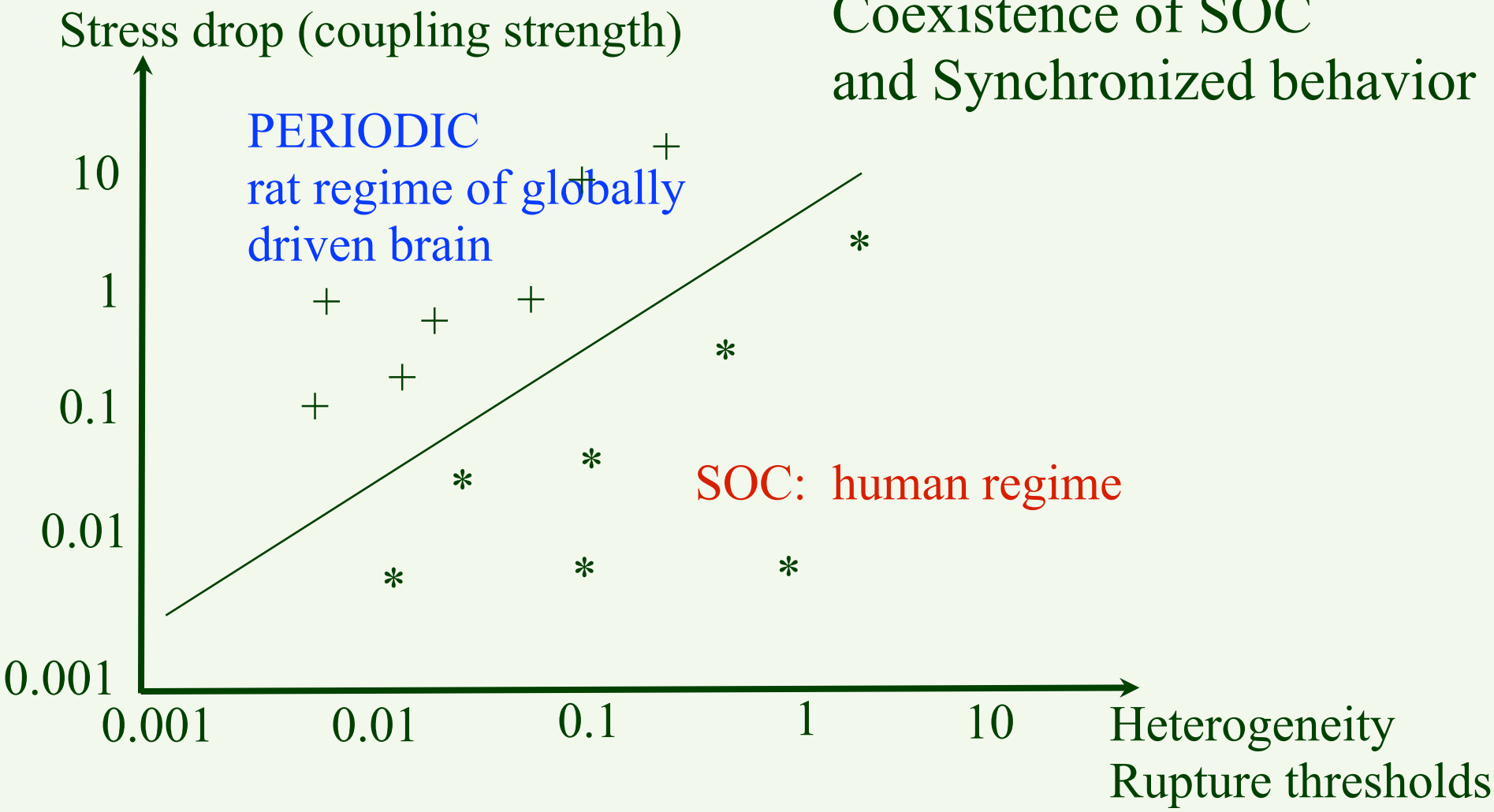


Omori: Direct and Inverse









"Phase diagram" for the model in the space (heterogeneity, stress drop).
Crosses (+) correspond to systems which exhibit a periodic time evolution.
Stars * corresponds to systems that are self-organized critical, with a Gutenberg-Richter earthquake size distribution and fault localization whose geometry is well-described by the geometry of random directed polymers.

Endogenous versus Exogenous

Extinctions
- -meteorite at the Cretaceous/Tertiary KT boundary
- -volcanic eruptions (Deccan traps)
- -self-organized critical events

Discoveries
- -serendipity
- -maturation

Financial crashes
- -external shock
- -self-organized instability

Volatility bursts in financial time series
- -external shock
- -cumulative effect of "small" news

Earthquakes
- -tectonic driving
- -triggering

Immune system
- -external viral or bacterial attack
- - " internal" (dis-)organization

Parturition
- -mother/foetus triggered?
- -mother-foetus complex?

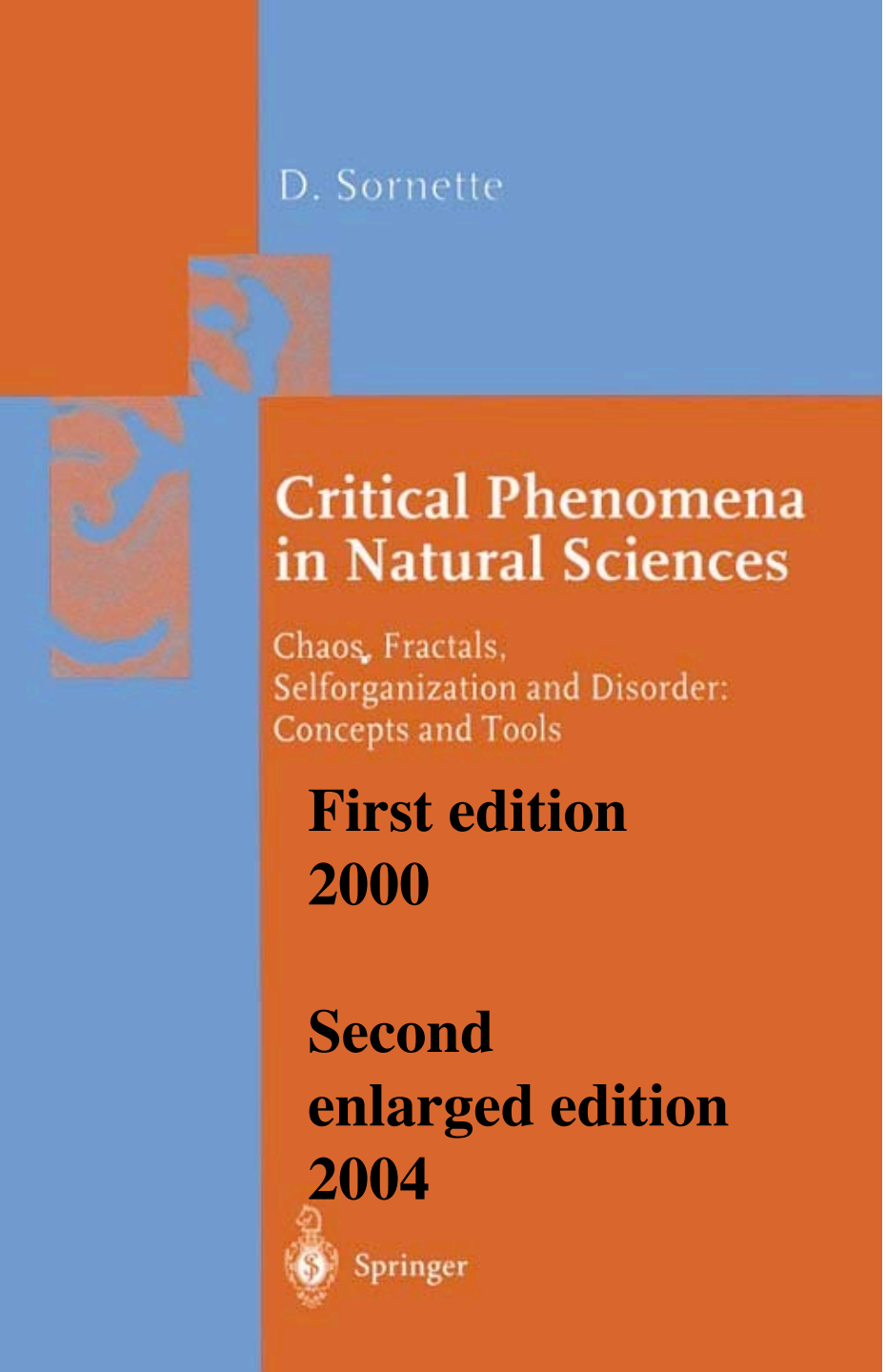
Brain (learning)
- -external inputs
- -internal self-organization and reinforcements (role of sleep)

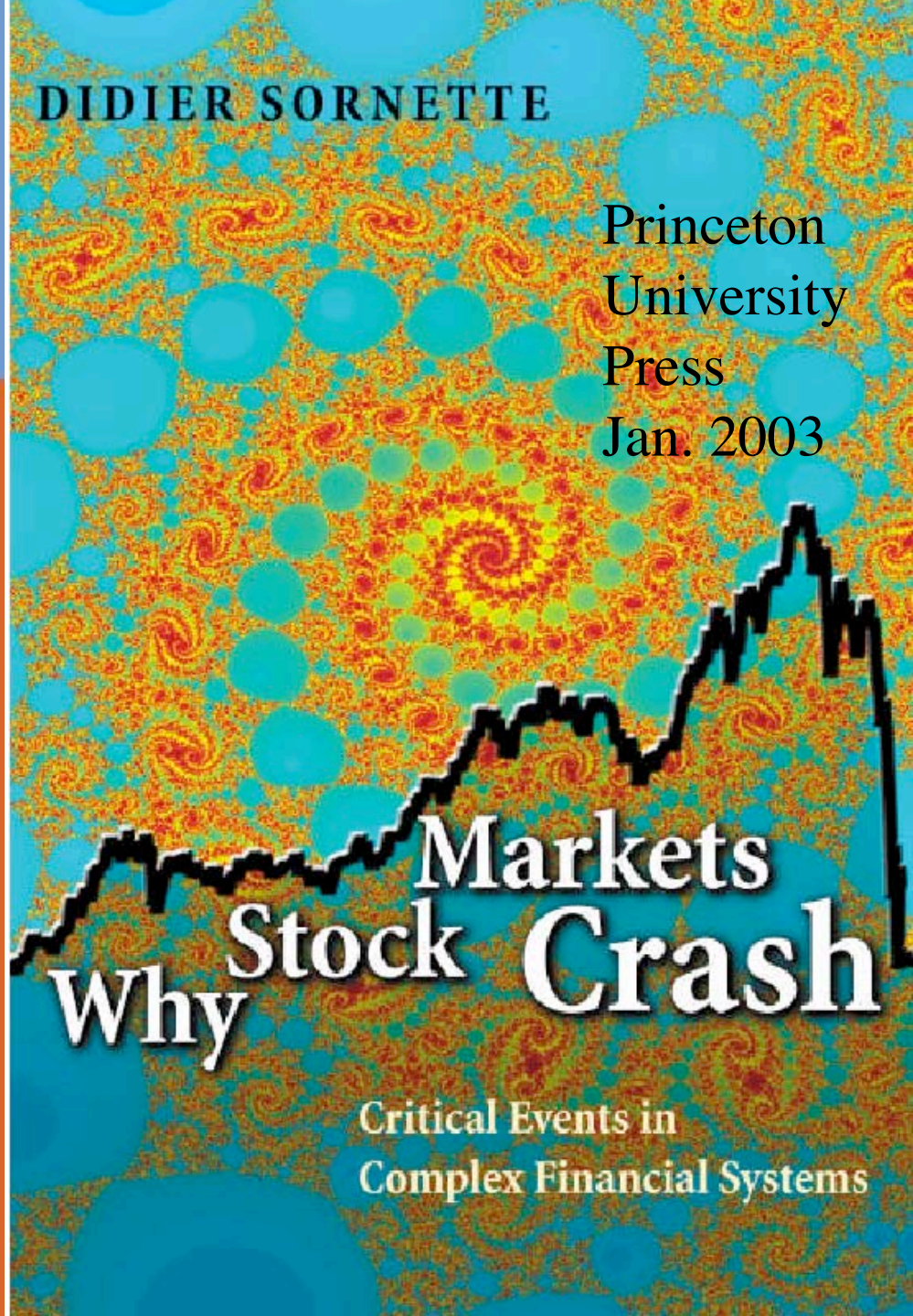
Aviation industry recession
- -September 11, 2001
- -structural endogenous problems

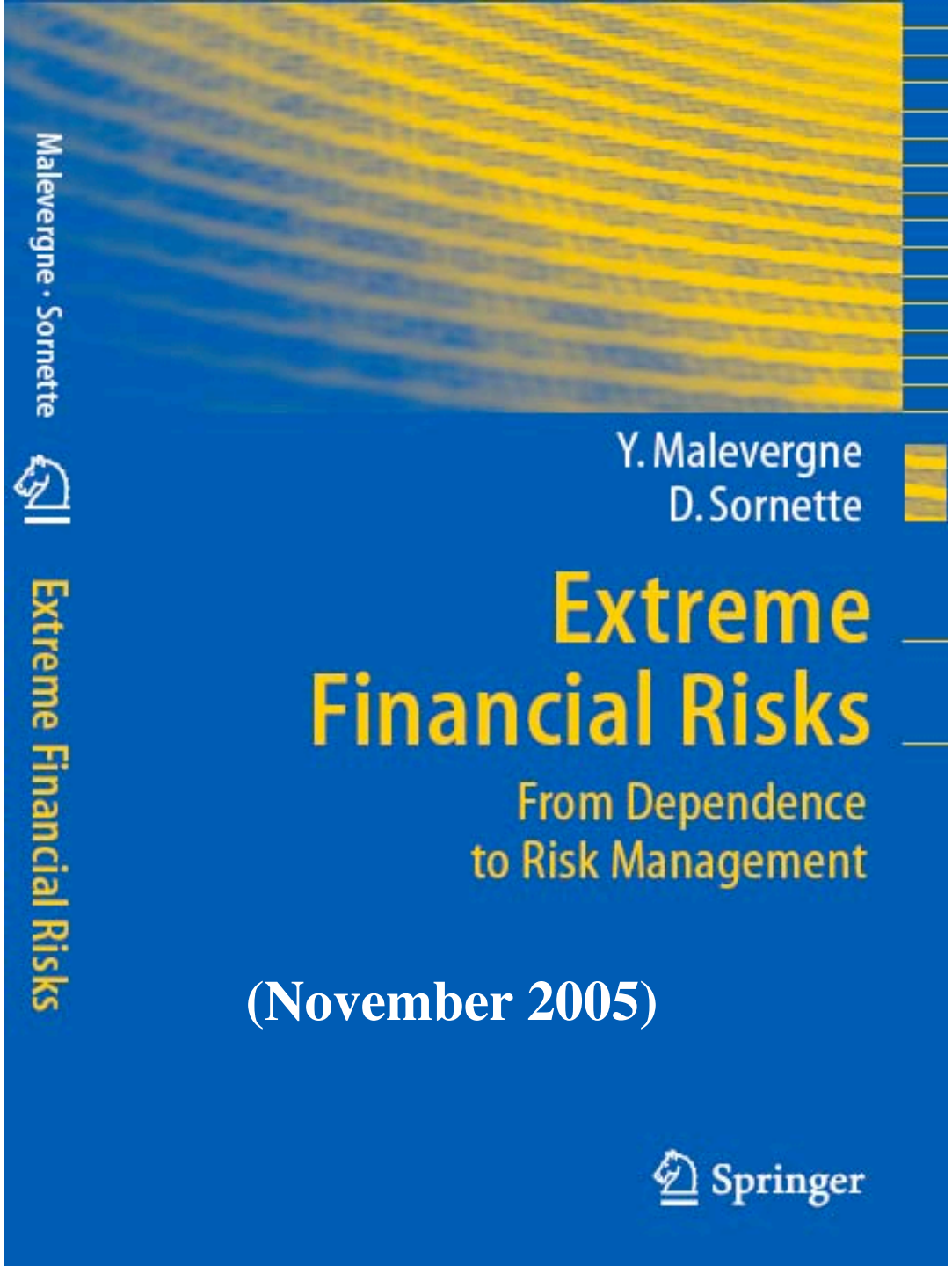
Commercial success and sales
- -Ads
- -epidemic network

Recovery after wars?
- -internally generated (civil wars)
- -externally generated

Social unrests
- -triggering factors
- -rotting of social tissue


D. Sornette
Critical Phenomena in Natural Sciences
Chaos, Fractals, Selforganization and Disorder: Concepts and Tools
First edition 2000
Second enlarged edition 2004
Springer


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



Y. Malevergne
D. Sornette

Extreme Financial Risks

From Dependence to Risk Management

(November 2005)