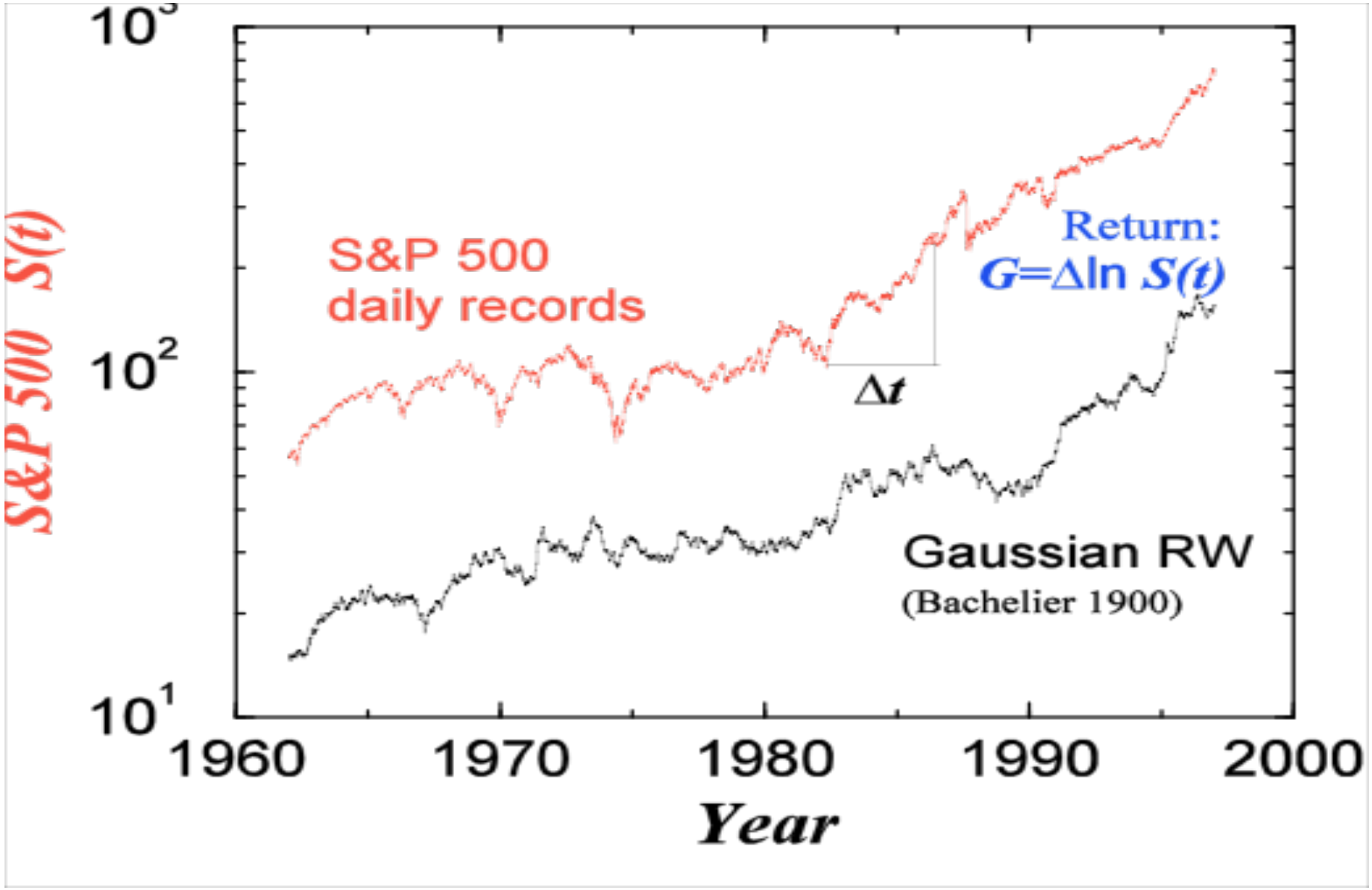
Can physicists contribute to economics/finance?

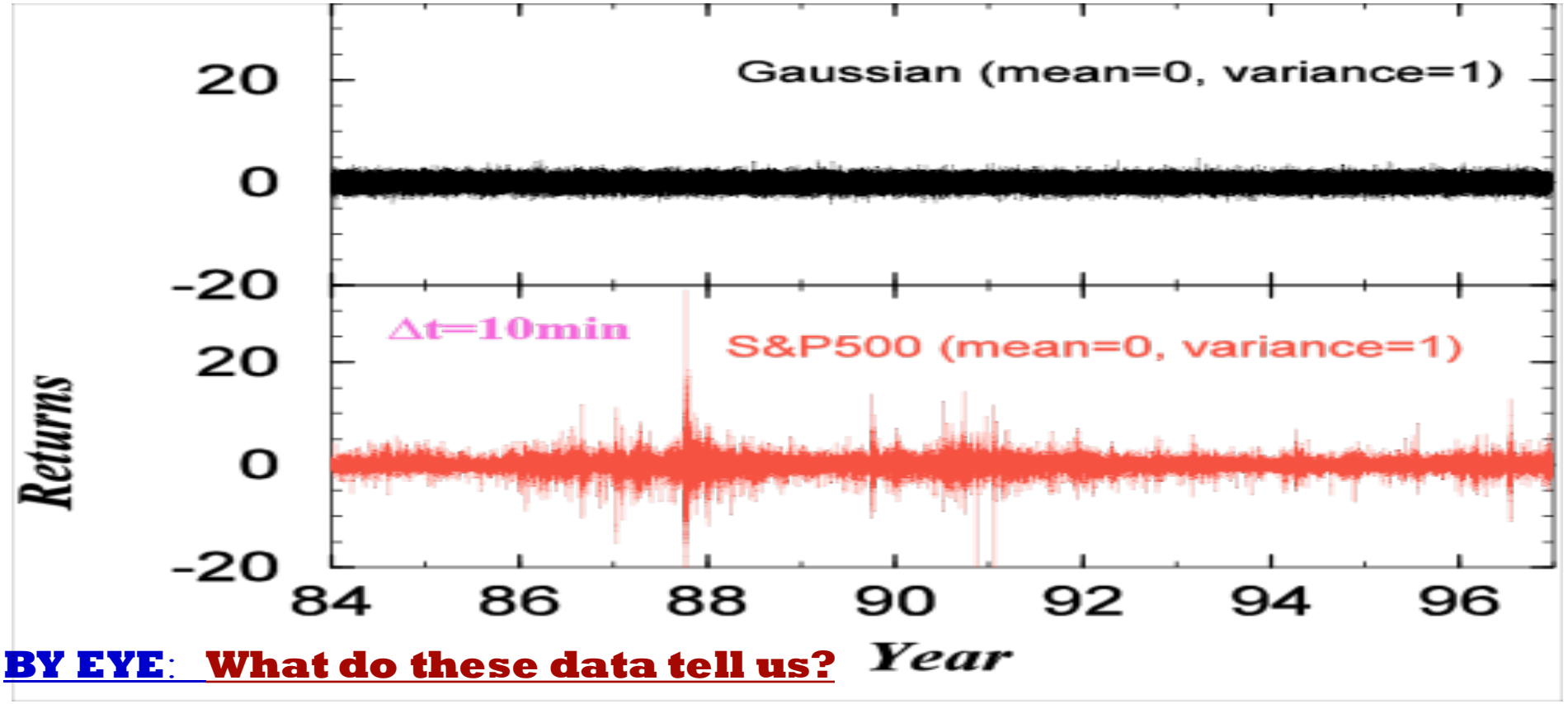
- get an economics partner...& respect him/her!
- get as much data as exists ("big data")
- ask "What are these data telling us?"
- to find out, quantify each finding...
- Do not be too timid: e.g., Aggregate, ...
- try to relate all findings (ex: price, volume, intertrade times, volatility,...)
- Make "model" relating all facts **("cheating"?)**

Dedication: TINBERGEN/EHRENFEST the first econophysicists?

THE PUZZLE: "SWITCHING WITHOUT SWITCHES"



"Big switch" : 19 Oct. 1987 (25% worldwide "earthquake/tsunami")



BY EYE: **What do these data tell us?**

Q: can your **eye** see the power law? that it is inverse cubic?

Returns non-Gaussian (known qualitatively, but under-appreciated!)

Large events cluster (like earthquakes) (also known qualitatively)

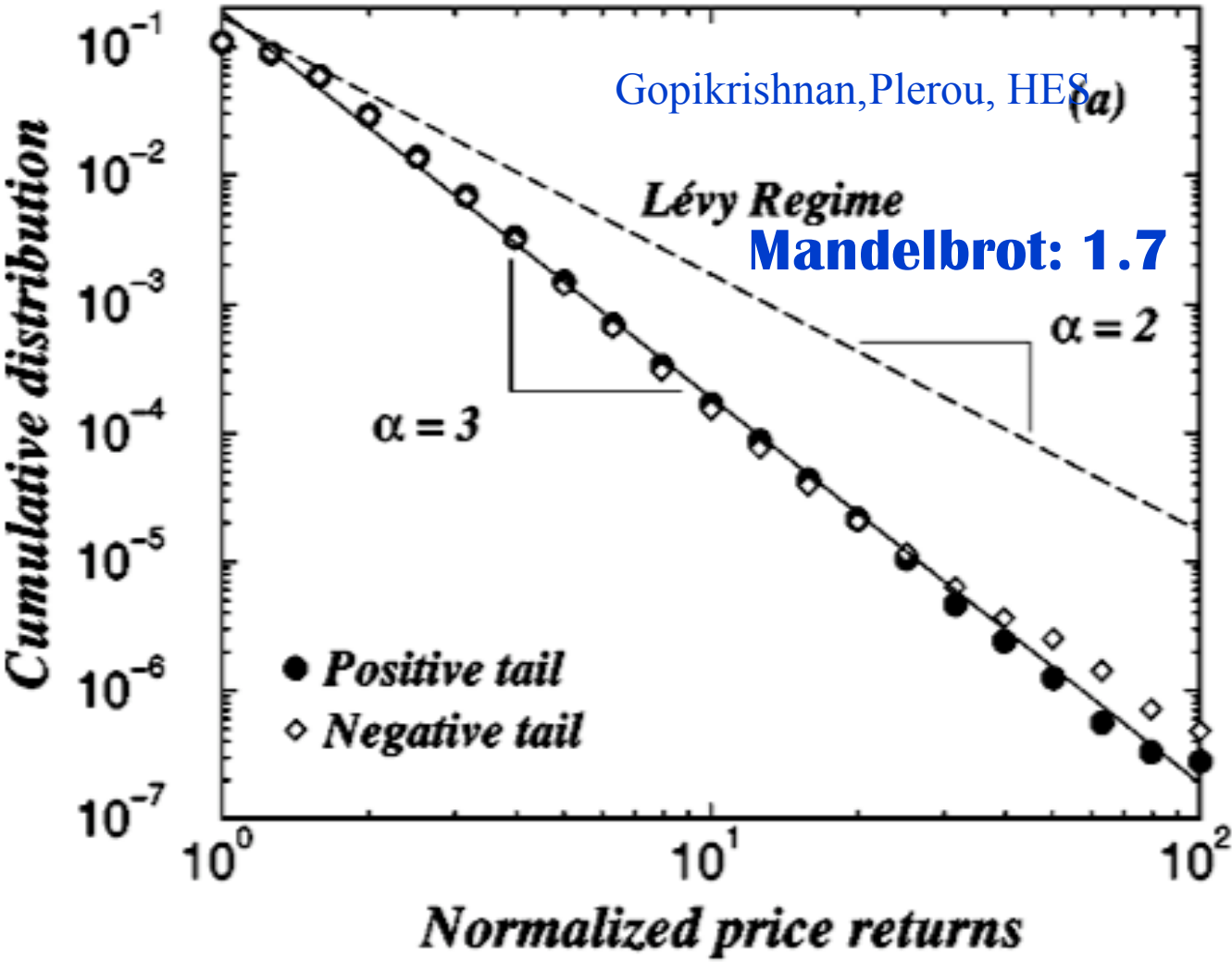
"Aftershocks" Omori-correlated (Palermo 03; BU 07)

"Aftershocks of each aftershock" also Omori-correlated: (BU)

holds over **6** orders of magnitude on y-axis (**8** for pdf: inverse quartic)

200,000 data points per stock **X** 1000 stocks = **200,000,000** data points

events 8 orders of magnitude MORE RARE than everyday values conform to the SAME pdf Gutenberg-Richter earthquake law: mag = 7 quake **same** law as mag = 1 quake



Note: there is NOT a perfect power law due to corrections at both ends of a power law region, just as for power laws in turbulence.

The Economist

"How?" "Models?": Herd vs. News?

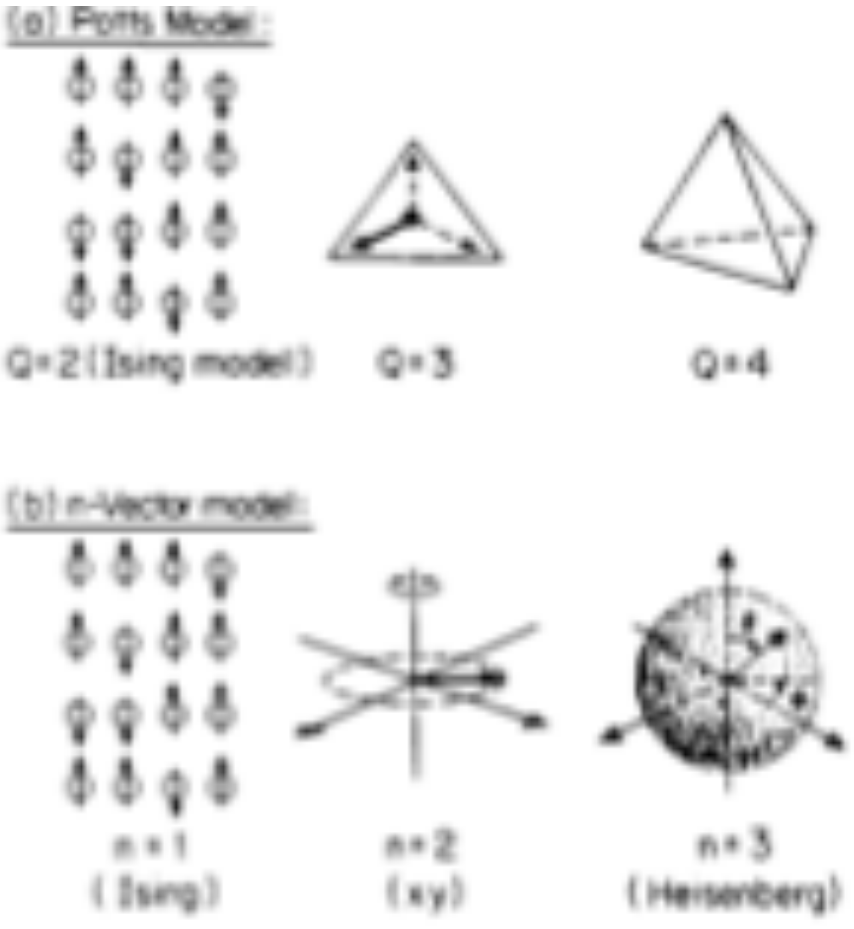
(1) "herd effect" (exchange int. J). (2) news effect (external field H)

Each stock is a unit, interacting with other stocks (units) and bathed in a magnetic field H.
J depends on the two stocks, and H depends on the stock. Both can change with time.

Possible models:
(a) Units can be in Q different DISCRETE states: "Potts Model" (Potts 1952).

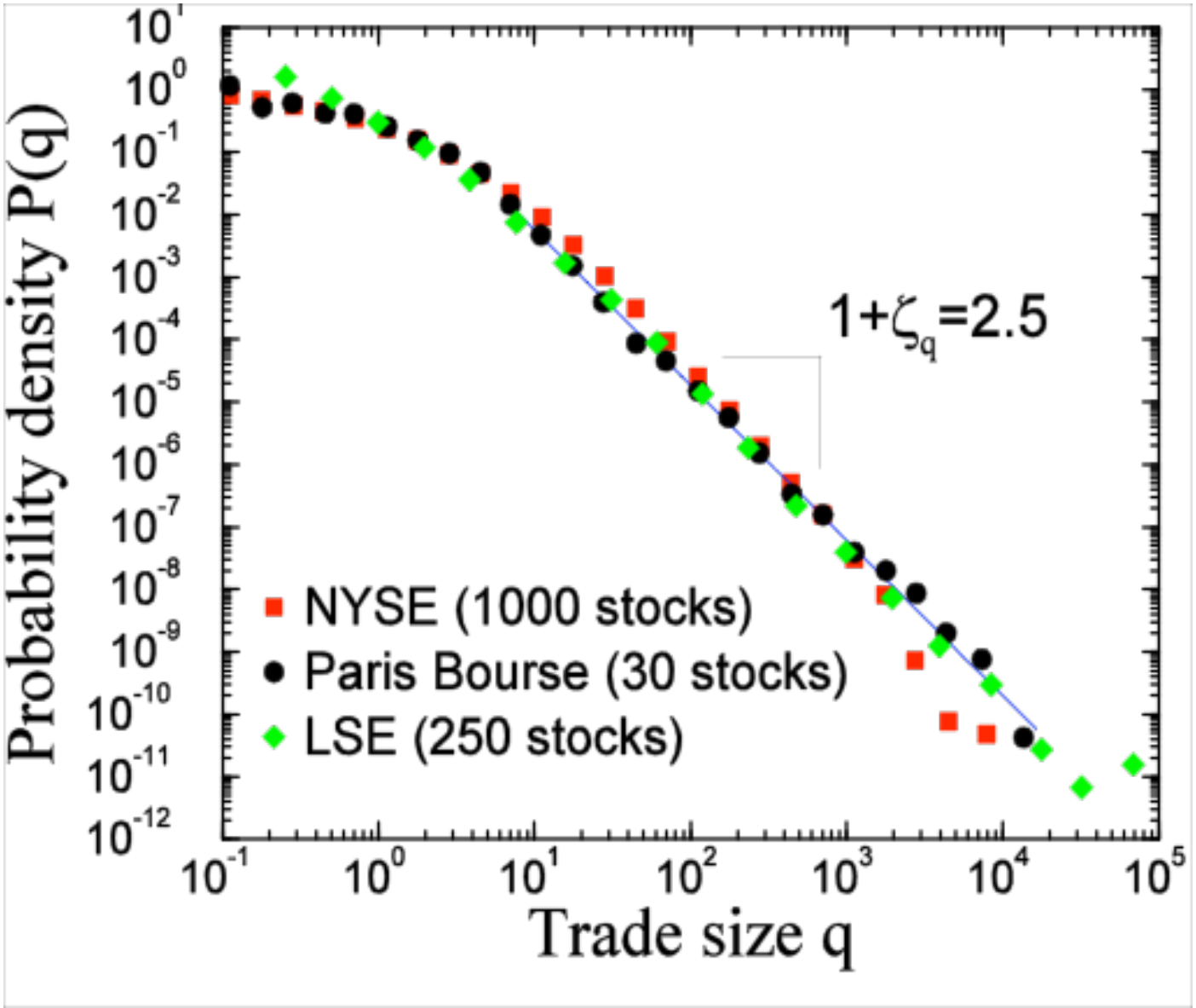
(b) n-dimensional units. Each can be in a CONTINUUM of states: "n-Vector Model" (HES 1969)

(c) modified Edwards-Anderson "spin glass" (w/ t-dep interactions)



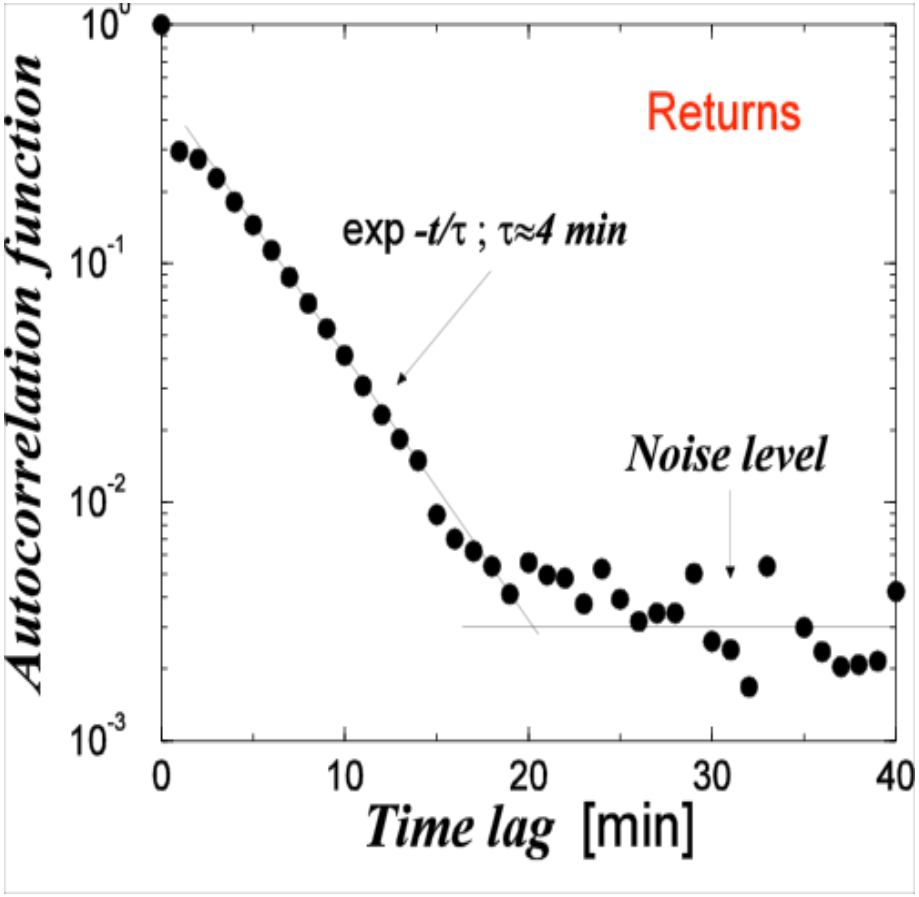
TEST #1: if interacting system of subunits, should be "universality"

DATA Show: power-law exponents are Universal (indep of time period, country, volatility (ex 1987,2008,.. same!). implies what??



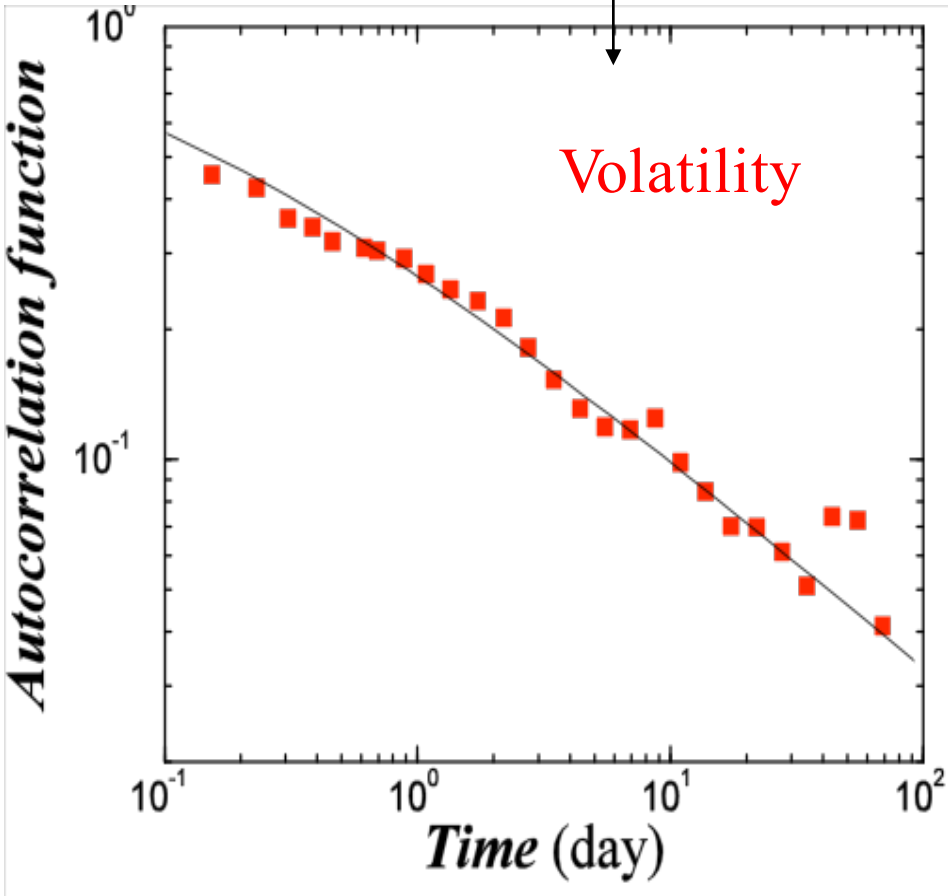
Test 2: Are there time Correlations?

((economists knew these results, qualitatively, as volatility clustering....so calculate autocorrelation function and get a "law"))

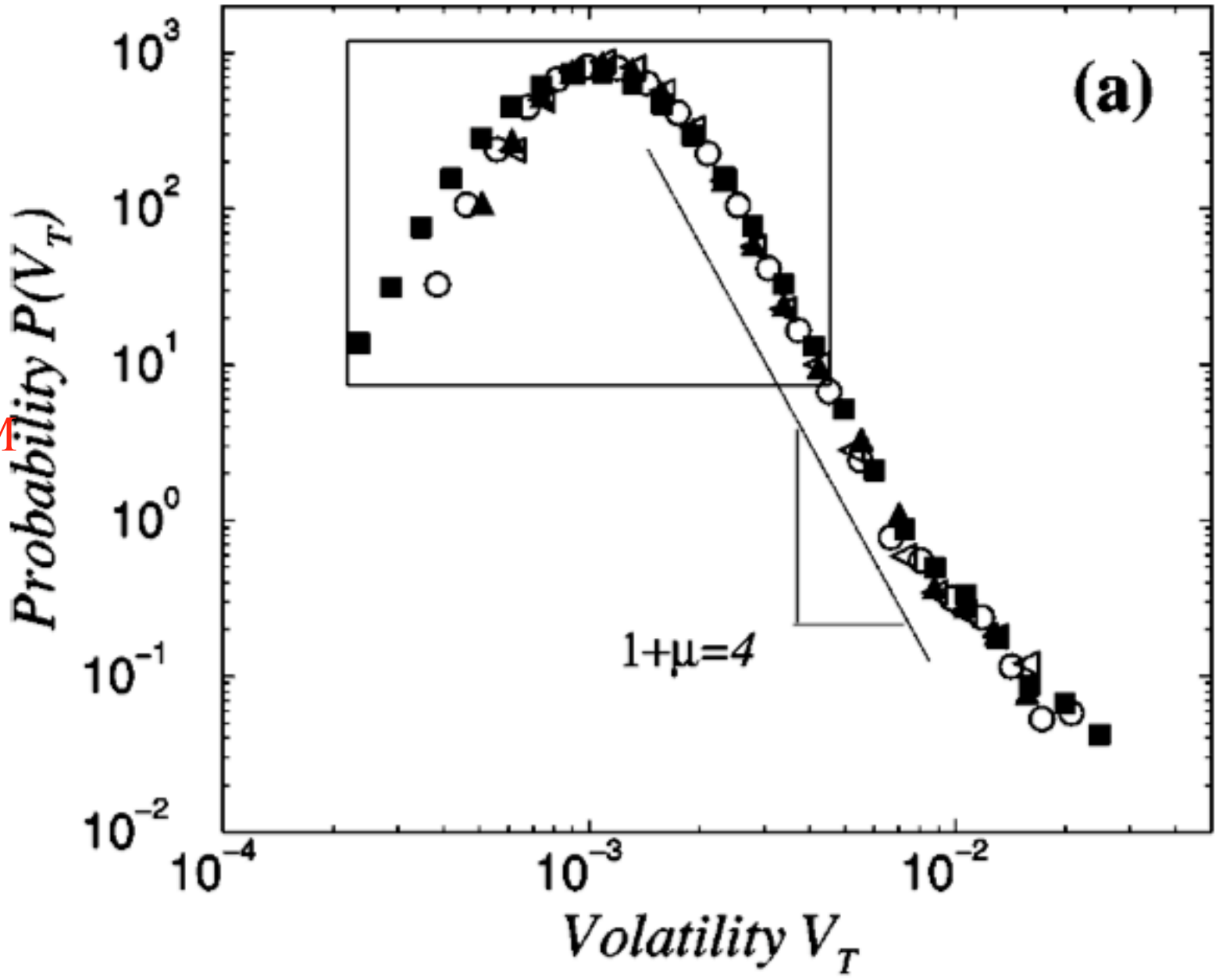


- Returns are UN-correlated after 4 min
- Absolute value of returns (volatility) is long range correlated, so returns CAN NOT BE serially independent.

$\longleftarrow R_t = \mathrm{sgn}(R_t) \quad |R_t|$



TEST 3: Crossover in Volatility pdf from (known) log-normal to (new) power law **(Surprise!)**



Liu,Cizeau,Meyer.``The Statistical Properties of the Volatility of Price Flucts" Phys. Rev. E 60, 1390.

Can a law describe bubbles and crashes in financial markets?

Goal: every trade---msec level...

Tobias Preis [1,2] and H. Eugene Stanley [1]

Physics World, May 2011

DETAILS IN:

T. Preis, J. Schneider, HES``Switching Processes inFinancial Markets," PNAS 108, 7674 (2011).

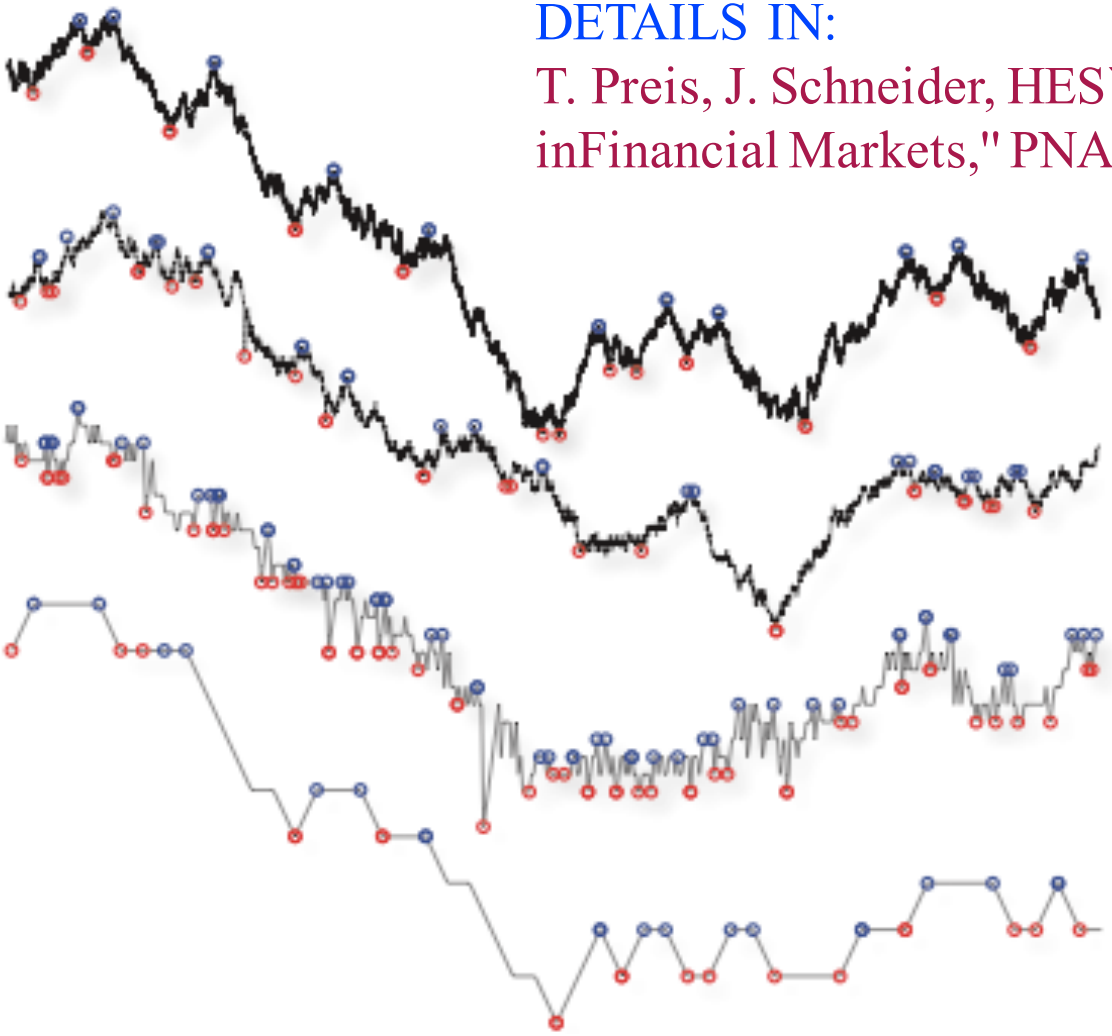
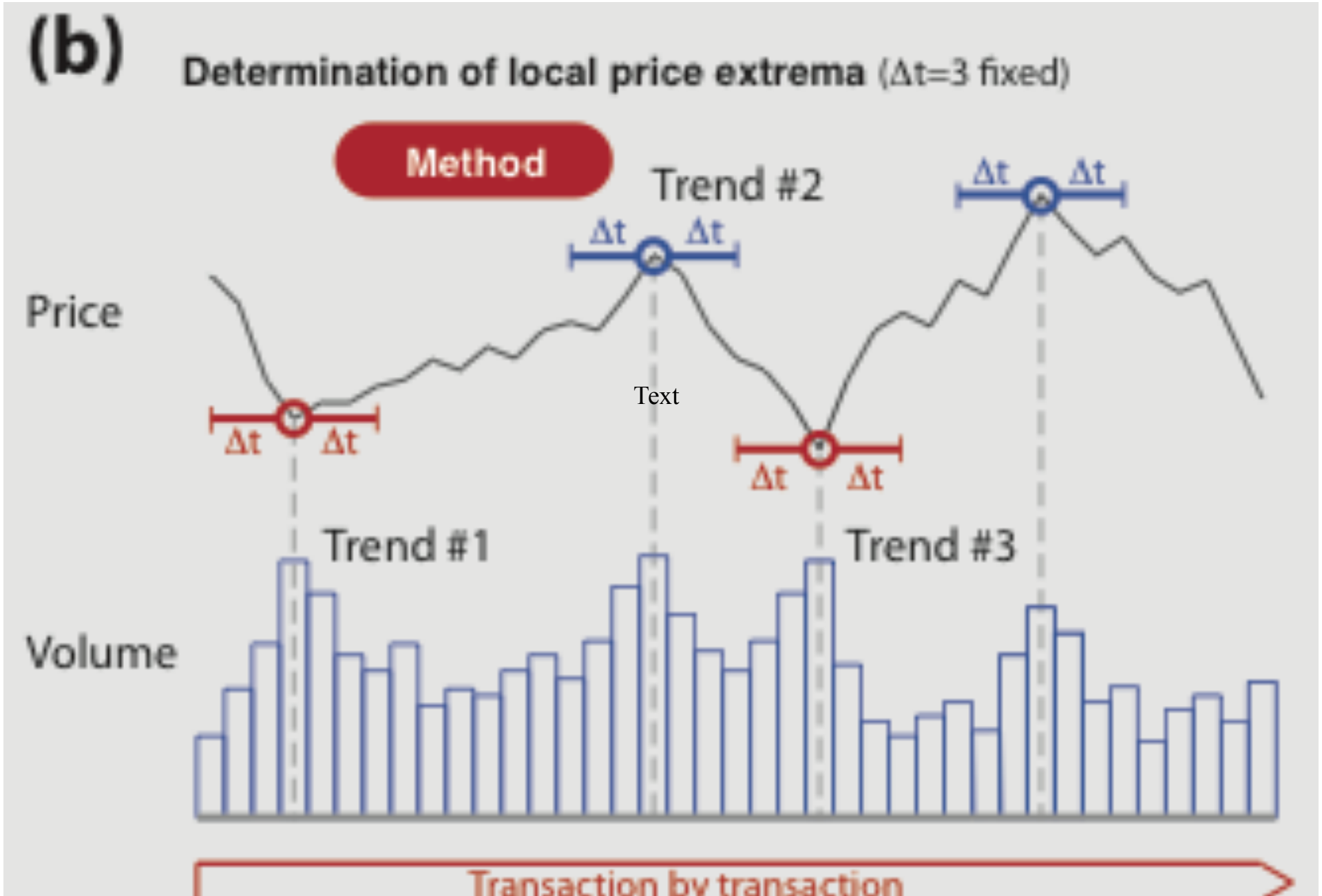


Figure 1 | Scale-free behavior of financial market fluctuations. Financial market time series feature identical properties on very different time scales. All four curves are subsets of a 14 million transactions dataset taken from a German DAX future time series. The price curves cover time periods of roughly 1 day (top curve), 1 hour, 10 minutes, and 1 minute (bottom curve). Local maximum and minimum values are marked as blue and red circles.

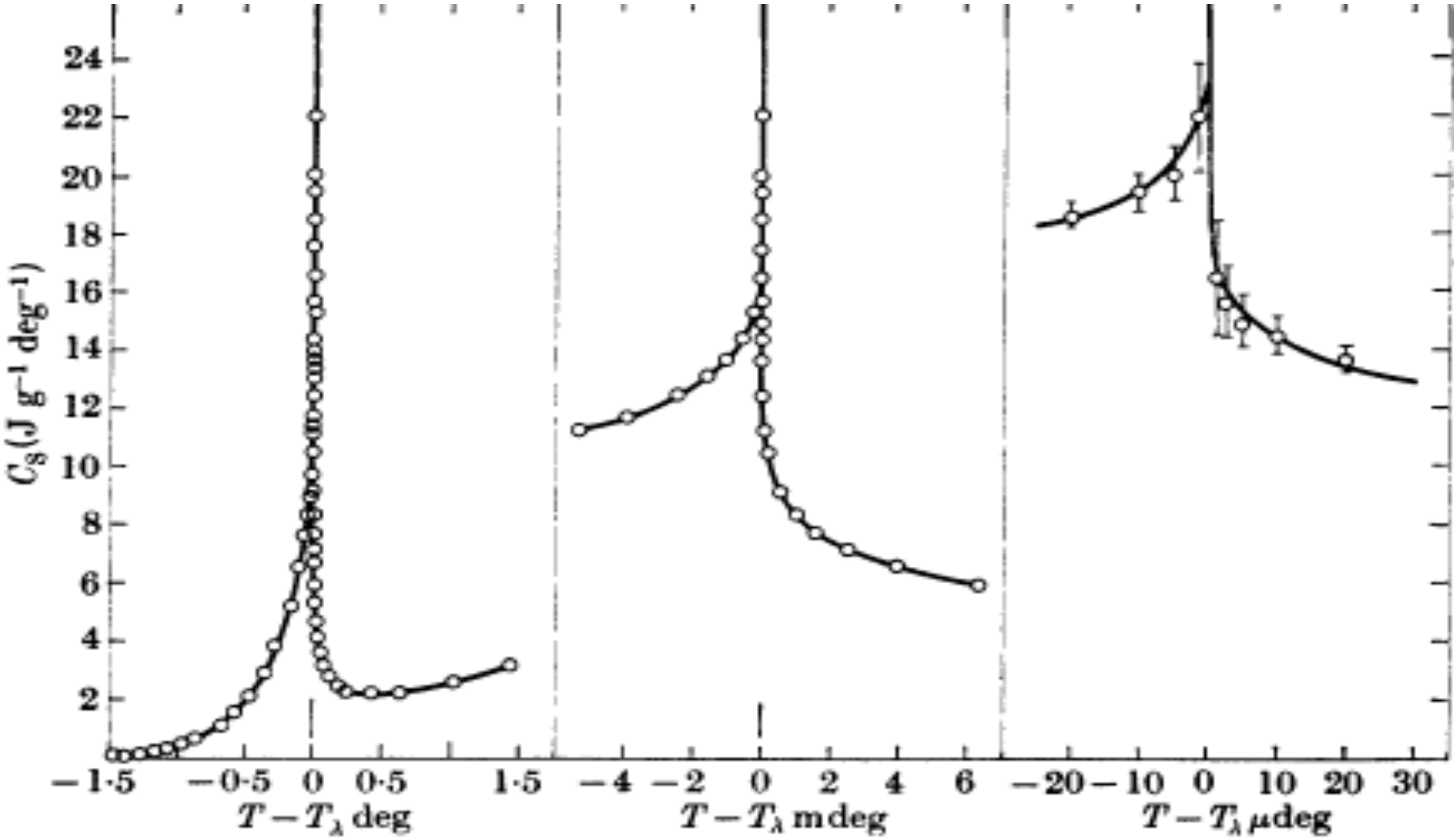
BIG QUESTION: How to quantify/analyze?????

ANS: :: Preis/HES/Schneider (2011 PNAS; May 2011 Physics World)

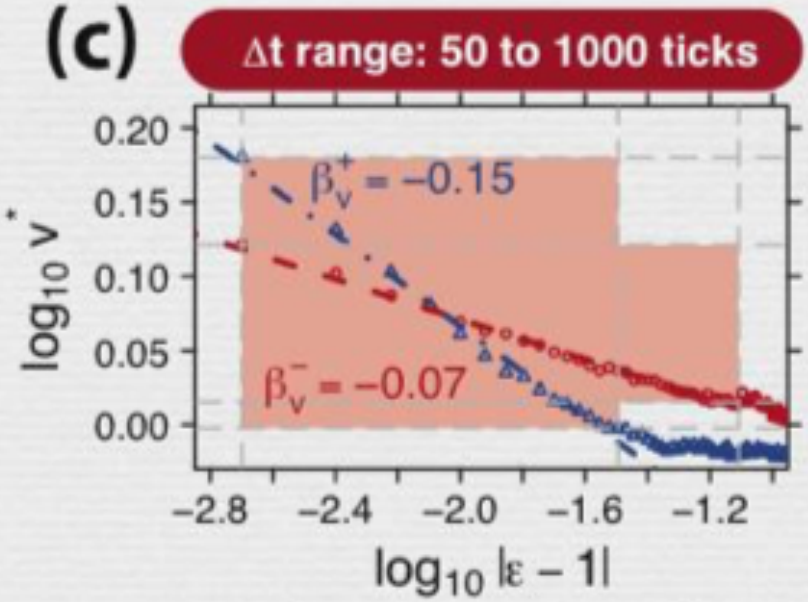


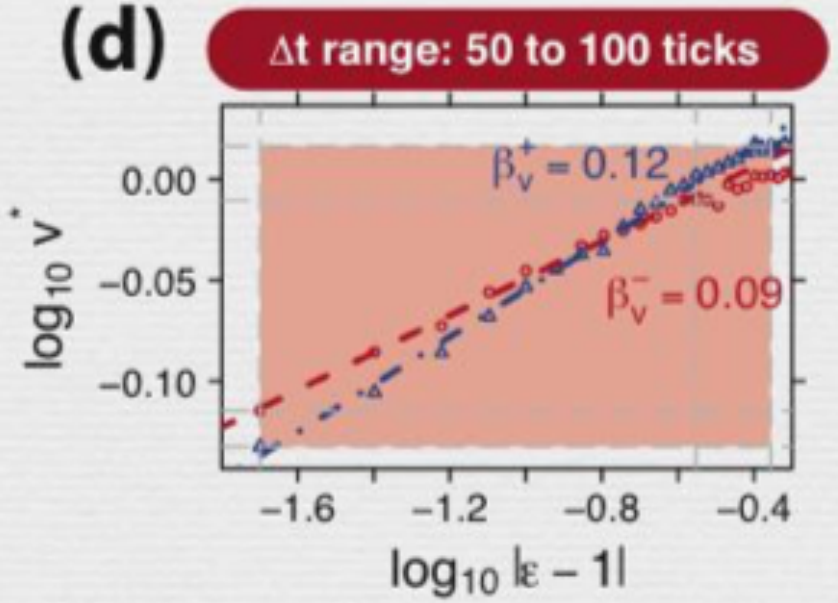
SCALE FREE SPECIFIC HEAT NEAR HELIUM SWITCH POINT

Note: Same FUNCTION for 3 different scales: 6 orders of magnitude!!!



Quantities With Scale-Free Behavior



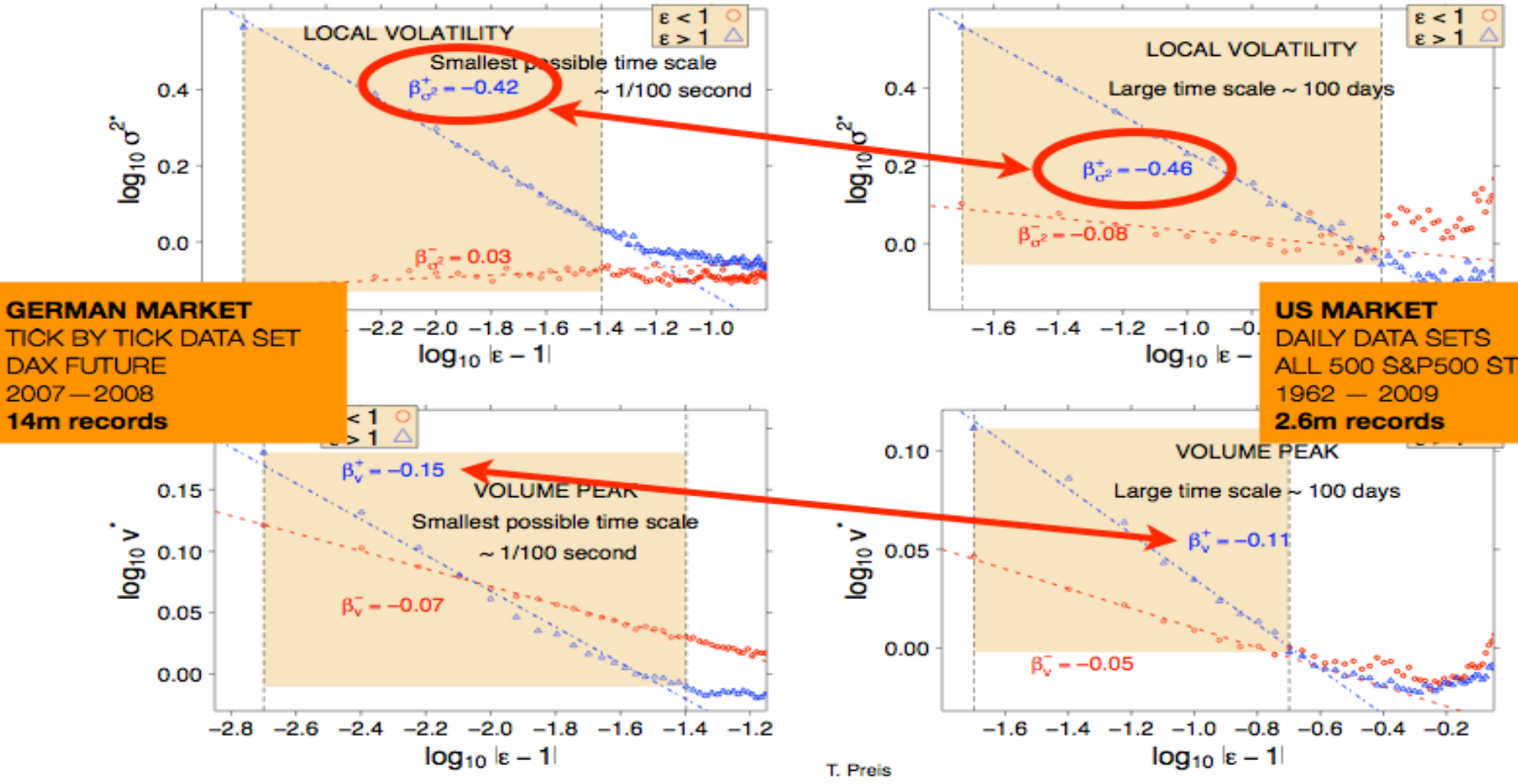


- Randomly reshuffling confirms our findings.

Preis/HES/Schneider (2011 PNAS; May 2011 Physics World)

FROM THE VERY SMALL TO THE VERY LARGE

~1/100 SECOND → ~100 DAYS



GERMAN MARKET
TICK BY TICK DATA SET
DAX FUTURE
2007—2008
14m records

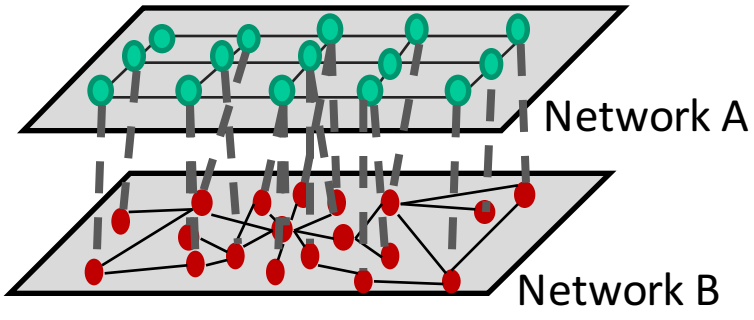
US MARKET
DAILY DATA SETS
ALL 500 S&P500 STOCKS
1962 — 2009
2.6m records

100x60x60x24x100 = 1,000,000,000....9 orders of magnitude !

Preis/HES/Schneider (2011 PNAS, May 2011 Physics World)

Critical Breakdown Threshold for 2 Interdependent Networks

Failure in network A
causes failure in network B
causes further failure in network A …..CASCADES



What are the critical breakdown thresholds for such interdependent networks?
What is size of cascade failures?

FURTHER EXAMPLES OF INTERDEPENDENT NETWORKS:

- *Economy*: Networks of banks, insurance companies, and firms which interact and depend on each other.

- *Physiology*: The human body is composed of inter-dependent networks (hip!)

- *Biology*: A specific cellular function is performed by a network of interacting proteins, which depend on other networks

Buldyrev, Parshani, Paul, Stanley, Havlin, Nature, **464**, 1025 (2010)