REPORT ON IHP-Trimester T1-2015

"DISORDERED SYSTEMS, RANDOM SPATIAL PROCESSES AND SOME APPLICATIONS"

ORGANIZERS

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1. SUMMARY

The trimester brought together scientists working on the following three topical areas, with strong common cultural roots and wide research interest intersections:

A. probabilistic methods on random spatial processes, for instance on growth models, percolation, coalescence, non-equilibrium phase transitions.

B. statistical mechanics of interacting particle systems, especially disordered models like spin glasses, diluted systems, directed and pinned polymers.

C. "complex systems" approached with mathematical and physical methods, in particular agent based models applied to socio-economic problems, inverse problems, multi-fractal models.

The program, anchored around those three main topics and subtopics, featured the following activities:

- 1 introductory school ar CIRM, Marseille
- 14 thematic courses
- 3 one-week workshops
- 3 public lectures

A COMPLETE LIST OF PARTICIPANTS WITH THEIR AFFILIATION CAN BE FOUND IN THE WEB SITE OF THE INSTITUT HENRI POINCARE:

http://www.ihp.fr/en/CEB/T1-2015#jTab3

2. ACTIVITIES

We now summarize the content of each activity. Besides regular activities the trimester participants had the chance to discuss in several research group meetings.

Introductory School

The school was held during the period January 5th - 9th at CIRM, Marseille. There were 5 lectures who gave six-hour courses on some of the main topics of the trimester.

Invited lecturers:

E. Agliari "Random walks: theory, techniques and applications"

The first part of these lectures is devoted to diffusion processes and related models. In particular, we focus on random walks on graphs and we review the main analytical techniques for their study. Non-trivial phenomenologies (e.g., splitting between local and average properties, two-particles type problem) emerging when random walks are set in highly inhomogeneous structures (e.g., quasi-self-similar graphs, combs) are also discussed. In the second part of these lectures we highlight a close connection between the random walk problem and a series of fundamental statistical-mechanics models (e.g., the oscillating network, the free scalar field, the spherical model). In fact, the latter are described by a Hamiltonian which is linear in the adjacency matrix related to the embedding structure, in such a way that the main concepts and parameters characterizing random walks (e.g., recurrence and transience, as well as the spectral dimension) also affect the properties of these models. The strong analogies between diffusion theory and (mean-field) statistical mechanics is further deepened from a methodological perspective: using the Curie-Weiss model and the Sherrington-Kirckpatrick model, as prototypes for simple and complex behaviors, respectively, we will show how to solve for their free energy by mapping this problem into a random-walk framework, so to use techniques originally meant for the latter. Finally, we present two examples of statistical-mechanics models where the topics described above come into play. Both examples are inspired by quantitive sociology applications.

L.P. Arguin "Extrema of log-correlated random-variables: principles and examples"

The study of the distributions of extrema of a large collection of random variables dates back to the early 20th century and is well established in the case of independent or weakly correlated variables. Until recently, few sharp results were known in the case where the random variables are strongly correlated. In the last few years, there have been conceptual progress in describing the distribution of extrema of the log-correlated Gaussian fields. This class of fields includes important examples such as branching Brownian motion and 2D the Gaussian free field. In this series of lectures, we will study the statistics of extrema of the log-correlated Gaussian fields. The focus will be on explaining the guiding principles behind the results. We will also discuss why these techniques are expected to be applicable to a variety of problems such as the maxima of characteristic polynomials of random matrices and more, boldly, the maxima of the Riemann Zeta function.

A. Cavagna "Collective behaviour in biological systems"

Introduction: a phenomenon on many scales, fundamental questions, physics vs biology, the problem of scalability, more is different - small vs large groups, empirical observations. Structure: relevant observables, polarization and global order, radial correlation function, spatial distribution of the neighbours, topological vs metric interaction, cognitive vs sensory bottlenecks, the problem of the border. Correlation: interaction vs correlation, relevance of behavioural fluctuations, velocity correlation function, what is the correlation length, scaling relations, when the group is more than the sum of its parts, scale-free correlations, orientation vs speed correlations, spontaneous symmetry breaking, statistical inference, basic relations in probability, general Bayesian framework, what does it mean to fit a model, the problem of the prior, model selection and the Occam razor, why you should keep your model simple, maximum entropy method for living groups, the minimal model compatible with the data, how to cope with motion - spins vs birds, spin wave approximation, maximum entropy for orientation, maximum entropy for speed, near a critical point?

I. Corwin "Integrable probability"

A number of probabilistic systems which can be analyzed in great detail due to certain algebraic structures behind them. These systems include certain directed polymer models, random growth process, interacting particle systems and stochastic PDEs; their analysis yields information on certain universality classes, such as the Kardar-Parisi-Zhang; and these structures include Macdonald processes and quantum integrable systems. We will provide background on this growing area of research and delve into a few of the recent developments.

S. Redner "Applications of Statistical Physics to Coarsening and the Dynamics of Social Systems"

When the Ising model, initially at infinite temperature, is suddenly cooled to zero temperature, a rich coarsening dynamics occurs that exhibits surprising features. In two dimensions, the ground state is reached only about 2/3 of the time, and the evolution is characterized by two distinct time scales, the longer of which arises from topological defects. There is also a deep connection between domain topologies and continuum percolation. In three dimensions, the ground state is never reached. Instead domains are topologically complex and contain a small fraction of "blinker" spins that can flip perpetually with no energy cost. Moreover, the relaxation time grows exponentially with system size. Insights gained from the coarsening kinetics of spin systems will then be applied to social dynamics. I will first discuss the voter model, a paradigmatic description of consensus formation in a population of interacting agents. Each voter can be in one of two opinion states and continuously updates its opinion at a rate proportional to the fraction of neighbors of the opposite opinion. Exact results for the voter model on regular lattices will be reviewed. I'll then discuss extensions of the voter model that attempt to incorporate elements of reality, while remaining within the domain of analytically tractable. These will include: (i) the voter model on complex graphs, where consensus is generally achieved quickly and via an interesting route, (ii) the voter model with more than two states, where stasis can arise, (iii) the bounded compromise model, in which two agents average their real-valued opinions if the difference is less than a threshold and do not evolve otherwise, and (iv) the Axelrod model, in which agents possess a multi-dimensional opinion variable and two agents interact only if they share at least one voting trait.

Thematic Courses

The 14 thematic courses took place during the entire trimester. On avergare they were six-hours long. They either focussed on some specialized topics or they have been the chance for extended presentation of general novel approaches.

Invited lecturers:

F. Camia "Brownian Loops and Conformal Fields"

The main topic of these lectures is the continuum scaling limit of planar lattice models. One reason why this topic occupies an important place in the theory of probability and mathematical statistical physics is that scaling limits provide the link between statistical mechanics and (Euclidean) field theory. In order to explain the main ideas behind the concept of scaling limit, I will focus on a "toy" model that exhibits the typical behavior of statistical mechanical models at and near the critical point. This "toy" model, known as the random walk loop soup, turns out to be interesting in its own right. It can be described as a Poissonian ensemble of lattice loops, or a lattice gas of loops since it fits within the ideal-gas framework of statistical mechanics. After introducing the model and discussing some interesting connections with the discrete Gaussian free field, I will present some results concerning its scaling limit, which leads to a Poissonian ensemble of continuum loops known as the Brownian loop soup. The latter was introduced by Lawler and Werner, and is a very interesting object with connections to the Schramm-Loewner Evolution and various models of statistical mechanics. In the second part of the lectures, I will use the Brownian loop soup to construct a family of functions that behave like correlation functions of a conformal field. I will then use these functions and their derivation to introduce the concept of conformal field and to explore the connection between scaling limits and conformal fields.

A. De Masi "Stochastic particle systems with confining forces",

I will consider stochastic evolutions of particles that are confined in a bounded region by means of different mechanisms at the boundary. The motivation comes from one of the basic questions in statistical mechanics concerning the structure of states which are stationary but not in thermal equilibrium. These states are characterized by the presence of a steady current flowing through the system and the Fouries (or Fick) law is expected to hold. I will present different ways to impose a current and then I will discuss and analyze the different effects so produced both at the microscopic and macroscopic level. Rather surprisingly, these studies have generated many interesting problems both mathematically and conceptually. There are many papers on this subject and I will focus on some of them.

H. Duminil-Copin "Geometric representations of low-dimensional lattice spin systems"

In this course, we will review recent results in the theory of geometric representations of low-dimensional spin systems such as Potts, spin O(n) and Ising models. We will introduce random-cluster models, loop O(n)-models and random current representations and will explain how these models can be used to study the spin models at criticality and determine in particular whether their phase transition is continuous or not.

F. Guerra "Equilibrium and off equilibrium properties of ferromagnetic and disordered statistical mechanics systems"

A self-contained review will be given about the equilibrium and off equilibrium properties of statistical mechanics systems, both in the case of ferromagnetic and disordered ones. A systematic use of interpolation arguments and convexity will be the main tool. The case of mean field will be treated throughly. The possible extensions to short range interaction will be pointed out.

G. Jona Lasinio "Macroscopic Fluctuation Theory",

Stationary non-equilibrium states describe steady flows through macroscopic systems. Although they represent the simplest generalization of equilibrium states, they exhibit a variety of new phenomena. Within a statistical mechanics approach, these states have been the subject of several theoretical investigations, both analytic and numerical. The macroscopic fluctuation theory, based on a formula for the probability of joint space-time fluctuations of thermodynamic variables and currents, provides a unified macroscopic treatment of such states for driven diffusive systems. The course will give a review of this theory including its main predictions and some relevant applications.

A. Kupiainen, "Quantum Field Theory for Probabilists"

The course consists of two parts. In the first one we give an introduction to the Renormalization Group as a method to study quantum field theory and statistical mechanics models at critical temperature. In the second part we apply these ideas to proving existence and uniqueness of solutions of stochastic PDE's driven by space time white noise. Examples are the KPZ and \phi^4_3 models.

C. Newman, "Riemann Hypothesis and Statistical Mechanics"

In this minicourse we discuss some old results concerning the location of zeros of partition functions (or moment generating functions) in certain statistical mechanics models and their possible connections to the Riemann Hypothesis (RH). A standard reformulation of the RH is as follows. The (two-sided) Laplace transform of a certain specific function \Psi on the real line is automatically an entire function on the complex plane; the RH is equivalent to this transform having only pure imaginary zeros. Also \Psi is a positive integrable function, so (modulo a multiplicative constant C) is a probability density function. A (finite) Ising model (with pair ferromagnetic interactions) is a specific type of probability measure P on the points S=(S_1,...,S_N) with each S_j = +1 or -1. The Lee-Yang theorem implies that that for non-negative a_1, ..., a_N, the Laplace transform of the induced probability distribution of a_1 S_1 + ... + a_N S_N has only pure imaginary zeros. The big question here is whether it's possible to find a sequence of Ising models so that the limit as N tends to \infty of such distributions has density exactly C \Psi. The course will focus on questions of this sort. Here are some background references: C. Newman, Z. f. Wahrschein. (Prob. Th. Re. Fields) 33 (1975) 25-93 (see, esp. p. 90) C. Newman, Proc. Amer. Math. Soc. 61 (1976) 245-251 C. Newman, Constr. Approx. 7 (1991) 389-399 A. Odlyzko, Num. Algorithms 25 (2000) 293-303.

E. Presutti "Phase transitions in systems with spatially non homogeneous interactions", I will describe recent results and works in progress on the absence/presence of phase transitions in systems with spatially non homogeneous interactions. In a first part I will consider the d ≥ 2 nearest neighbor ferromagnetic Ising model under the action of a non negative, space dependent magnetic field. It will be shown that at low temperatures the occurrence of a phase transition depends critically on the rate at which the magnetic field vanishes at infinity. In a second part I will consider two dimensional systems with "very small, short range vertical interactions" while the horizontal interaction is described by a two body Kac potential. I will first study the Ising case and then extend the analysis to a continuous system where on each horizontal line there is a system of hard rods with attractive Kac pair interaction.The goal is to prove that such a system has the phase transition predicted by van der Waals, which at this moment is still under study.

C. Rovelli "Statistical mechanics of gravity and thermodynamical origin of time"

Thermodynamics and statistical mechanics are universal, and we expect them to apply also to gravitational phenomena. But our understanding of gravity is given by general relativity, where temporal evolution is given in a form incompatible with standard thermodynamics and statistical mechanics. All principles of thermodynamics become wrong or meaningless in gravity: temperature fails to be constant at equilibrium (Tolman effect), energy is ill-defined, and it is not clear which among the many notions of time, if any, may underpin the second law. I discuss partial successes and open problems in the effort to extend the foundations of thermodynamics and statistical mechanics to a wider context encompassing relativistic gravity. Among the key ideas aiming to do so, is the idea that the physical flow of time of the second law is determined by, rather than determines, the statistical state of a covariant system. In the quantum field theoretical context, it is given by the Tomita flow generated by a state on the observables' algebra, and the origin of time's flow is related, via a theorem by Alain Connes, to the underlying quantum non-commutativity of the observable algebra.

T. Sasamoto
"The one-dimensional KPZ equation: its height distribution and algebraic structures"

In 1986, Kardar, Parisi and Zhang introduced a non-linear stochastic PDE to describe dynamics of interface motion. This KPZ equation has been studied intensively and extensively since then, but recently its one-dimensional version has been attracting particular attention because of its tractability and connections to various areas of mathematics and physics. In this lecture I will explain part of these developments . I will mainly focus on the height distribution for the KPZ equation. I will also explain the underlying algebraic structure such as random matrix theory, Schur process and Macdonald process in connection to related discrete interacting particle systems like ASEP and q-boson zero range process.

H. Spohn "Integrable stochastic models in the Kardar-Parisi-Zhang universality class"

The course covered:
-- determinantal processes and the statistical mechanics of line ensembles,
-- growth models and directed polymers in a random medium,
-- the Kardar-Parisi-Zhang stochastic PDE, sharp wedge initial conditions,
-- duality for interacting Brownian motions and other models in the KPZ class,
-- multi-component KPZ equations.

D. Stein "Short-range spin glasses: results and applications"

The aim of this lecture series is to introduce the subject of spin glasses, and more generally the statistical mechanics of quenched disorder, as a problem of general interest to physicists and mathematicians from multiple disciplines and backgrounds. Despite years of study, the physics and mathematics of quenched disorder remains poorly understood, and represents a major gap in our understanding of the condensed state of matter. While there are many active areas of investigation in this field, I will narrow the focus of this series to some aspects of our current level of understanding of the low-temperature equilibrium structure of realistic (i.e., finite-dimensional) spin glasses. I will begin with a brief review of the basic features of spin glasses and what is known experimentally. I will then turn to the problem of understanding the nature of the spin glass phase --- if it exists. The central question to be addressed is the nature of broken symmetry in these systems. Parisi's replica symmetry breaking approach, now mostly verified for mean field spin glasses, attracted great excitement and interest as a novel and exotic form of symmetry breaking. But does it hold also for real spin glasses in finite dimensions? This has been a subject of intense controversy, and although the issues surrounding it have become more sharply defined in recent years, it remains an open question. I will explore this problem, introducing new mathematical constructs such as the metastate along the way, as well as related questions such as the number of pure states and free energy fluctuations. If time permits, we will conclude with an examination of some of the applications of spin glass mathematics to problems in computer science, biology, and other fields.

R. Sun "Brownian web, Brownian net, and their universality"

The Brownian web is the collection of one-dimensional coalescing Brownian motions starting from every point in space-time. Originally conceived by Arratia in the context of the one-dimensional voter model and its dual coalescing random walks, the Brownian web has since been shown to arise in the scaling limit of many one-dimensional interacting particle systems with coalescent interaction, including zero-temperature dynamics of Ising and Potts models, true self-avoiding random walks, drainage networks, Hastings-Levitov planar aggregation models, and super-critical oriented percolation. The Brownian net is an extension of the Brownian web, which also allows for branching of the Brownian motions. It has been shown to arise in the scaling limit of many one-dimensional interacting particle systems with branching-coalescing interactions, including the voter model with selection, dynamics of Ising and Potts models with boundary nucleation, and one-dimensional random walks in i.i.d. space-time random environments. The goal of the lecture series is to introduce the Brownian web and the Brownian net, discuss some of their properties, and study how they arise in the scaling limits of various models of interest.

O. Zeitouni "Extrema of log-correlated Gaussian fields: from branching processes to the Gaussian free field"

This mini-course will review the use of the second moment method in proving limit laws for extremes of the two dimensional GFF; parallels and differences with branching random walks will be discussed.

Workshops

The main events of the trimester have been the three workshops. Each workshop took place in one of the three months and was centered around one of the three legs of the program: applicatipon to socio-economic systems (January), disordered systems (February), interacting particle systems and non-equilibrium (March).

Workshop1:
"Statistical Physics Methods in Social and Economic Systems",
January 26th to 30th

Invited speakers:

A. Barra "Insights in Economical Complexity: the hidden role of migrants small worlds"
D. Delli Gatti "Macroeconomic Debates: The State of the Art and the Computational Way Ahead"
J. Donier "How people's decisions impact prices: Empirical evidence and theory of a square root"
M. Fedele "Interacting Models in Social Sciences and Health Screening Campaigns"
M. Gallegati "The Economics in Crisis"
S. Gualdi "Tipping points and monetary policy in a stylized macroeconomic agent-based model"
P. Jensen "Are models drawn from physics relevant for social systems?"
M. Marsili "Lost in diversification"
J-P. Nadal "Entanglement between Demand and Supply in Markets with Bandwagon Goods"
L. Pareschi "Mean field and Boltzmann control of socio-economic systems"
M. Pisati "The Unbearable Lightness of the Social Sciences: Current Practices and Possible Futures"
M. Rasetti "The Topological Field Theory of Data: a program towards a new strategy for data mining"
S. Redner "Statistics of Basketball Scoring and Lead Changes"
R. Sandell "Why Sociologists should (and increasingly want to) "make out" with the hard sciences."
A. Sirbu "A new dimension for democracy: egalitarianism in the rank aggregation problem"
M. Smerlak "Thermodynamics of economic inequalities: precariousness, volatility and stratification"
G. Toscani "Wealth and knowledge in multi-agent systems. A Kinetic approach"
C. Vernia "Trust social network from collective data: interaction vs independence, connectedness vs fragmentation."

Workshop 2:
"Spin Glasses, Random Graphs and Percolation",
February 16th to 20th

Invited speakers:

D. Alberici "Monomer-Dimer model on a class of random graphs"
L.P. Arguin "Maxima of log-correlated Gaussian fields and of the Riemann Zeta function on the critical line"

G. Ben Arous "Scaling limit for the ant in a labyrinth"
A. Bovier "Extremal Processes of Gaussian Processes Indexed by Trees"
W.K. Chen "On the uniqueness and properties of the Parisi measure"
F. Den Hollander "Annealed Scaling for a Charged Polymer"
H. Duminil-Copin "A new proof of exponential decay of correlations in subcritical percolation and Ising models"
C. Giberti "Limit theorems for Ising models on random graphs"
F. Guerra "Legendre structures in statistical mechanics"
R. van der Hofstad "Competition on scale-free random graphs"
M. Holmes "WARM graphs"
D. Ioffe "A quantitative Burton-Keane estimate under strong FKG condition"
N. Kistler, "A multiscale refinement of the second moment method"
E. Mingione "A Monomer-Dimer model with random weights on the complete graph"
D. Panchenko "Chaos in temperature in generic 2p-spin models"
A. Sakai "Critical correlation in high dimensions for long-range models with power-law couplings"
S. Starr "Spin glass techniques for non-Hermitian random matrices"
D. Stein "Rugged Landscapes and Timescale Distributions in Complex Systems"
R. Sun "Polynomial chaos and scaling limits of disordered systems"
F. Toninelli "A class of (2+1)-dimensional growth process with explicit stationary measure"
F. Zamponi "Exact computation of the critical exponents of the jamming transition"
L. Zdeborova "Percolation on sparse networks"

Workshop 3:
"Interacting Particles Systems and Non-equilibrium Dynamics"
March 9th to 13th

Invited speakers:

C. Bernardin "3/4 fractional superdiffusion of energy in a harmonic chain with bulk noises"
G. Carinci "Non-equilibrium via current reservoirs"
F. Comets "Cover time of the random walk on the 2-dimensional torus"
I. Corwin "Stochastic quantum integrable systems"
B. Derrida "Universal current fluctuations in non equilibrium systems"
Pablo Ferrari "Phase transition for the dilute clock model."
Patrick Ferrari "Height fluctuations for the stationary KPZ equation"
G. Giacomin "Synchronization phenomena and non equilibrium statistical mechanics: the Kuramoto model"
G. Jona Lasinio "Time dependent large deviations and thermodynamic transformations"
A. Kupiainen "Renormalizing Stochastic PDE's"
J Kurchan "Thermal dynamics and Darwinian dynamics",
H. Lacoin "Convergence to equilbrium for the exclusion process on the circle"
J. Lebowitz "Lee-Yang Zeros, Central limit Theorems and More"
R. Livi "Checking energy transport in new models",
C. Perez Espigarez "The spatial fluctuation theorem"
L. Rolla "Absorbing-state Phase Transitions: Challenges for Mathematicians"
E. Saada "Supercritical behavior of asymmetric zero-range process with sitewise disorder"
T. Sasamoto "Fluctuations for one-dimensional Brownian motions with oblique reflection"
H. Spohn "One-dimensional Kardar-Parisi-Zhang equation with several components"
J. Tailleur "What is the Pressure of an Active Particle Fluid?"
C. Toninelli "Kinetically constrained models: non-equilibrium dynamics"
D. Tsagkarogiannis "Current reservoirs in the simple exclusion process."

Public Lectures

The three public lectures took place on Thursday's afternoon of each workshop. They were intented as scientific presentations for scholars attending the workshops, but still accessible to the general public.

January 29, 2015 at 5 p.m.
— Jean-Philippe Bouchaud *"Crises économiques et financières : un point de vue de physicien"*

> « The Economic Crisis is a Crisis for Economic Theory » a récemment écrit Alan Kirman. La théorie en question affirme que les agents sont rationnels et les marchés sont « efficients » : les prix reflètent parfaitement, de manière non biaisée, toute l'information disponible. De tels marchés sont intrinsèquement stables : les bulles n'existent pas, les crises sont provoquées par des chocs exogènes, mais jamais induites par leur propre dynamique. Les modèles théoriques classiques ne peuvent accommoder l'idée de crises « endogènes ». Pourtant, cette vision idéale (idyllique ?) est remise en cause par de nombreuses observations empiriques qui suggèrent fortement que les fluctuations des marchés sont principalement d'origine endogène, amplifiées par de multiples boucles de rétroaction, certaines induites par des biais comportementaux, comme par exemple le mimétisme. Nous discuterons quelques modèles théoriques qui permettent d'éclairer utilement certains phénomènes économiques ou financiers. Nous montrerons aussi comment la modélisation et/ou la régulation des marchés financiers peuvent en elles-mêmes contribuer à leur instabilité. La (regrettable) complexité des systèmes économiques pose des questions scientifiques tout à la fois urgentes et fascinantes, pour lesquelles les concepts et les méthodes de la physique statistique semblent particulièrement adaptés.

February 19, 2015 at 5 p.m.
— Andrea Cavagna *"The seventh Starling: the Wonders of Collective Animal Behaviour"*

> The wonderful evolutions of the great flocks of birds across the skies of our cities, often in aerial duel with a falcon, are both a fascinating sight, and a scientific mystery. How does the flock keep its staggering cohesion? How can it take decisions, as changing direction, or landing on a tree, as a single organism? What are the behavioural rules each animal obeys to? Some of these questions were already asked by Pliny the Elder over two thousands years ago. Indeed, science has been puzzled for a long time by the fundamental mechanisms of collective animal behaviour, not only in the case of bird flocks, but also for fish schools, insect swarms, and mammal herds. In the last fifty years, a number of theories and mathematical models formulated by biologists, mathematicians and physicists, have tried to describe these phenomena. However, it has been for a long time very hard to evaluate the correctness of these theories, because of the scarcity of experimental data. Only very recently, thanks to the development of new technologies and computer algorithms, it has been possible to obtain quantitative data on the three dimensional movement of large flocks of birds. Starlings have offered the first and most beautiful case of study. Results of these researches have been surprising, and forced scientists to rethink some of the pillars taken for granted by the previous theories. It has been discovered that each single bird interacts with only a handful of neighbors, approximately seven. And yet, the simple behavioural rule of the seven starlings grants a perfect cohesion of a flock of thousands of birds. Moreover, the data revealed the origin of the marvelous collective response of flocks, able to react as one to the attack of predators and to transfer information across the group with the sharpest efficiency. In this lecture I will illustrate the main and most recent progresses of collective animal behaviour, a

cross-disciplinary field where biology, mathematics, computer science and physics meet and merge into an entire new discipline.

March 12, 2015 at 5 p.m.
— *Frank den Hollander "Comment mieux comprendre le comportement des réseaux complexes?"*

Partout dans le monde les gens sont connectés à travers des réseaux. Pensez à Internet, Facebook et Twitter, mais aussi au trafic routier, transport de marchandises, téléphone mobile et à l'électricité. Ces réseaux sont devenus indispensables à notre société moderne. Cependant, ils sont généralement de nature très complexe: grande taille, structure compliquée, très dynamiques, souvent surchargés, parfois imprévisibles, et des fois même vulnérables. Ceci est inquiétant. Pour mieux comprendre les réseaux complexes, les modéliser de façon adéquate, les contrôler et les optimiser de façon efficace, de toutes nouvelles idées sont nécessaires. Les mathématiques sont une arme puissante. Dans cet exposé, je vais donner des exemples de réseaux complexes, discuter de questions clés, et donner une impression de ce que les mathématiques ont à offrir. La combinaison "stochastique" (= l'art du hasard) et "algorithmique" (= l'art du calcul) forme la base pour une nouvelle perspective sur les réseaux. L'objectif final est de construire des réseaux intelligents.