

Statistical Mechanics (SM)

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What is the course about ?

- statistics
Distributions, Moments, Fluctuations...
- mechanics
Rules, Laws, principles
- The course outline may change as we progress

Course Evaluation

- Homeworks and Interactions in the Class : 40 %
- A small presentation : 30 %
- One Exam (open book, take home) : 30 %

What I assume about you

- You know
 - Vector and Matrix Algebra
 - Matrix Diagonalization
 - Complex Integrations
 - Differential Equations and Solutions
 - Basic Classical and Quantum Mechanics
 - Some computer knowledge

Do assume about me (safely)

- I am not an authority
- I am still learning....
- Please do not mind
if I ask your name

Do ask questions

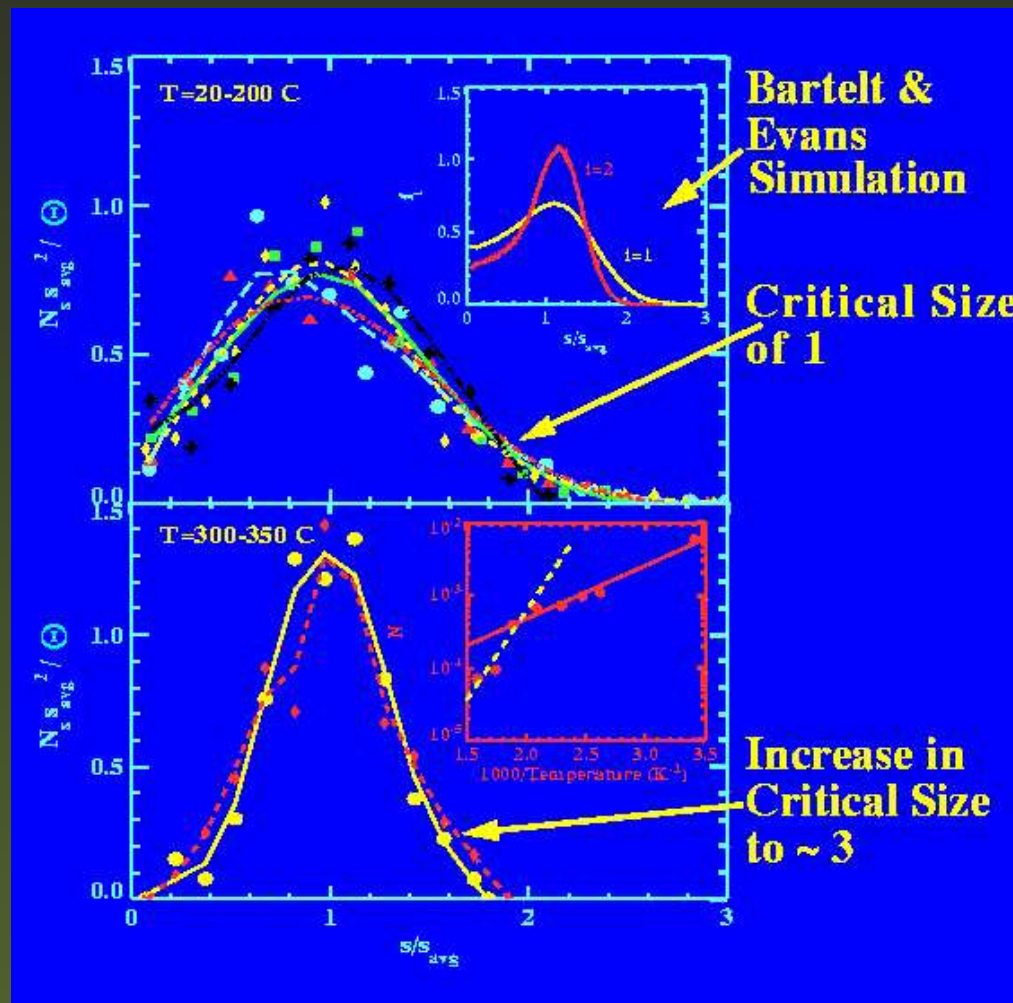
- I have time for you (Rm. 458)
- Language ?

Statistics

Distributions

- Uniform Distributions
- Normal Distributions
- Exponential Distributions
- Power-law distributions

Normal distribution

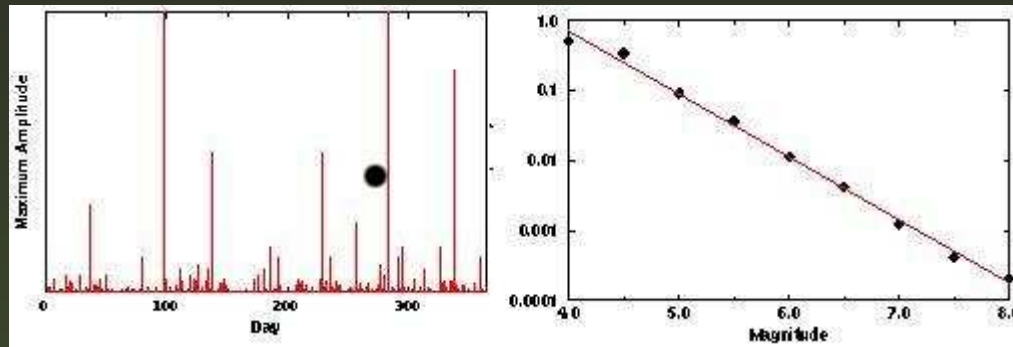


Island size distribution (Fe deposition)

Exponential distribution

HW : find some data from internet.

Powerlaw distributions



Gutenberg-Richter law : earthquakes $>$ magnitude 4

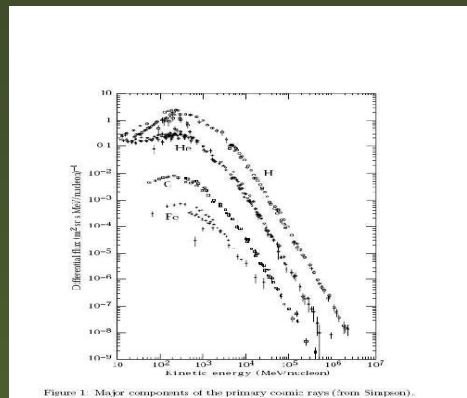
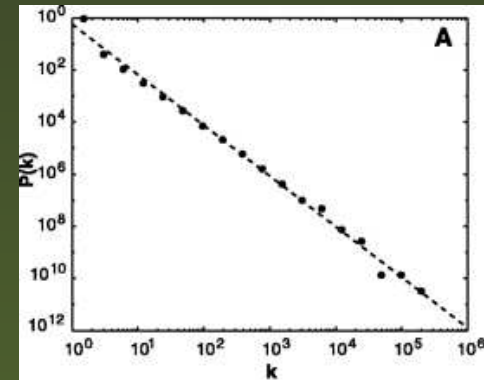


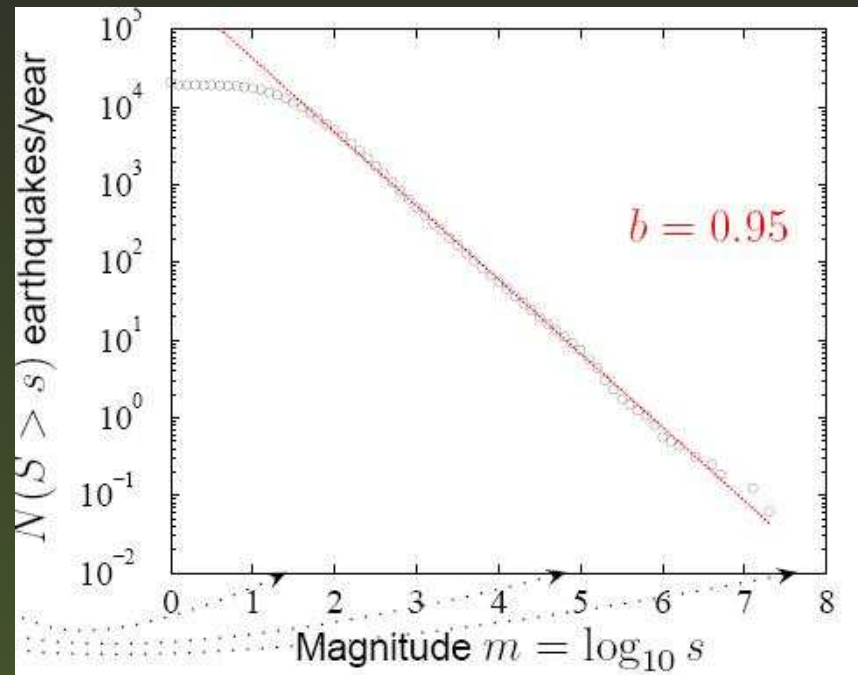
Figure 1: Major components of the primary cosmic rays (from Simpson).

Energy distribution of cosmic ray flux

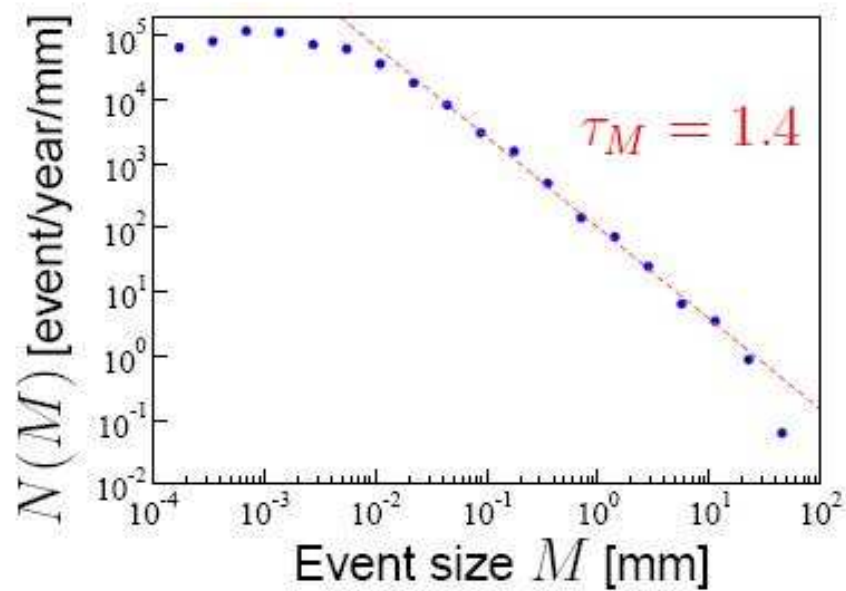
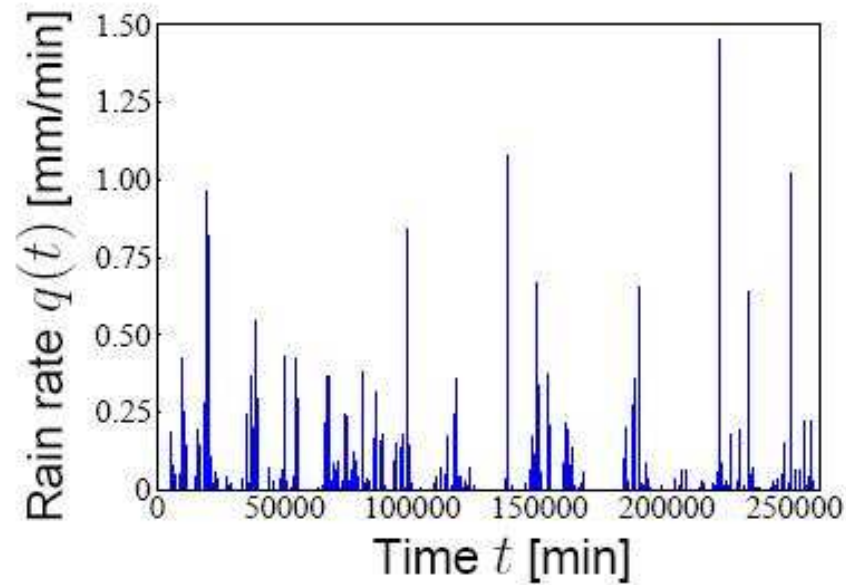


Link distribution of www

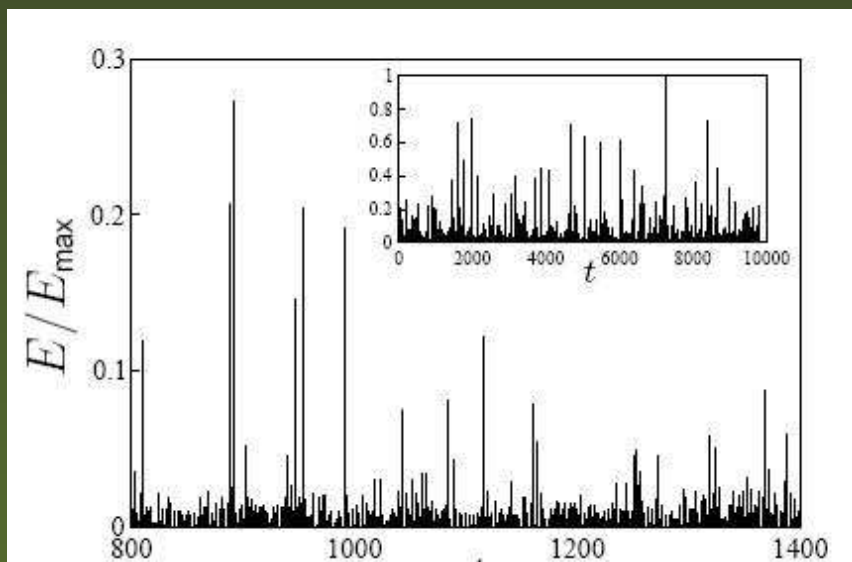
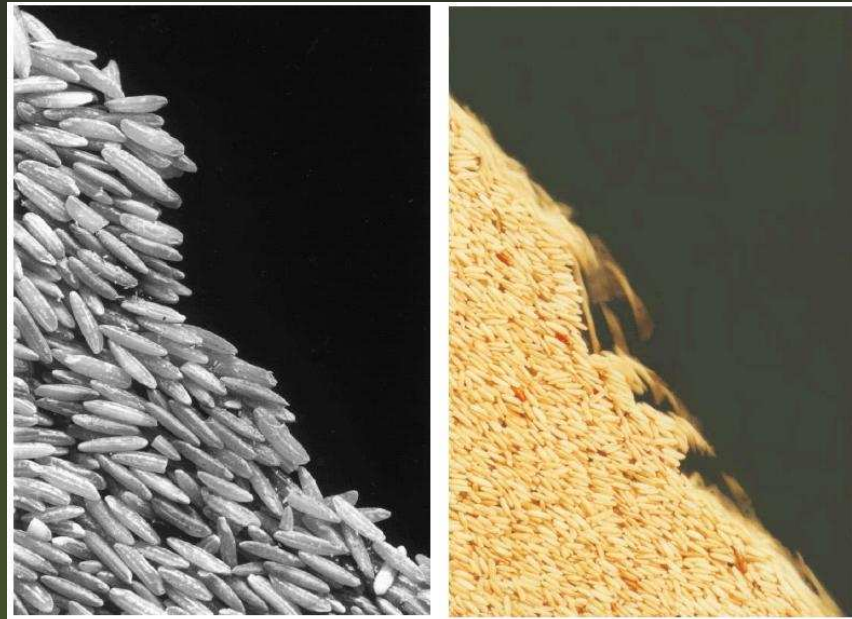
Earthquakes



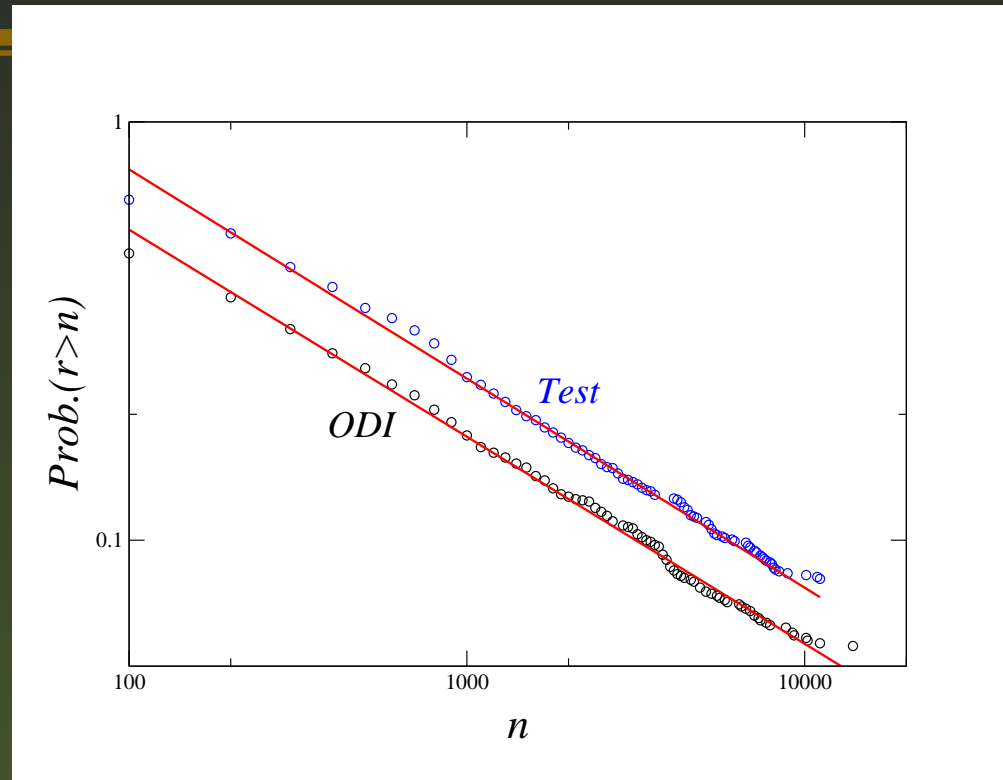
Rain Fall



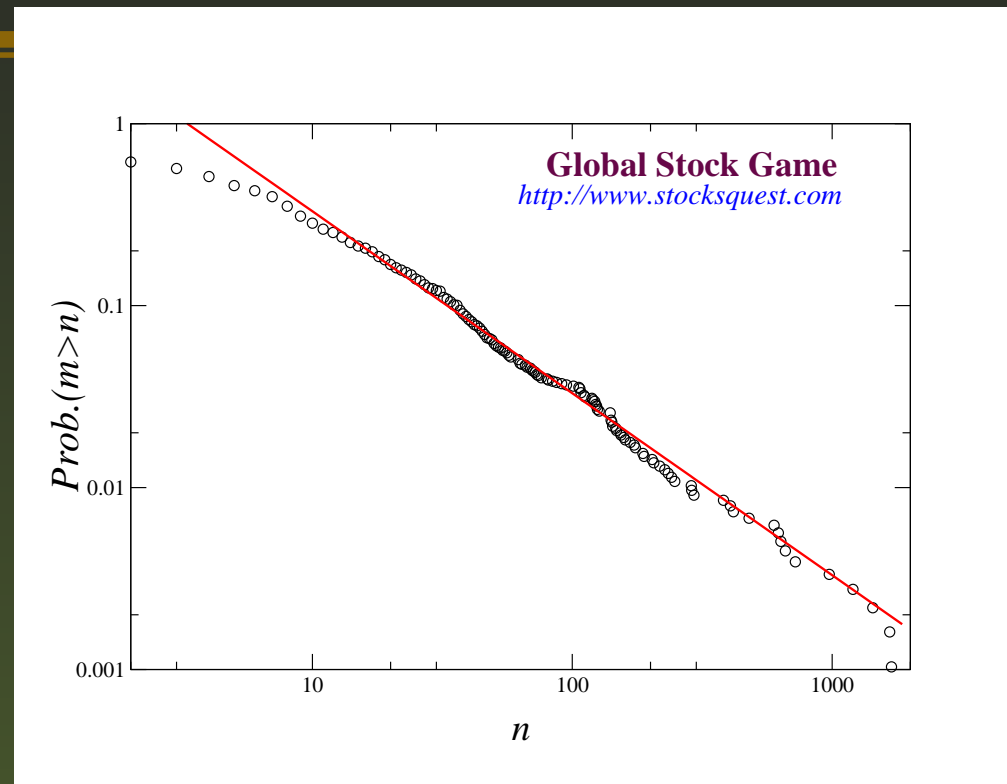
Distribution of Avalanches



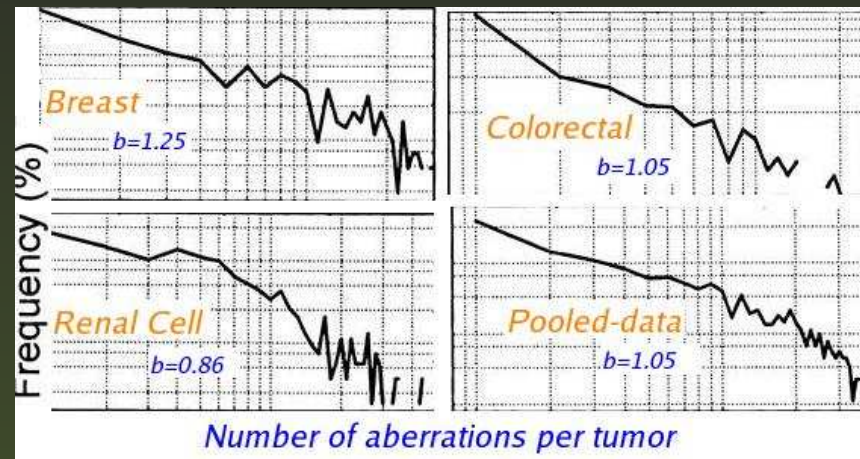
Cricket



Stock-Market

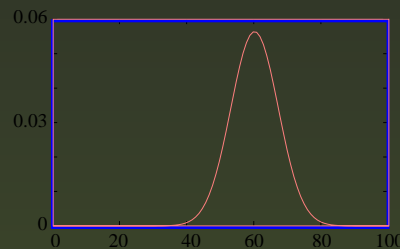


Cancer-Cell



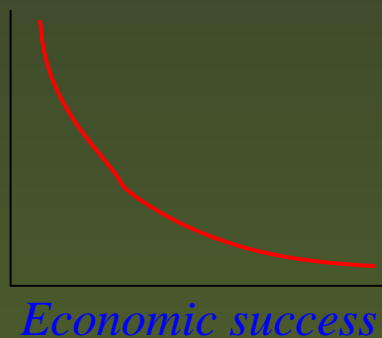
A question I asked ...

- Mark distribution of school students



Normal Distribution : most students are average.

- Why some people are more successful ?



- Why Power-law distribution ?

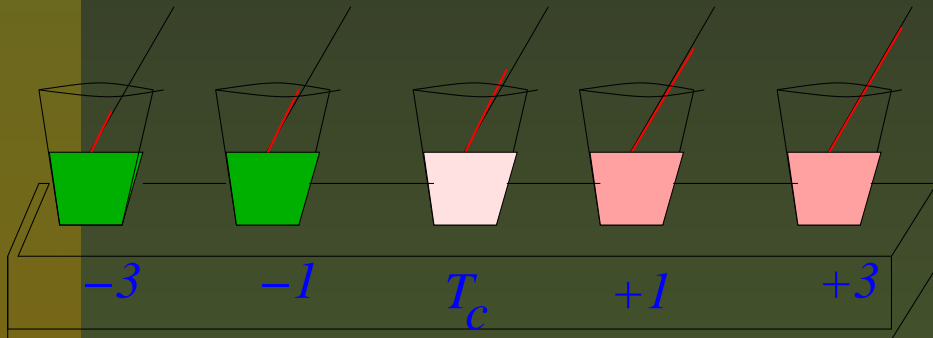
Celebrity Market : Medicine, Law, IT and Movie industry must fol-

Why some people are more successful ?

... because success comes easily to people who are already successful.

Exciting power-laws ...

- Exponential : $P(n) = \exp(-n/\xi)$
 - Length-scale ξ
 - Negligible probability for $n > \xi$



- Power-law : $P(n) = (n - n_c)^{-\alpha}$
 - No such scale
 - Power-law \equiv Scale-free \equiv Criticality
 - Hard to maintain a critical state
 - Non-equilibrium ?

Two ways of research

- You know the statistics and try to find a mechanics/dynamics.
 - biology, society, economics, archeology, chemistry etc.
- You know the mechanics and predict the statistics
 - We will learn in the class...
 - Applicable for limited systems, only at equilibrium
(most phenomena occurs in non-equilibrium conditions, general theory is a challenge)
 - Equilibrium stat mech is a good start...
 - But it is just a beginning

Our course.

A big assembly of people (identical or not)

You know how each individual behaves

You know how they interact with each other

What is their mass behaviour ?

No astrology please.... (show an example : time average
= ensemble avr)