بسمه تعالی

گزارشی کوتاه از مدرسه بهاره سیستم های پیچیده
ICTP

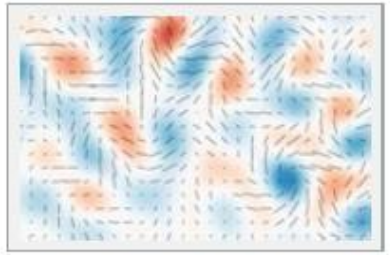
تریسته، ایتالیا

محمد شرافتی

بهار ۱۳۹۸

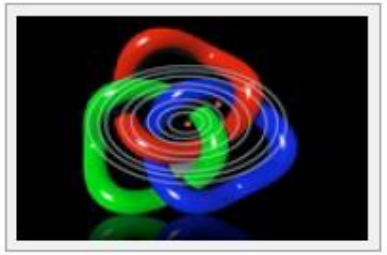
6 Sections in ICTP

HECAP



The High Energy, Cosmology and Astroparticle Physics (HECAP) section studies

CMSP



The Condensed Matter and Statistical Physics (CMSP) section investigates the physics

MATH

The Mathematics section is mainly oriented towards geometry and analysis.

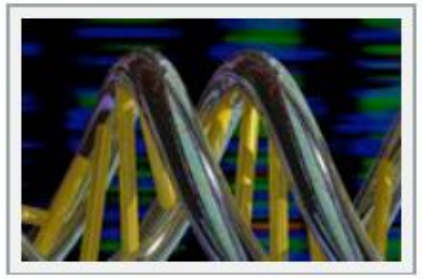
ESP

The Earth System Physics (ESP) section studies a wide spectrum of the Earth

AP

ICTP's diverse Applied Physics section encompasses areas of research that respond

New Areas



ICTP's three new research areas could

ارائه ICTP – دکتر موحد

http://facultymembers.sbu.ac.ir/movahed/index.php/courses/109-research-methods-course

ICTP Programs

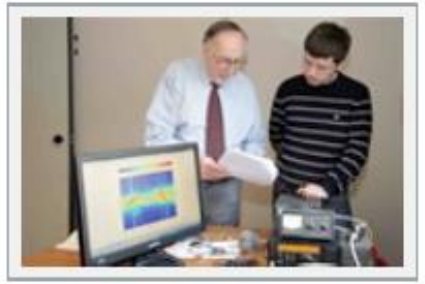
Pre-PhD Programmes

Postgraduate Diploma Programme
ICTP/IAEA Sandwich Training Education Programme

Degree Programmes

Joint ICTP/SISSA PhD in Physics or Mathematics
Joint PhD Fluid Mechanics
Joint Laurea
Joint ICTP/Collegio Carlo Alberto
Masters Complex Systems
Masters in Medical Physics

Career Development



Federation Scheme
Associates Scheme

Laboratory Opportunities

TRIL
ICTP/ELETTRA Users
ICTP Labs

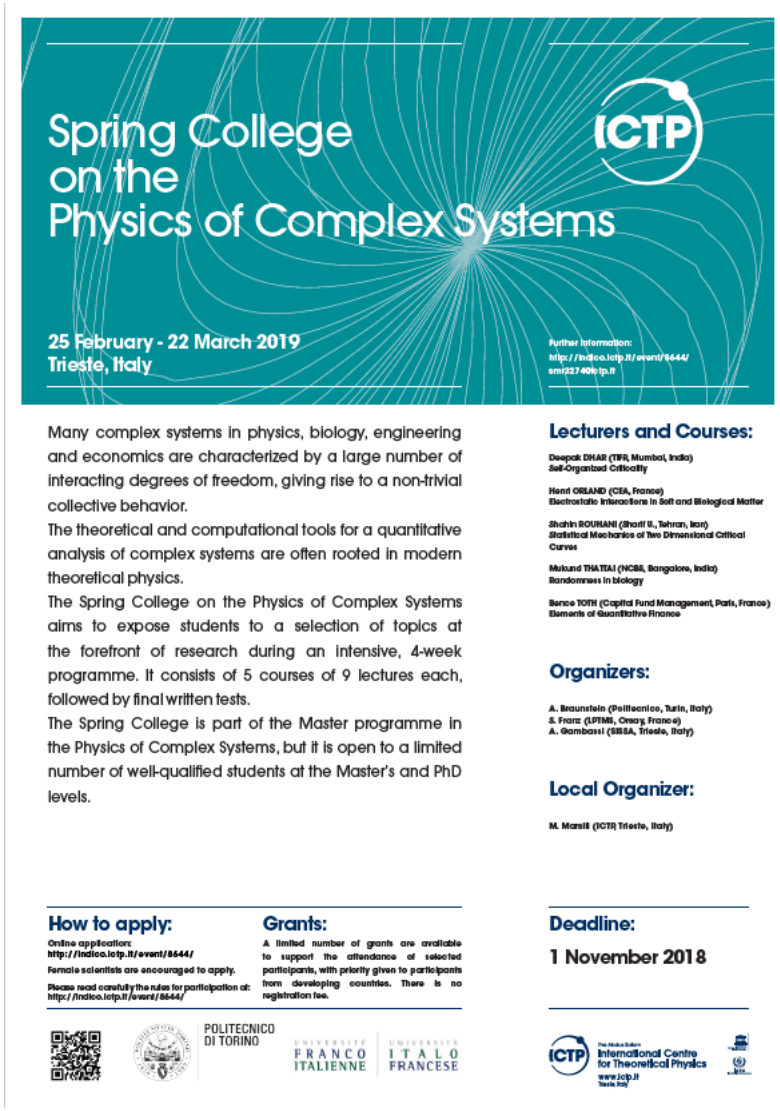
Scientific Outreach

Office of External Activities
ICTP in Brazil
ICTP in Africa
Science Dissemination Unit
African Review of Physics

ارائه ICTP – دکتر موحد

http://facultymembers.sbu.ac.ir/movahed/index.php/courses/109-research-methods-course

Suggested programs



Spring College on the Physics of Complex Systems

ICTP

25 February - 22 March 2019
Trieste, Italy

Further information:
http://indico.ictp.it/event/8644/
smr/3274@ictp.it

Many complex systems in physics, biology, engineering and economics are characterized by a large number of interacting degrees of freedom, giving rise to a non-trivial collective behavior.
The theoretical and computational tools for a quantitative analysis of complex systems are often rooted in modern theoretical physics.
The Spring College on the Physics of Complex Systems aims to expose students to a selection of topics at the forefront of research during an intensive, 4-week programme. It consists of 5 courses of 9 lectures each, followed by final written tests.
The Spring College is part of the Master programme in the Physics of Complex Systems, but it is open to a limited number of well-qualified students at the Master's and PhD levels.

Lecturers and Courses:

Deepak DHAR (TIFR, Mumbai, India)
Self-Organized Criticality

Henri ORLAND (CEA, France)
Electrostatic Interactions in Soft and Biological Matter

Shahin ROUHANI (Sharif U., Tehran, Iran)
Statistical Mechanics of Two Dimensional Critical Curves

Mukund THATTAI (NCBS, Bangalore, India)
Randomness in Biology

Bence TOTH (Capital Fund Management, Paris, France)
Elements of Quantitative Finance

Organizers:

A. Braunstein (Politecnico, Turin, Italy)
S. Franz (LPTMS, Orsay, France)
A. Gambassi (SISSA, Trieste, Italy)

Local Organizer:

M. Marsili (ICTP, Trieste, Italy)

How to apply:

Online application:
http://indico.ictp.it/event/8644/

Female scientists are encouraged to apply.

Please read carefully the rules for participation at:
http://indico.ictp.it/event/8644/

Grants:

A limited number of grants are available to support the attendance of selected participants, with priority given to participants from developing countries. There is no registration fee.

Deadline:

1 November 2018

POLITECNICO DI TORINO
UNIVERSITÉ FRANCO ITALIENNE
UNIVERSITÀ ITALO FRANCESE
ICTP The Abdus Salam International Centre for Theoretical Physics
www.ictp.it
Trieste, Italy

Spring College on the Physics of Complex Systems

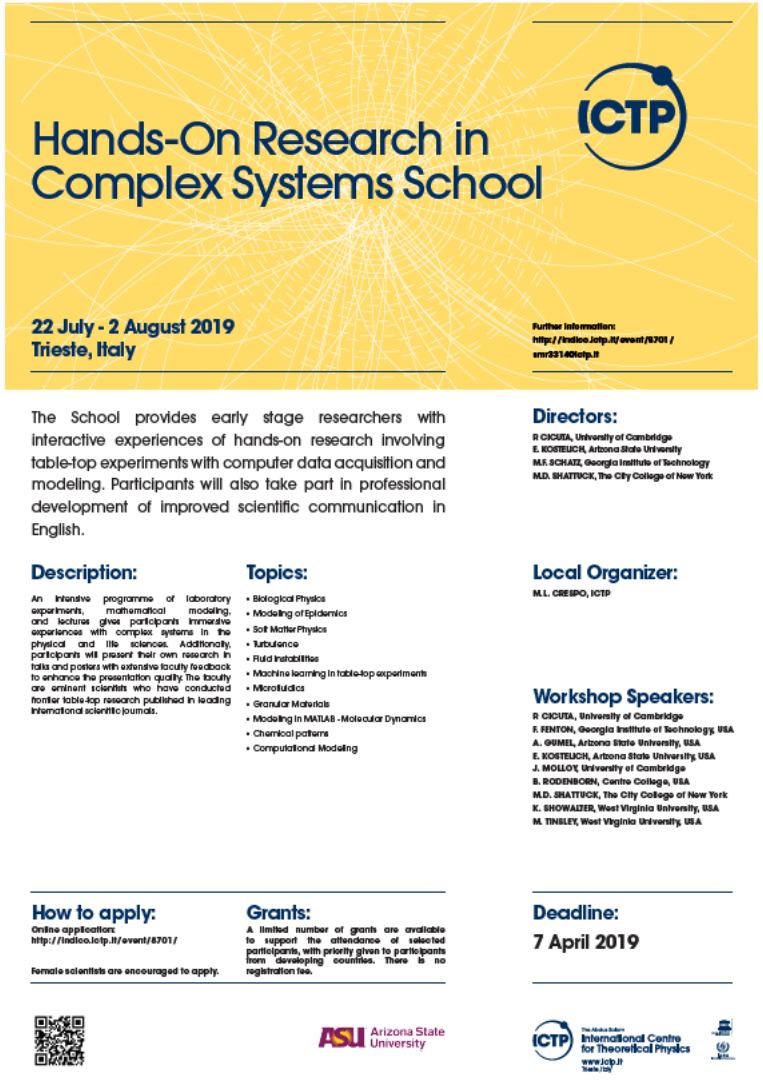
Duration: About 4 weeks

Time to Apply: Around November

Poster: Optional

Grant: Yes!

Suggested programs



Hands-On Research in Complex Systems School

22 July - 2 August 2019
Trieste, Italy

Further information:
http://indico.ictp.it/event/8701/
smr3314@ictp.it

The School provides early stage researchers with interactive experiences of hands-on research involving table-top experiments with computer data acquisition and modeling. Participants will also take part in professional development of improved scientific communication in English.

Description:

An intensive programme of laboratory experiments, mathematical modeling, and lectures gives participants immersive experiences with complex systems in the physical and life sciences. Additionally, participants will present their own research in talks and posters with extensive faculty feedback to enhance the presentation quality. The faculty are eminent scientists who have conducted frontier table-top research published in leading international scientific journals.

Topics:

- Biological Physics
- Modeling of Epidemics
- Soft Matter Physics
- Turbulence
- Fluid Instabilities
- Machine learning in table-top experiments
- Microfluidics
- Granular Materials
- Modeling in MATLAB - Molecular Dynamics
- Chemical patterns
- Computational Modeling

Directors:

R CIGUTA, University of Cambridge
E. KOSTELICH, Arizona State University
M.K. SCHATZ, Georgia Institute of Technology
M.D. SHATTUCK, The City College of New York

Local Organizer:

M.L. CRESPO, ICTP

Workshop Speakers:

R CIGUTA, University of Cambridge
F. FENTON, Georgia Institute of Technology, USA
A. GUMEL, Arizona State University, USA
E. KOSTELICH, Arizona State University, USA
J. MOLLOY, University of Cambridge
B. RODENBORN, Centre College, USA
M.D. SHATTUCK, The City College of New York
K. SHOWALTER, West Virginia University, USA
M. TINSLEY, West Virginia University, USA

How to apply:

Online application:
http://indico.ictp.it/event/8701/

Female scientists are encouraged to apply.

Grants:

A limited number of grants are available to support the attendance of selected participants, with priority given to participants from developing countries. There is no registration fee.

Deadline:

7 April 2019

Arizona State University

The Abdus Salam International Centre for Theoretical Physics
www.ictp.it
Trieste / Italy

Hands-On Research in Complex Systems School

Duration: 10 Days

Time to Apply: Around April

Poster: Optional

Grant: Yes!

Suggested programs

The CODATA-RDA Research Data Science Summer School

ICTP

5 - 16 August 2019
Trieste, Italy

Further information:
http://indico.ictp.it/event/8706/
smr3317@ictp.it

This school provides early career researchers (at MSc-level to 3 years after their PhD) and professionals (who register via ITU Academy) with the necessary set of foundational data science skills to enable them to analyse their data in an efficient and effective manner for the 21st century.

Description:

The material covered here is fundamental to all areas of data science and hence open to researchers and professionals from all disciplines that deal with significant amounts of data. The goal is to provide a practical introduction to these topics with extensive labs and seminars.

Individuals with a background in high energy/particle physics, IoT/Big-Data analytics, bioinformatics and climate data sciences can apply to one of the advanced workshops that run immediately after the school.

Topics:

- Open Science
- Introduction to Unix Shell
- Programming for Analysis
- Git
- Research Data Management
- Author Carpentry
- Data Visualisation
- Information Security
- Machine Learning
- Computational Infrastructures

How to apply:

Online application:
http://indico.ictp.it/event/8706/

Female students and scientists are encouraged to apply.

Grants:

A limited number of grants are available to support the attendance of selected participants from developing countries. Professionals and corporate entities must register and apply via the ITU Academy platform.

Directors:

R. MURENZI, TWAS
N. MULDER, University of Cape Town, South Africa
R. GURICK, Indiana University, USA
H. SHANAHAN, Royal Holloway University, UK
S. HODSON, CODATA, France
L. BEZUIDENHOUT, University of Oxford, UK.
M. CORDOBA, Universidad de Costa Rica, Costa Rica
R. COBE, UNESP, Brazil
S. JONES, University of Glasgow, UK
I. GIROTTO, ICTP
U. SINGH, ICTP
M. ZENNARO, ICTP

Local Organizer:

C. ONIME, ICTP

Deadline:

18 April 2019

SPRINGER NATURE elixir twas ITU CODATA H3ABioNet RDA

ICTP The Abdus Salam International Centre for Theoretical Physics www.ictp.it Trieste, Italy

The CODATA-RDA Research Data Science Summer School

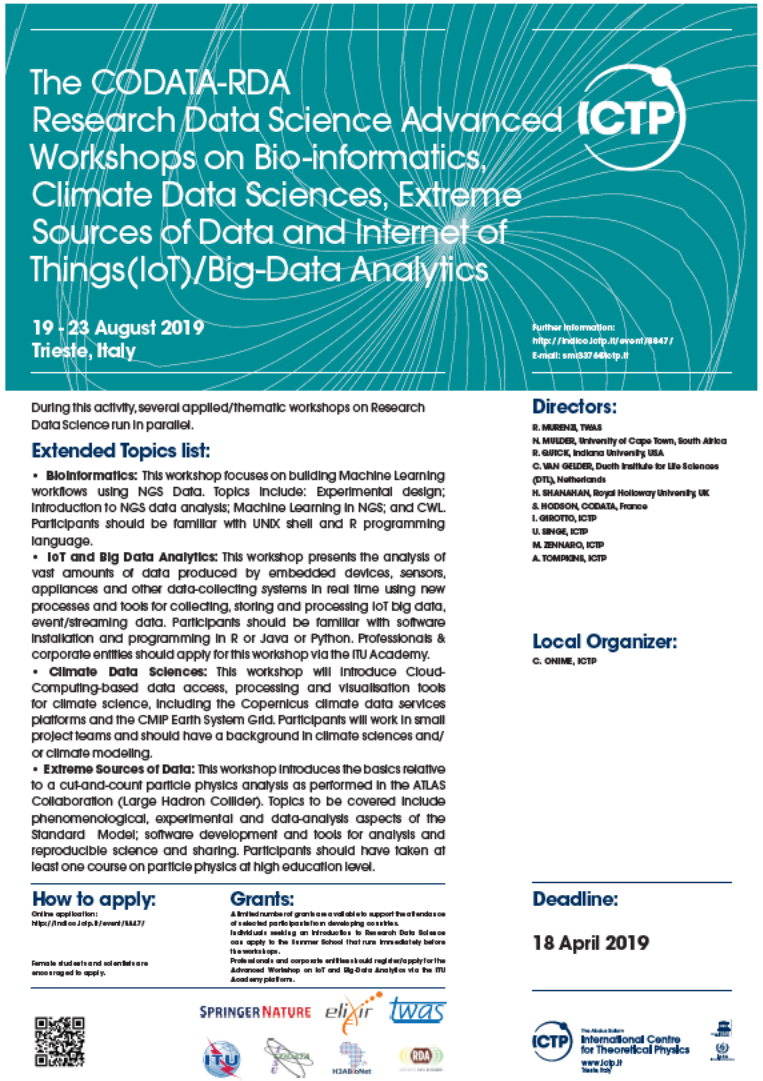
Duration: 12 Days

Time to Apply: Around April

Poster: Necessary!

Grant: Yes!

Suggested programs



The CODATA-RDA Research Data Science Advanced Workshops on Bio-informatics, Climate Data Sciences, Extreme Sources of Data and Internet of Things(IoT)/Big-Data Analytics

19 - 23 August 2019
Trieste, Italy

Further information:
http://indico.ictp.it/event/8847/
E-mail: smr3376@ictp.it

During this activity, several applied/thematic workshops on Research Data Science run in parallel.

Extended Topics list:

- **Bioinformatics:** This workshop focuses on building Machine Learning workflows using NGS Data. Topics include: Experimental design; Introduction to NGS data analysis; Machine Learning in NGS; and CWL. Participants should be familiar with UNIX shell and R programming language.
- **IoT and Big Data Analytics:** This workshop presents the analysis of vast amounts of data produced by embedded devices, sensors, appliances and other data-collecting systems in real time using new processes and tools for collecting, storing and processing IoT big data, event/streaming data. Participants should be familiar with software installation and programming in R or Java or Python. Professionals & corporate entities should apply for this workshop via the ITU Academy.
- **Climate Data Sciences:** This workshop will introduce Cloud-Computing-based data access, processing and visualisation tools for climate science, including the Copernicus climate data services platforms and the CMIP Earth System Grid. Participants will work in small project teams and should have a background in climate sciences and/or climate modeling.
- **Extreme Sources of Data:** This workshop introduces the basics relative to a cut-and-count particle physics analysis as performed in the ATLAS Collaboration (Large Hadron Collider). Topics to be covered include phenomenological, experimental and data-analysis aspects of the Standard Model; software development and tools for analysis and reproducible science and sharing. Participants should have taken at least one course on particle physics at high education level.

How to apply:
Online application:
https://indico.ictp.it/event/8847/

Female students and scientists are encouraged to apply.

Grants:
A limited number of grants are available to support the attendance of selected participants from developing countries.
Individuals seeking an introduction to Research Data Sciences can apply to the Summer School that runs immediately before the workshops.
Professionals and corporate entities should register/apply for the Advanced Workshop on IoT and Big-Data Analytics via the ITU Academy platform.

Directors:
R. MURENZI, TWAS
N. MULDER, University of Cape Town, South Africa
R. GURICK, Indiana University, USA
C. VAN GELDER, Dutch Institute for Life Sciences (DTL), Netherlands
H. SHANAHAN, Royal Holloway University, UK
S. HODSON, CODATA, France
I. GIROTTO, ICTP
U. SINGE, ICTP
M. ZENNARO, ICTP
A. TOMPKINS, ICTP

Local Organizer:
C. ONIME, ICTP

Deadline:

18 April 2019

SPRINGER NATURE elixir twas ITU CODATA H3ABioNet RDA

ICTP The Abdus Salam International Centre for Theoretical Physics www.ictp.it Trieste, Italy

The CODATA-RDA Research Data Science Advanced Workshops on

Bio-informatics,
Climate Data Sciences,
Extreme Sources of Data and Internet of Things(IoT)/Big-Data Analytics

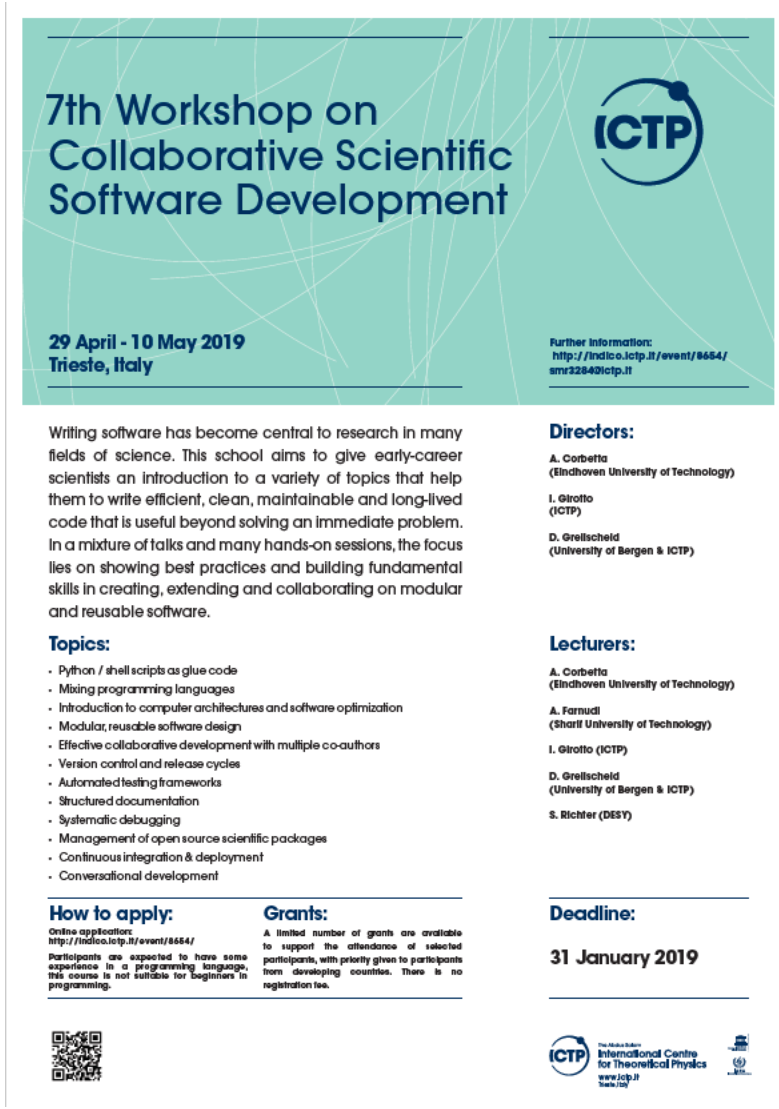
Duration: 4 Days

Time to Apply: Around April

Poster: Necessary!

Grant: Yes!

Suggested programs



7th Workshop on Collaborative Scientific Software Development

ICTP

29 April - 10 May 2019
Trieste, Italy

Further information:
http://indico.ictp.it/event/8654/
smr3284@ictp.it

Writing software has become central to research in many fields of science. This school aims to give early-career scientists an introduction to a variety of topics that help them to write efficient, clean, maintainable and long-lived code that is useful beyond solving an immediate problem. In a mixture of talks and many hands-on sessions, the focus lies on showing best practices and building fundamental skills in creating, extending and collaborating on modular and reusable software.

Topics:

- Python / shell scripts as glue code
- Mixing programming languages
- Introduction to computer architectures and software optimization
- Modular, reusable software design
- Effective collaborative development with multiple co-authors
- Version control and release cycles
- Automated testing frameworks
- Structured documentation
- Systematic debugging
- Management of open source scientific packages
- Continuous integration & deployment
- Conversational development

How to apply:

Online application:
http://indico.ictp.it/event/8654/

Participants are expected to have some experience in a programming language, this course is not suitable for beginners in programming.

Grants:

A limited number of grants are available to support the attendance of selected participants, with priority given to participants from developing countries. There is no registration fee.

Directors:

A. Corbetta
(Eindhoven University of Technology)

I. Girotto
(ICTP)

D. Greilscheid
(University of Bergen & ICTP)

Lecturers:

A. Corbetta
(Eindhoven University of Technology)

A. Farnudi
(Sharif University of Technology)

I. Girotto (ICTP)

D. Greilscheid
(University of Bergen & ICTP)

S. Richter (DESY)

Deadline:

31 January 2019

ICTP The Abdus Salam International Centre for Theoretical Physics
www.ictp.it
Trieste/Italy

7th Workshop on Collaborative Scientific Software Development

- Python / shell scripts as glue code
- Mixing programming languages
- Introduction to computer architectures and software optimization
- Modular, reusable software design
- Effective collaborative development with multiple co-authors
- Version control and release cycles
- Automated testing frameworks
- Structured documentation
- Systematic debugging
- Management of open source scientific packages
- Continuous integration & deployment
- Conversational development

Duration: 10 Days

Time to Apply: Around January

Poster: Optional!

Grant: Yes!

The world's most valuable resource is no longer oil, but data, The Economist, May 6th 2017

Why ICTP ?

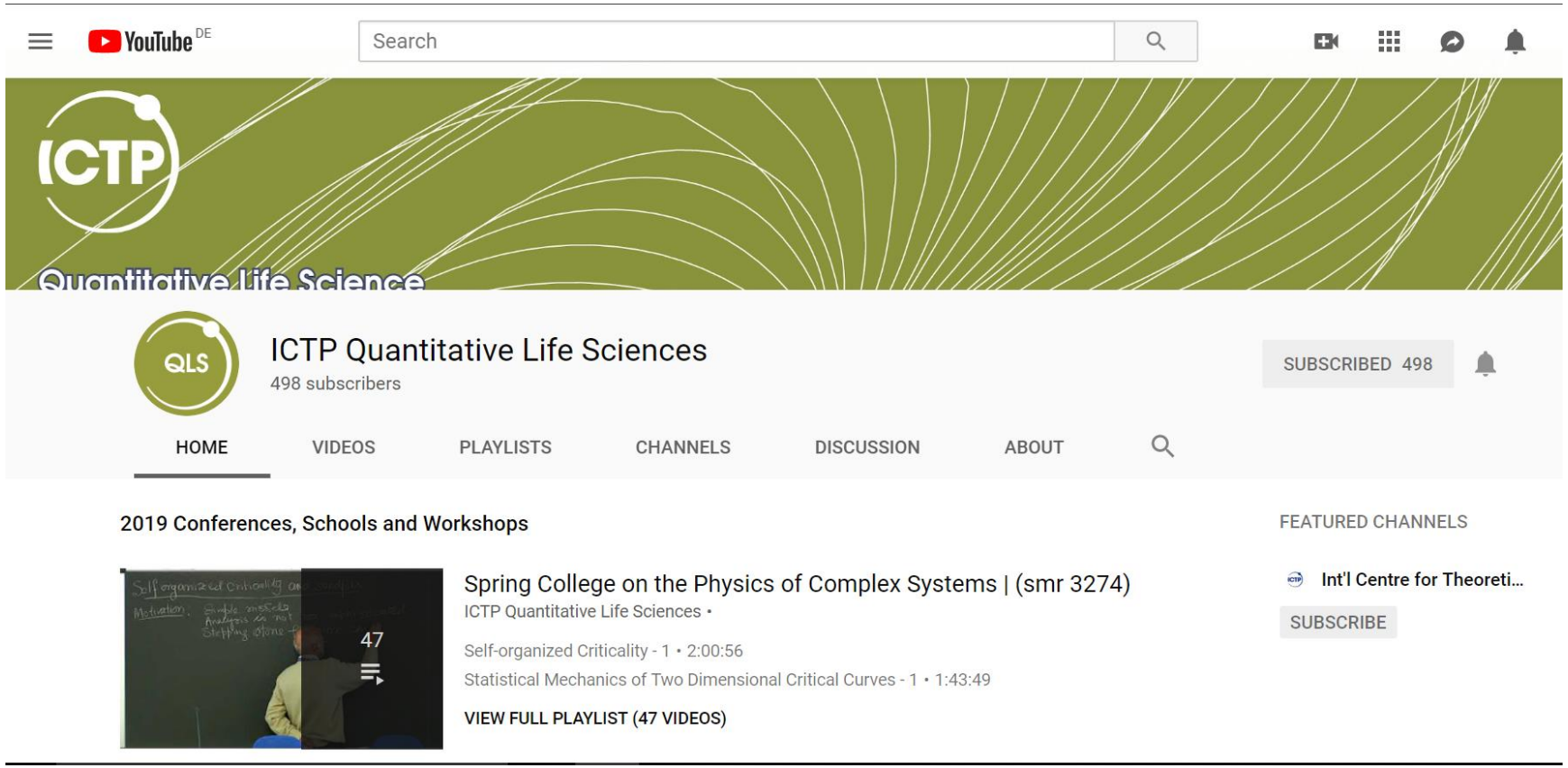
1. Why not?!
2. Grants
3. Easy to get the visa
4. Designed for Developed Countries
5. Girls encourage to Apply
6. …..

Spring College on the Physics of Complex Systems(2019)

1. *Self-Organized Criticality*
2. *Statistical Mechanics of Two Dimensional Critical Curves*
3. *Elements of Quantitative Finance*
4. *Randomness in Biology*
5. *Electrostatic Interactions in Soft and Biological Matter*

- Deepak DHAR (IISER, Pune, India)
- Shahin ROUHANI (Sharif U., Tehran, Iran)
- Bence TOTH (Capital Fund Management, Paris, France)
- Mukund THATTAI (NCBS, Bangalore, India)
- Henri ORLAND (CEA, France)

Spring College on the Physics of Complex Systems(2019)



School Materials: http://indico.ictp.it/event/8644/other-view?view=ictptimetable
Videos : https://www.youtube.com/channel/UC3cvRkdfO-76JKosmx1tiXw

Self-Organized Criticality

Deepak DHAR (IISER, Pune, India)

ELSEVIER

Available online at www.sciencedirect.com

SCIENCE DIRECT®

Physica A 369 (2006) 29–70

PHYSICA A

www.elsevier.com/locate/physa

Theoretical studies of self-organized criticality

Deepak Dhar*

Department of Theoretical Physics, Tata Institute of Fundamental Research, Homi Bhabha Road, Mumbai 400 005, India

Available online 2 May 2006

Abstract

These notes are intended to provide a pedagogical introduction to the abelian sandpile model of self-organized criticality, and its related models. The abelian group, the algebra of particle addition operators, the burning test for recurrent states, equivalence to the spanning trees problem are described. The exact solution of the directed version of the model in any dimension is explained. The model's equivalence to Scheidegger's model of river basins, Takayasu's aggregation model and the voter model is discussed. For the undirected case, the solution for one-dimensional lattices and the Bethe lattice is briefly described. Known results about the two dimensional case are summarized. Generalization to the abelian distributed processors model is discussed. Time-dependent properties and the universality of critical behavior in sandpiles are briefly discussed. I conclude by listing some still-unsolved problems.

Keywords: Abelian; Sandpile; Avalanches; Self-organized criticality; Dissipation; River networks

Self-organized criticality

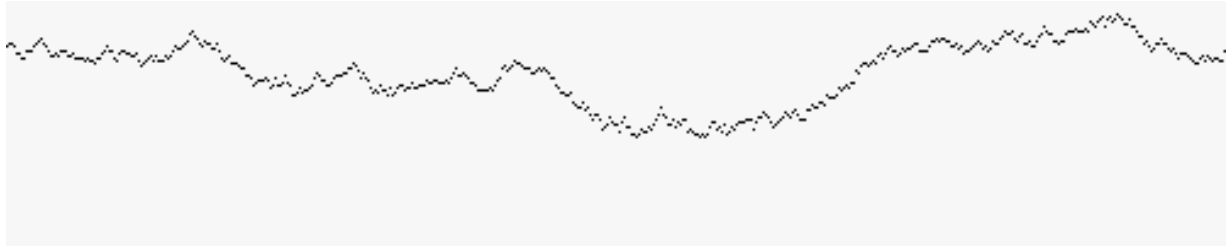
In physics, **self-organized criticality** (**SOC**) is a property of dynamical systems that have a critical point as an **attractor**. Their macroscopic behavior thus displays the spatial and/or temporal **scale-invariance** characteristic of the critical point of a **phase transition**, **but without the need to tune control parameters** to a precise value, because the system, effectively**, tunes itself as it evolves towards criticality**.

The concept was put forward by Per Bak, Chao Tang and Kurt Wiesenfeld ("BTW") in a paper published in 1987 in Physical Review Letters, and is considered to be one of the mechanisms by which complexity arises in nature. Its concepts have been enthusiastically applied across fields as diverse as **geophysics, physical cosmology, evolutionary biology and ecology, bio-inspired computing and optimization (mathematics), economics, quantum gravity, sociology, solar physics, plasma physics, neurobiology and others**.
SOC is typically observed in **slowly driven non-equilibrium** systems with a **large number of degrees of freedom** and **strongly nonlinear dynamics**. Many individual examples have been identified since BTW's original paper, but to date there is no known set of general characteristics that guarantee a system will display SOC. [1]

[1] Wikipedia

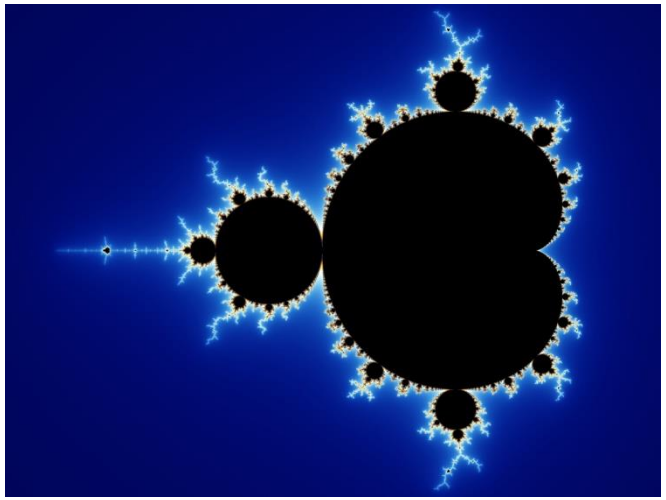
Self-organized criticality

Fractals!



Fractal simulation[2]

1. Scale invariant
2. Steady state (overall properties are roughly unchanged over the time scale of observation)



Fractal simulation[2]

[2] Wikipedia

Self-organized criticality

1. Scale invariant
2. Steady state (overall properties are roughly unchanged over the time scale of observation)
3. **Non-Equilibrium! (they are open and dissipative systems which require input of energy from outside at a constant rate to offset the dissipation)**

[3] Theoretical studies of self-organized criticality, Deepak Dhār, Physica A, DOI: 10.1016/j.physa.2006.04.004

Self-organized criticality

1. Individual events must be statistically independent spatially and temporally distributions leading to random white time distributions.

2. Size or occurrence frequency distribution must be scale-free and be characterized by a power law function over some size Range.[3]

3. Seeing Power low without any fine-tuning of parameters during its dynamics.

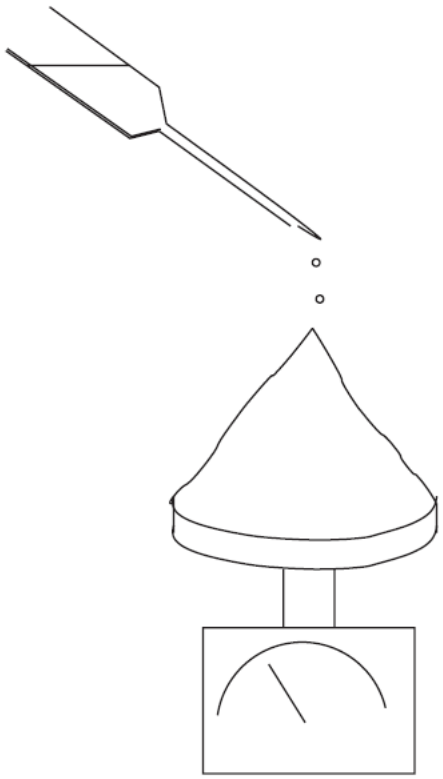
4. It must be such that the systems under their natural evolution are driven to a state at the boundary between the stable
and unstable states.[4]

[4] Theoretical studies of self-organized criticality, Deepak Dhār, Physica A, DOI: 10.1016/j.physa.2006.04.004

[3] Self-Organized Criticality, https://www.youtube.com/watch?v=KnOkkC4QND8

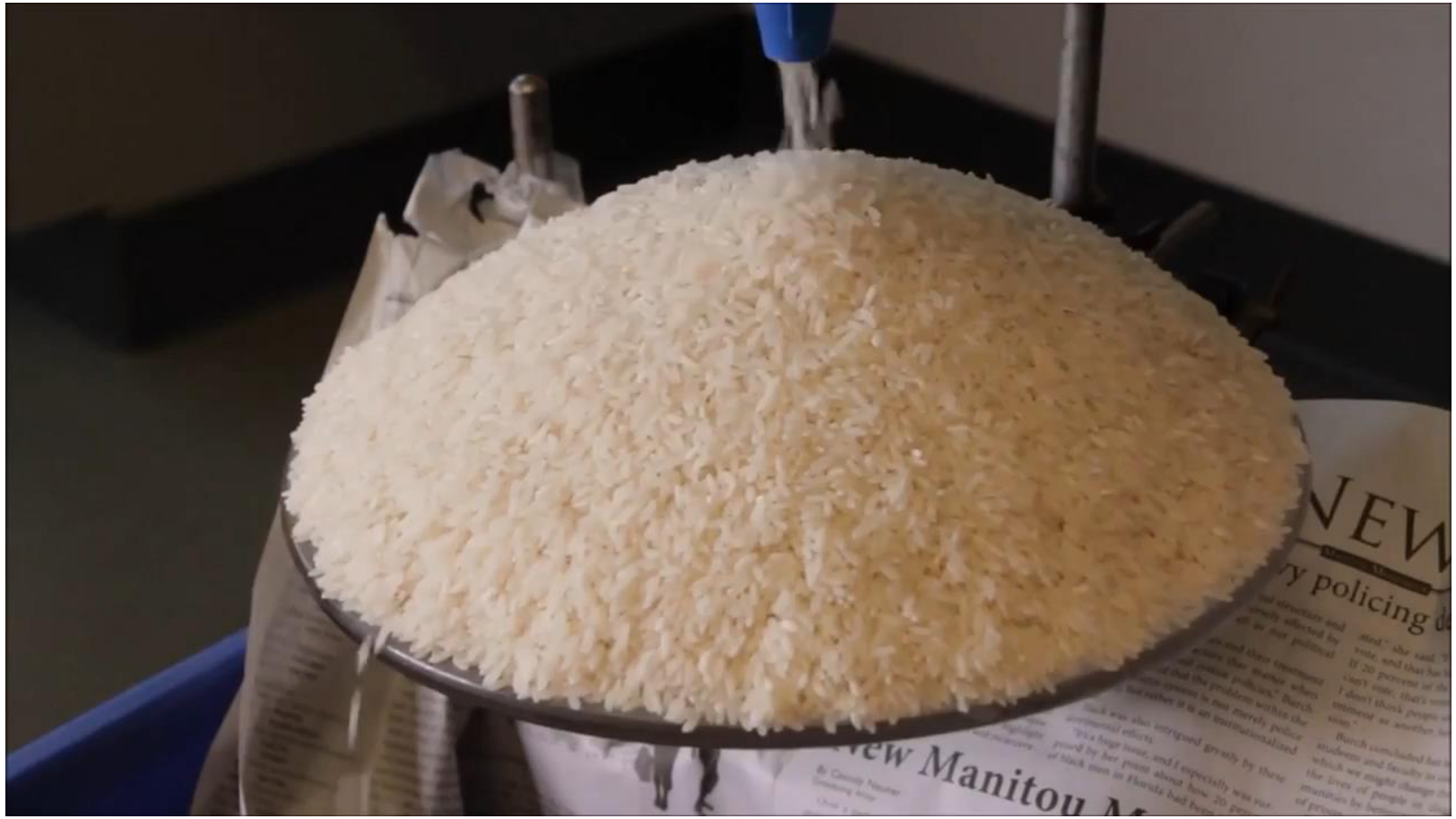
Simple Example:

Sandpile Model



[5] Theoretical studies of self-organized criticality, Deepak Dhār, Physica A, DOI: 10.1016/j.physa.2006.04.004

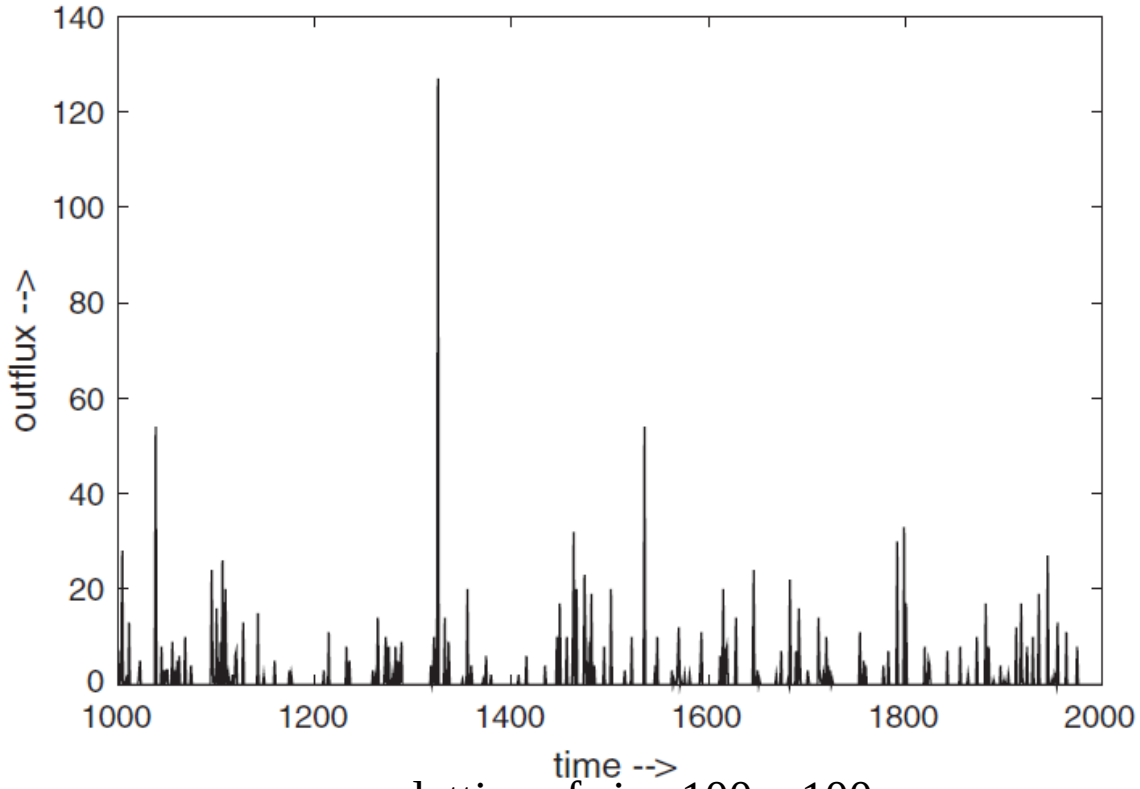
Self-organized criticality
Sandpile Model



[6] Self-Organized Criticality, https://www.youtube.com/watch?v=KnOkkC4QND8

Self-organized criticality
Sandpile Model

D. Dhar / Physica A 369 (2006) 29–70



square lattice of size 100 x 100

Sand added to system by constant small rate BUT! It leaves the system in very irregular manner.

SOC ideas have been applied, e.g. models of forest fires, biological evolution, brain activity, etc.

[7] Theoretical studies of self-organized criticality, Deepak Dhār, Physica A, DOI: 10.1016/j.physa.2006.04.004

Simulation of Sandpile Model

4	2	4	3
2	3	4	4
4	1	2	2
3	1	3	4

Add a grain →

4	2	4	3
2	3	5	4
4	1	2	2
3	1	3	4

Reach the threshold →

Then Topple!

4	2	5	3
2	4	1	5
4	1	3	2
3	1	3	4

4	3	1	5
2	4	3	1
4	1	3	3
3	1	3	4

Threshold = 4 grains

Reach the thresh →

Then Topple!

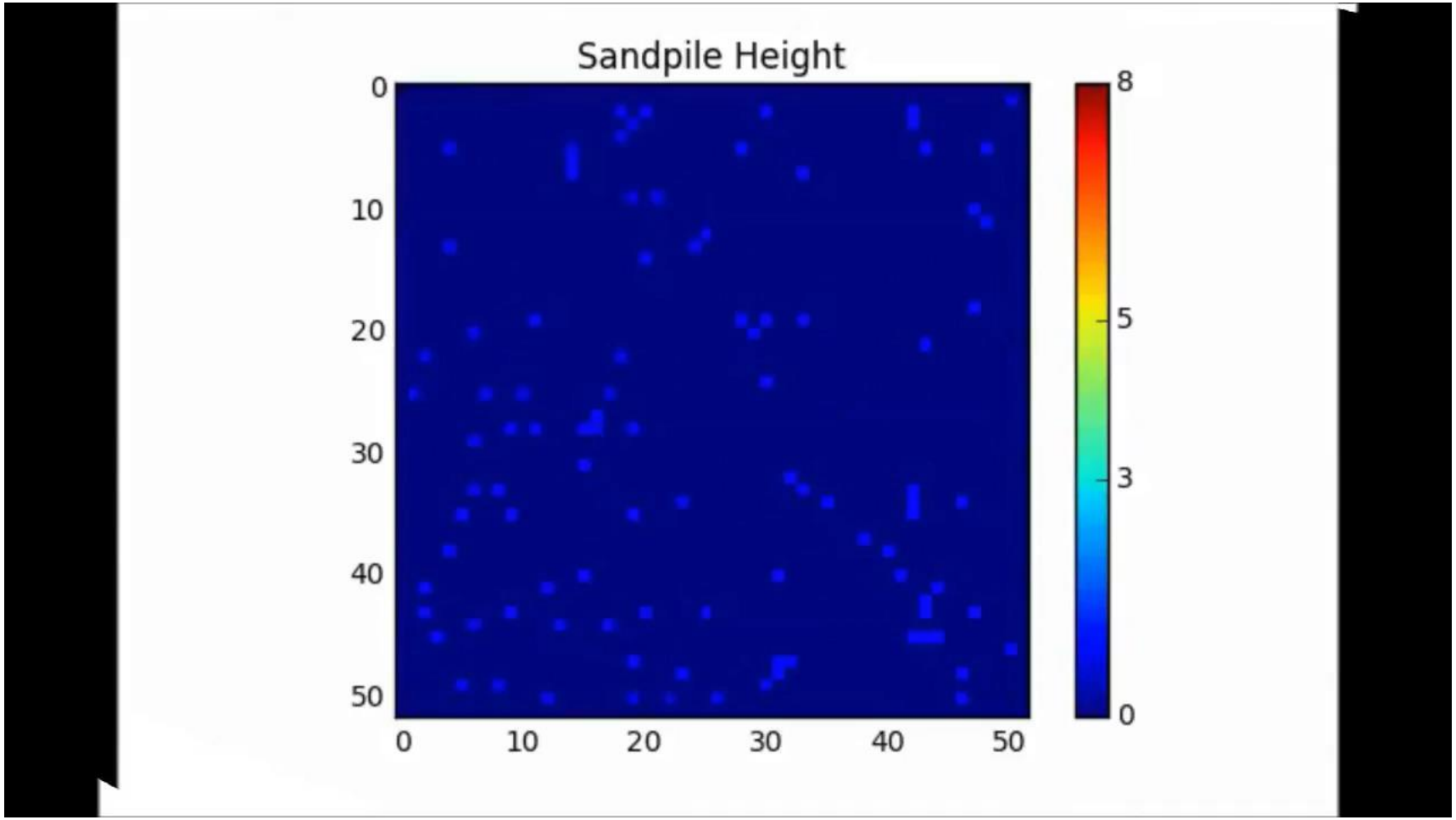
4	3	2	1
2	4	3	2
4	1	3	3
3	1	3	4

Four Topples
Three steps!

Steady State!

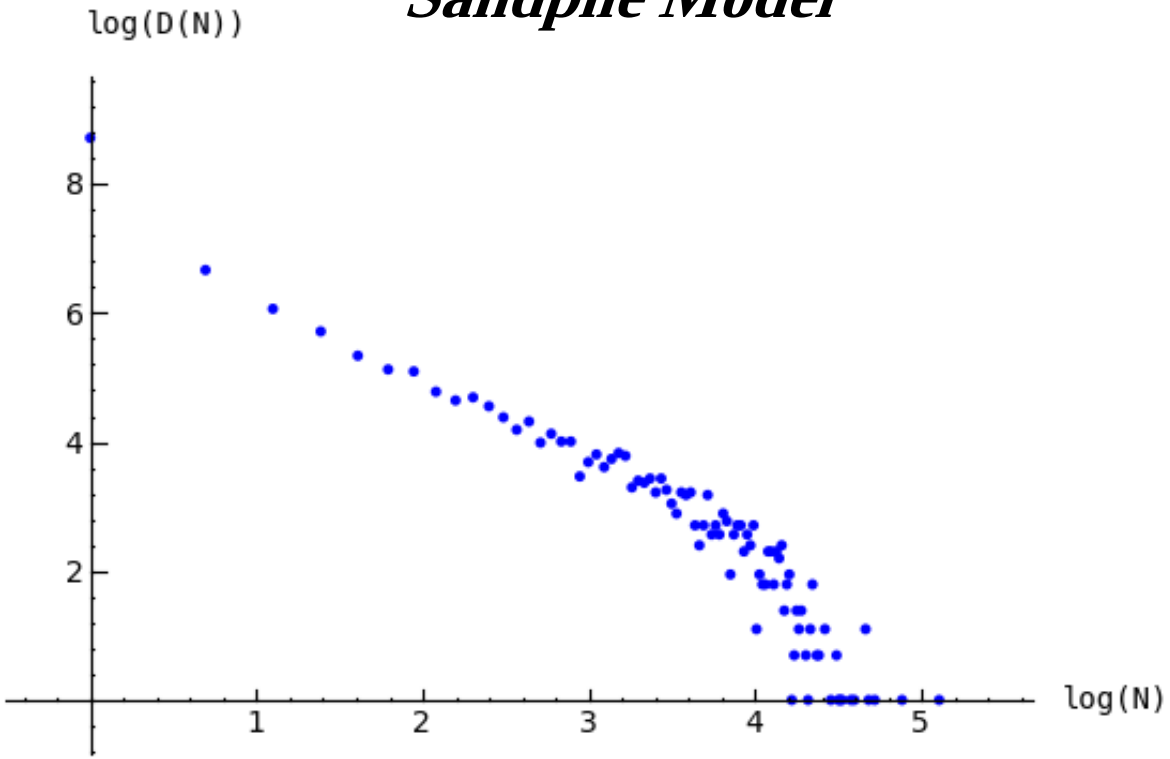
[8] Theoretical studies of self-organized criticality, Deepak Dhār, Physica A, DOI: 10.1016/j.physa.2006.04.004

Simulation of Sandpile Model



[9] Self-Organized Criticality, https://www.youtube.com/watch?v=KnOkkC4QND8

Self-organized criticality
Sandpile Model



Distribution of avalanche sizes[10]

Slope = 1.14

http://doc.sagemath.org/html/en/thematic_tutorials/sandpile.html

[10] Self-Organized Criticality, http://doc.sagemath.org/html/en/thematic_tutorials/sandpile.html

Randomness in Biology

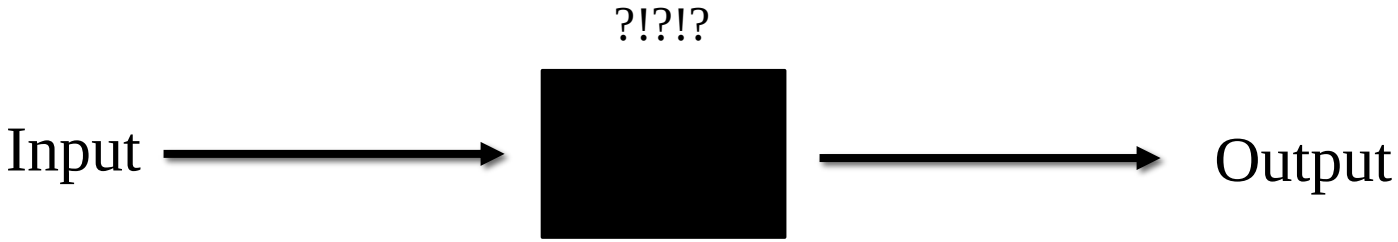
Dr. Mukund Thattai | NCBS

Genomics, mechanism and function of eukaryotic membrane traffic

"The idea is to look for ways that can transform molecular interactions, biochemical activities and biophysical mechanisms into logical and informational structures and processes. This will lead to an understanding of the cell as a logical and computational machine." *– Paul Nurse, Great Ideas of Biology, 2003.*

How does cellular complexity emerge from microscopic disorder? As a physicist practicing biology, I am interested in how cells are organised and function. I study the dynamic endomembrane organelles of eukaryotic cells, and the network of vesicles that traffic cargo between them. I wish to understand how local molecular interactions generate the global membrane traffic network.

What is randomness ?



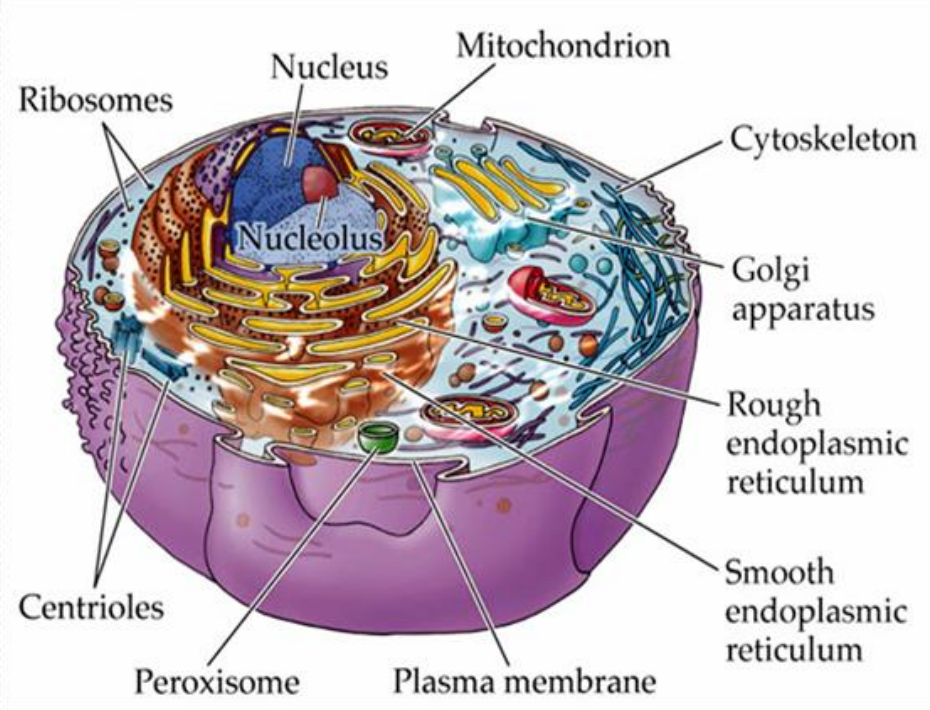
Even if your input is steady your output has fluctuations

This fluctuations are unavoidable

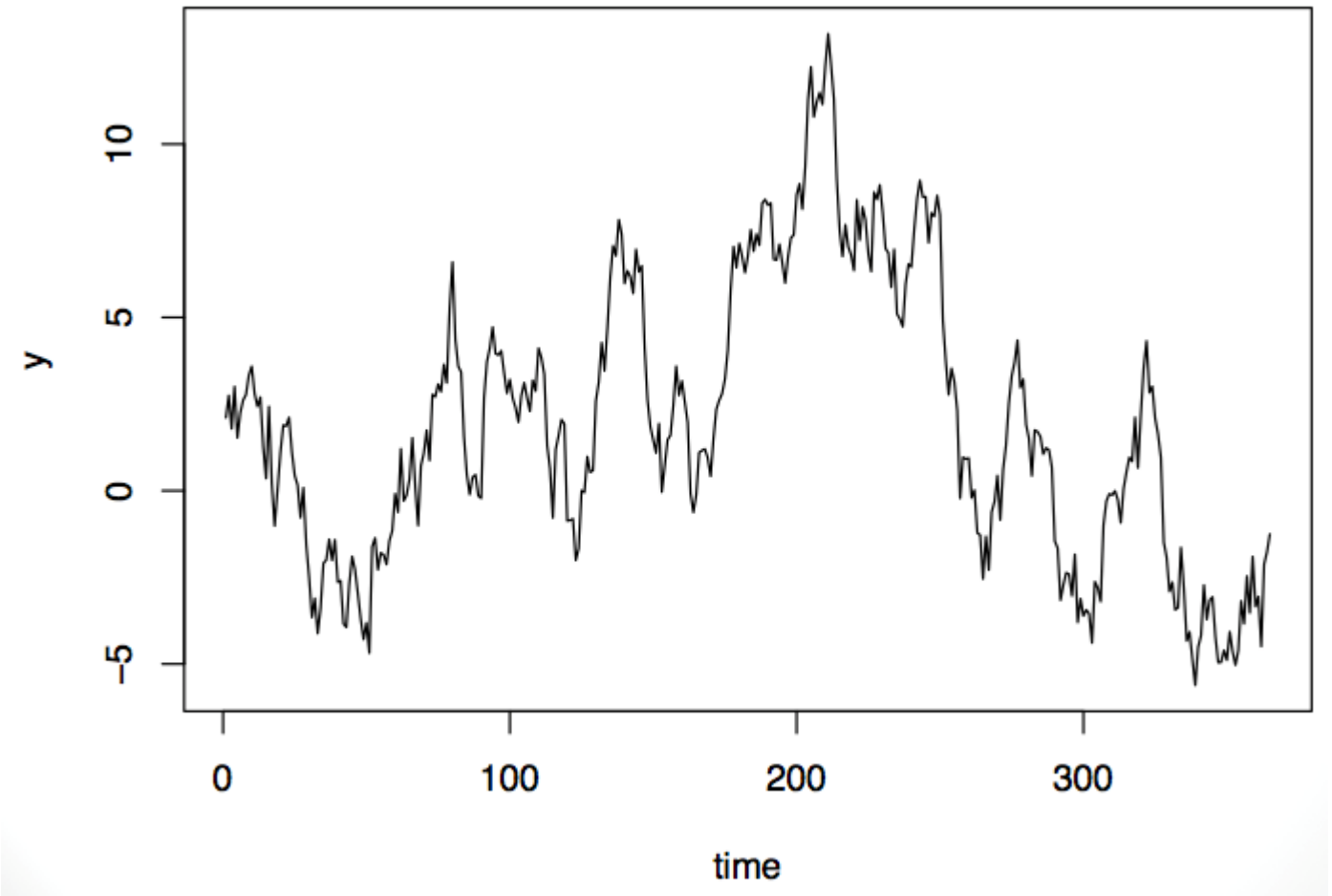
A cell as physical system

Biological systems are such system that you can see obviously statistical fluctuations == Stochastic Process

A cell has very very small size, around Nano meter!
THEN! A little fluctuations has big impact on your system.



What is stochastic process?



What is stochastic process

Is that curve a stochastic process ?
If we see similar that curve would it be a stochastic process ?

NO!

If you run a system for several times with same initial conditions, and you get different final results it means final results in not reproducible,

This is a stochastic process

Like Temperature in room, particles with Brownian motions.

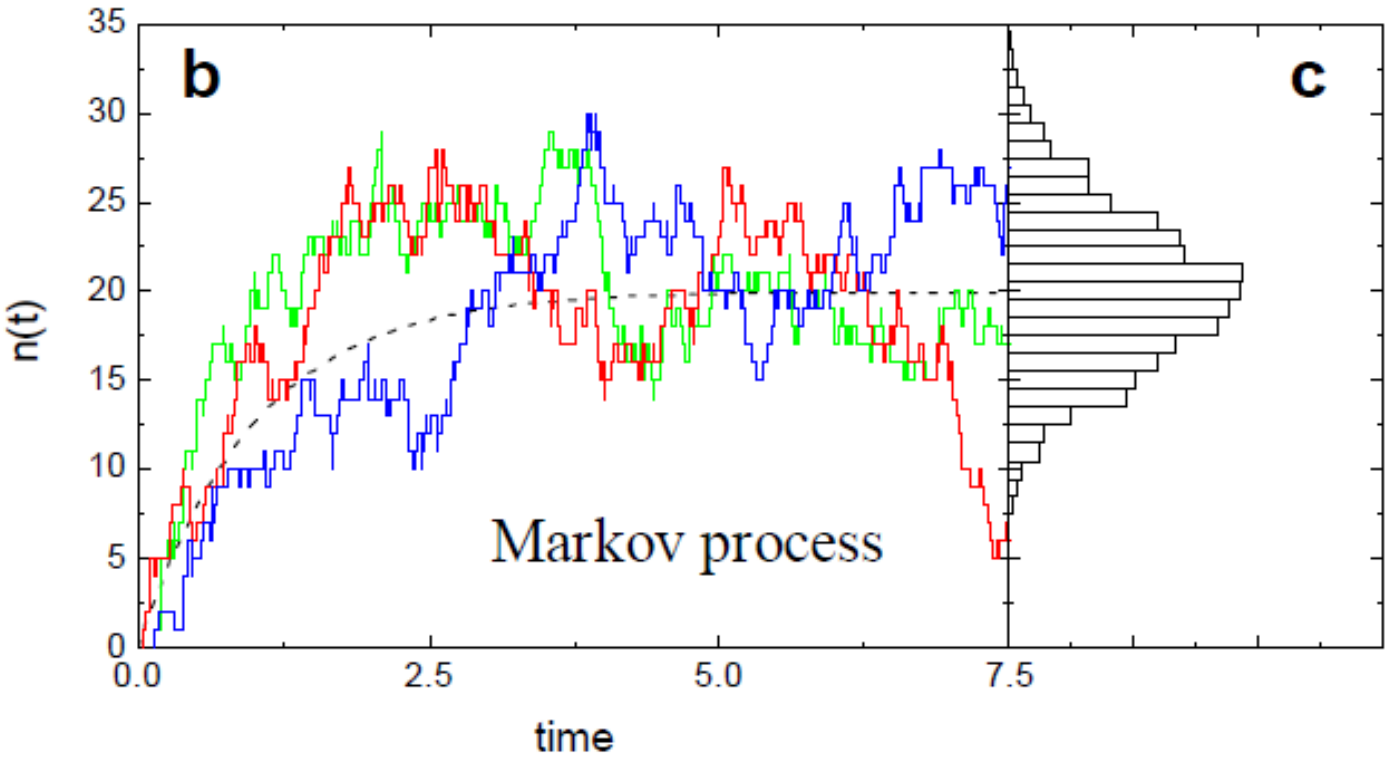
A simple chemical reaction:

$$\frac{dn}{dt} = k - \gamma n \equiv f_n - g_n .$$

Suppose a specific molecule x created by k and destroyed with γ

n = total number of molecules
k = creation rate
γ = destruction rate

How to get distribution function

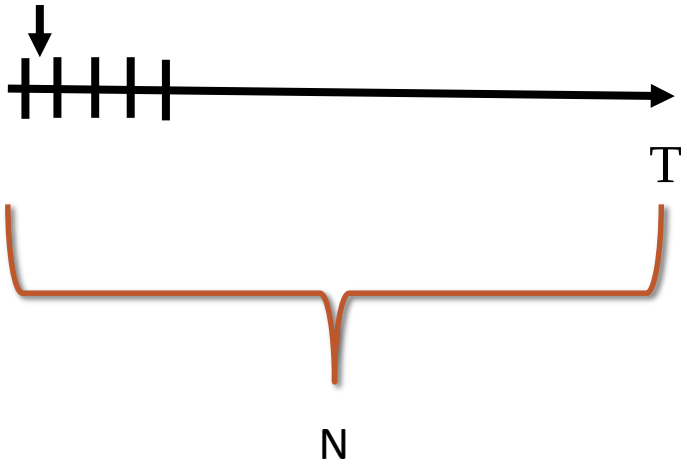


If we ran several experiments of this kind, recording the number of molecules present after some fixed time had elapsed, we would find a distribution of possible values.

[12] The origin and consequences of noise in biochemical systems, A. van Oudenaarden and Mukund Thattai , MIT– October 2004 , 7.81/8.591/9.531 Systems Biology

Probabilistic formulation of reaction kinetics: the Master Equation

The chance that the reaction occur is $\frac{r * T}{N} = r * dt$



r = reaction occurrence rate
T = large time interval

Number of reaction occurrence in average = r *T

The probability of reaction with rate r occurring in a small time interval dt is just r*dt .

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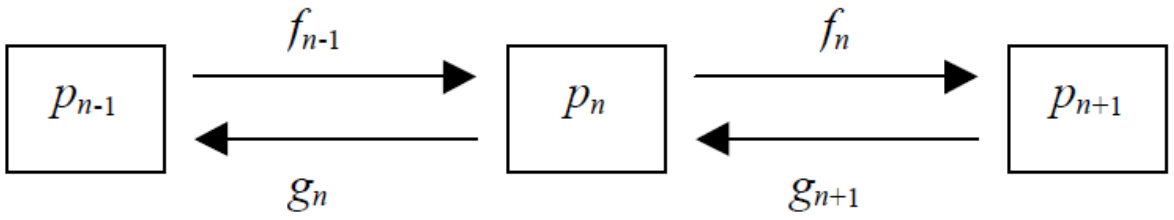
Master equation

consider an ensemble of identical systems, each having the same initial conditions

$P_n(t)$ the number of these systems which have precisely n molecules at time t.

$$\frac{dp_n}{dt} = -(f_n + g_n)p_n + f_{n-1}p_{n-1} + g_{n+1}p_{n+1}\,.$$

Master equation



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Moments of the probability distribution $P_n(t)$

$$\frac{d}{dt}\langle n\rangle = \frac{d}{dt}\sum np_n = -k\sum np_n + k\sum np_{n-1} - \gamma\sum n^2 p_n + \gamma\sum n(n+1)p_{n+1}$$

$$\frac{d}{dt}\langle n\rangle = k - \gamma\langle n\rangle .$$

The mean molecule number still obeys the deterministic equation.

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Steady state

$$dp_n/dt = 0. \qquad 0 = -(k+\gamma n)p_n + kp_{n-1} + \gamma(n+1)p_{n+1}$$

setting $\bar{n} = k/\gamma$,

$$(n+1)p_{n+1} - \bar{n}p_n = np_n - \bar{n}p_{n-1}.$$

$$p_n = \frac{\bar{n}}{n}p_{n-1} = \frac{\bar{n}^2}{n(n-1)}p_{n-2} = \ldots = \frac{\bar{n}^n}{n!}p_0 \quad \Rightarrow \quad \sum p_n = p_0 \sum \frac{\bar{n}^n}{n!} = p_0 e^{\bar{n}}$$

$$p_n = \frac{\bar{n}^n}{n!}e^{-\bar{n}} \qquad \bar{n} = k/\gamma$$

The Poisson distribution

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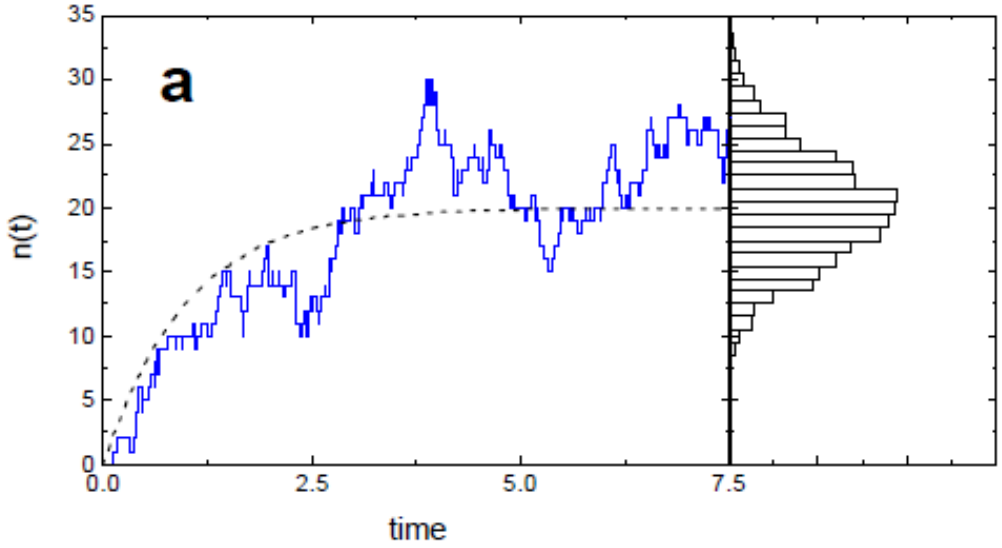
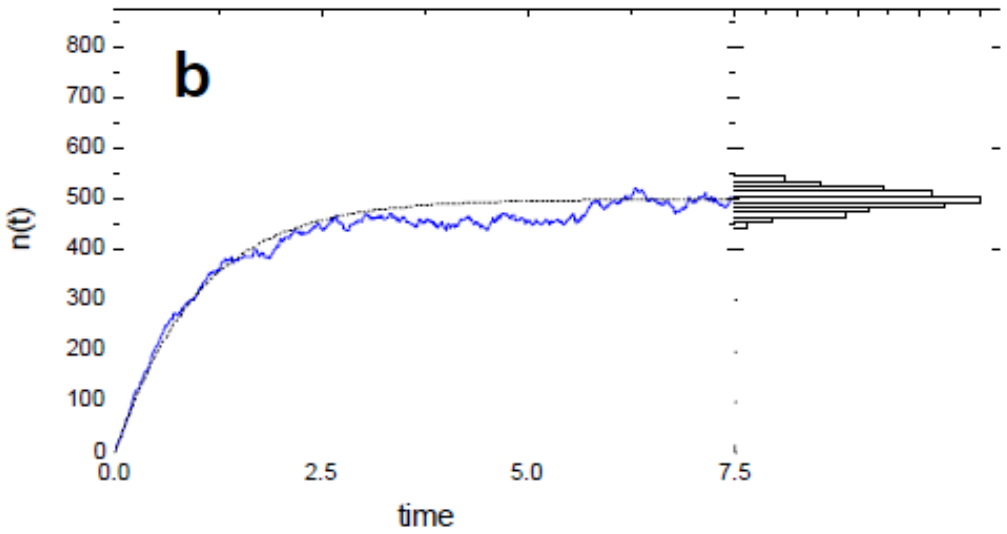
Fluctuation can be neglected as the number of molecules involved increases





The limit of large numbers

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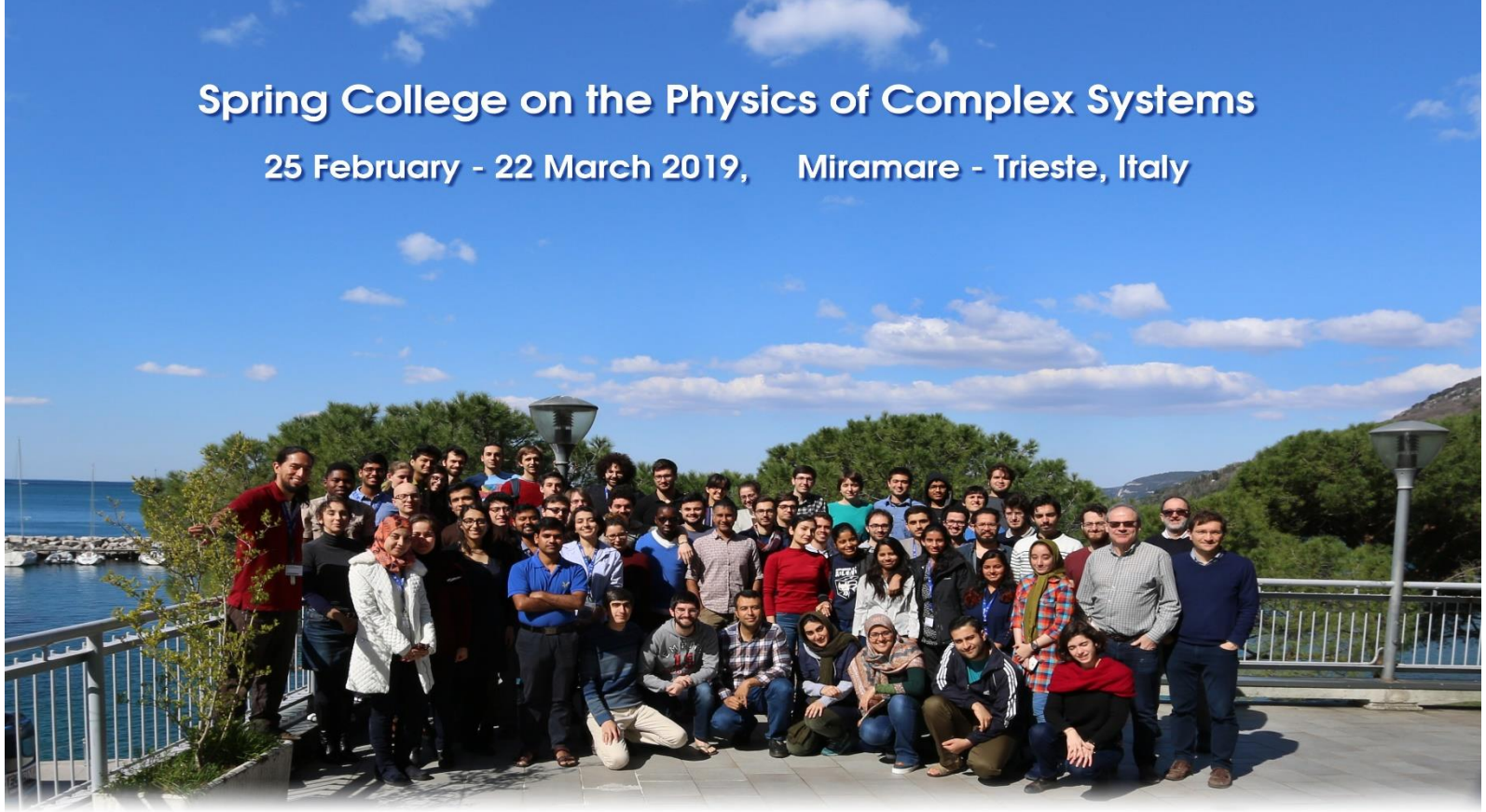

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Thanks!