Titles and abstracts for invited speakers

(In chronological order)

NetSci School

- **Mark Newman**

University of Michigan
Mon June 2, 9-10:15am and 1:30-3pm

"Networks: An introduction"

- **Melanie Mitchell** and **Vikram Vijayaraghavan**

Portland State University and University of California at Davis
Mon June 2, 10:30am-noon

"Introduction to Networks Lab"

Abstract: Students will experiment with creating networks and measuring their structural properties using interactive simulations. Students will also learn about various options for freely available network analysis software packages.

- **Airlie Chapman**

University of Washington
Mon June 2, 3:30-5pm

"Control Theory for non-specialists"

- **Mason Porter**

Oxford University
Tues June 3, 9-10:30am and 11am-noon

"Introduction to Multilayer Networks"

Abstract: In this presentation, I'll give an introduction to the study of multilayer networks, which is one of the burgeoning areas of network science and complex systems more generally. I'll present a general framework for multilayer networks that encompasses multiplex networks, networks of networks, and more; and I'll guide you through the rapidly growing and occasionally treacherous literature on multilayer networks. I'll also discuss the issue of multilayer data sets and indicate some important open problems. The main reference for my presentation is a review article that I have recently written with several of my collaborators: M. Kivel, A. Arenas, M. Barthelemy, J. P. Gleeson, Y. Moreno, and M. A. Porter, [2014], "Multilayer Networks", to appear in Journal of Complex Networks (arXiv:1309.7233).

- **Melanie Mitchell**

Portland State University
Tues June 3, 1:30-3pm

"The Complexity Explorer Project: MOOCs and Web-Based Curricula for Complex Systems"

Abstract: I will describe the Santa Fe Institutes Complexity Explorer project, which provides educational materials and free online courses (MOOCs) related to complex systems science. I will talk about the general landscape of MOOCs and specifically about my experience creating and running several MOOCs on the SFIs platform. I will also discuss the many curricular materials our team has developed for teaching students about complex systems, from high school through graduate school.

• **Yang-Yu Liu**
Harvard Medical School and Brigham and Womens Hospital
Tues June 3, 3:30-5pm

"Controllability and observability of complex systems"

Abstract: The ultimate proof of our understanding of complex systems is reflected in our ability to control them. Although control theory offers mathematical tools for steering engineered systems towards a desired state, a framework to control complex systems is lacking. In this talk I will show that many dynamic properties of complex systems can be quantitatively studied, via a combination of tools from control theory, network science and statistical physics. In particular, I will focus on two dual concepts, i.e. controllability and observability, of general complex systems. Controllability concerns our ability to drive the system from any initial state to any final state within finite time, while observability concerns the possibility to deduce the systems internal state from observing its input-output behavior. I will show that by exploring the underlying network structure of complex systems one can determine the driver (or sensor) nodes that with time-dependent inputs (or measurements) will enable us to fully control (or observe) the whole system.

NetSci Conference

—— Wednesday June 4 ——

• **Jon Kleinberg**
Cornell University
Weds June 4, 9-9:40am *__Keynote address__*

"Local Structure and Information Sharing in Large Social Networks "

• **Michael Kearns**
University of Pennsylvania
Weds June 4, 9:40-10:10am

"Behavioral Network Science"

• **Frank Schweitzer**
ETH Zurich
Weds June 4, 10:30-11am

"How we collaborate - A complex network approach"

Abstract: Collaboration networks are a widespread phenomenon: scientists collaborate in writing papers, firms announce research and development (R&D) alliances to generate

patents, developers join open source projects to produce, and to improve, software. Analysing large-scale datasets about the interaction of such actors allows us to reveal temporal patterns in their interaction. But, what is more important, we are able to link the structure and dynamics of such social networks to their performance. Success and failure can be defined both on the individual level, where we look e.g. into the career paths of scientists or the life cycles of firm collaborations, and on the global level, where we analyse e.g. the resilience of research areas or the pace of software projects. Our insights are developed based on concepts of complex networks which are merged with prediction methods developed in computer science. They only became possible after mining big data with fine-grained temporal resolution, to extend the network analysis beyond the established static and aggregated approach.

- **Jessica Flack**

University of Wisconsin, Madison
Weds June 4, 11-11:30am

"Collective Computation and Control in Social Systems"

- **Naoki Masuda**

University of Tokyo and University of Bristol
Weds June 5, 11:30am-noon

"Dominance hierarchy of worker ants as directed networks"

Abstract: Group-living animals, from insects to mammals, often form dominance hierarchy, which is a directed network. The direction of the link represents aggression by one individual on the other subordinate individual. Dominance hierarchy is considered to serve to regulate resource allocation such as food and mates within the group. In small groups of animals, it has been long known that the hierarchy is often perfectly linear, allowing unique ranking of the individuals. However, perfect linearity is often violated in large groups. In addition, large dominance hierarchy is not sufficiently understood mainly because most of the existing methods are not necessarily suitable for treating sparse networks observed in large groups. In this presentation, we analyse aggressive dominance hierarchy formed by worker ants as large directed networks and then discuss evolutionary implications of the results.

—— Thursday June 5 ——

- **Reka Albert**

Pennsylvania State University
Thurs June 5, 9-9:40am ***Keynote address***

"Network Analysis Elucidates the Outcomes of Within-Cell Networks"

Abstract: Interaction networks formed by gene products form the basis of cell behavior (growth, survival, apoptosis, movement). Experimental advances in the last decade helped uncover the structure of many molecular-to-cellular level networks, such as protein interaction or metabolic networks. For other types of interaction and regulation inference methods based on indirect measurements have been used to variable degrees of success. These advances mark the first steps toward a major goal of contemporary biology: to map out, understand and model in quantifiable terms the topological and dynamic properties of the various networks that control the behavior of the cell. Such an understanding would also

allow the development of comprehensive and effective therapeutic strategies.

This talk will focus on my group's recent work on discrete dynamic modeling of signal transduction networks in various organisms. These models can be developed from qualitative information yet show a dynamic repertoire that can be directly related to the real system's outcomes. For example, our model of the signaling network inside T cells predicted therapeutic targets for the blood cancer T-LGL leukemia, several of which were then validated experimentally. I will then present a method to integrate network structure and dynamics into an expanded network. Extension of existing network measures and analyses, performed on this expanded network, allows an efficient way to determine the dynamic repertoire of the network and to predict manipulations that can stabilize or, conversely, block, certain outcomes. In general, network biology and network medicine will grow in importance and offer a fertile ground for network scientists.

- **Cris Moore**

Santa Fe Institute
Thurs June 5, 9:40-10:10am

"Physics-inspired algorithms and phase transitions in community detection"

Abstract: Detecting communities, and labeling nodes, is a ubiquitous problem in the study of networks. Recently, we developed scalable Belief Propagation algorithms that update probability distributions of node labels until they reach a fixed point. In addition to being of practical use, these algorithms can be studied analytically, revealing phase transitions in the ability of any algorithm to solve this problem. Specifically, there is a detectability transition in the stochastic block model, below which no algorithm can label nodes better than chance.

I'll explain this transition, and give an accessible introduction to Belief Propagation and the analogy with free energy and the cavity method of statistical physics. We'll see that the consensus of many good solutions is a better labeling than the "best" solution — something that is true for many real-world optimization problems. While many algorithms overfit, finding "communities" even in random graphs where none exist, our method focuses on statistically-significant communities.

I'll then turn to spectral methods. It's popular to classify nodes according to the first few eigenvectors of the adjacency matrix or the graph Laplacian. However, in the sparse case these operators get confused by localized eigenvectors, focusing on high-degree nodes or dangling trees rather than large-scale communities. As a result, they fail significantly above the detectability transition. I will describe a new spectral algorithm based on the non-backtracking matrix, which avoids these localized eigenvectors: it is optimal in the sense that it succeeds all the way down to the transition.

This is joint work with Aurelien Decelle, Florent Krzakala, Elchanan Mossel, Joe Neeman, Allan Sly, Lenka Zdeborova, and Pan Zhang.

- **James Gleeson**

University of Limerick
Thurs June 5, 10:30-11am

"Competing for attention: branching-process models of meme popularity"

Abstract: Copying-with-innovation models offer a simplistic, yet sometimes surprisingly accurate, viewpoint on how online consumers choose among multiple possible alternatives: e.g., what app to download, what YouTube video to watch, or what hashtag to use when tweeting? We apply branching-process analysis to models of meme diffusion wherein users remember and copy the actions of their online friends. If users possess very long memories, the models reduce to cumulative advantage (preferential attachment) models of Yule-Simon type. However, in the case of finite-length user memory, the competition between memes for the limited resource of users attention leads to meme popularities described by critical branching processes. In this competition-induced criticality regime that is typical of so-called neutral models, we calculate the (time-dependent) distributions of popularity and show that they exhibit very heavy tails, with power-law exponents less than 2. The fact that the models are analytically tractable implies that the effects on popularity of, for example, network topology and memory-time distributions, can be made explicit. Predictions of the models are compared with empirical data from Twitter.

• **Thilo Gross**
University of Bristol
Thurs June 5, 11-11:30am

"The magical red arrow: Networks and localization in complex system"

Abstract: The defining feature of complex systems in emergence: These systems have properties that are not inherent in their constituents but emerge from the constituents' interactions. Over the past decade network models have become one of the primary tools for understanding this complexity. Treating a system as a network simplifies the constituents but retains the complex pattern of their interaction. Thus network models advance our understanding of complex systems by allowing simplification without simplifying the complexity away. However, ultimately we typically interested in simple answers that link a phenomenon at hand to a specific network feature, that can exist on different levels: Phenomena can be caused by single extraordinary nodes with certain properties, small clusters or communities, or network scale collective properties. In this talk I discuss mathematical approaches to identify causes of dynamical phenomena in complex networks. In particular I focus on the question what determines the scale at which a phenomenon arises. I present some evidence that suggests that a broad class of failures of complex systems is generally well localized, but the attempt to fix such failures locally naturally leads to a delocalization of further failures.

• **Dirk Helbing**
ETH Zurich
Thurs June 5, 11:30am-noon

"Mastering Complexity in the Digital Society: Top-Down, Bottom-Up, or Both?"

Abstract: The digital revolution is changing human history. The invention of the steam engine turned agricultural society ("economy 1.0") into industrial society ("economy 2.0"), and wide-spread education turned it into service society ("economy 3.0"). Now, the invention of computers, the Internet, the World Wide Web, and Social Media are transforming service societies into digital societies ("economy 4.0"). With computers reaching the level of human brainpower in about 10 years, with intelligent service robots, and the Big Data tsunami, 50 percent of jobs in the industrial and service sectors will probably be lost within the next

20 years. And most of our social and economic institutions will fundamentally change, but how? Will we have a super-government, which will take evidence-based decisions using Big Data and suggest us, what we have to do? Or will our economy and society be based on distributed control, organized in a participatory, bottom-up way? Using information and communication technologies, could we make Adam Smith's 300 year old vision of a self-regulating society come true? And, finally, what do we have to do to prepare our societies well for the on-going digital revolution, to avoid undesirable disruptions and social unrest? This talk will try to give some answers.

—— Friday June 6 ——

• **Vittoria Colizza**
Université Pierre et Marie Curie and Pierre Louis Institute of Epidemiology and Public Health
Fri June 6, 9-9:40am *Keynote address*
"Epidemics on temporal networks: targeted interventions and invasion conditions"

• **Eric Berlow**
Vibrant Data Labs
Fri June 6, 9:40-10:10am
"Towards a less obsessive control theory of complex networks"

• **Tina Eliassi-Rad**
Rutgers University
Fri June 6, 10:30am-11am
"Discovering Roles in Graphs: Algorithms and Applications"
Abstract: Given a graph, how can we automatically discover roles (or functions) of nodes? Roles compactly represent structural behaviors of nodes and generalize across various graphs. Examples of roles include "clique-members," "periphery-nodes," "bridges," etc. Are there good features that we can extract for nodes that indicate role-membership? How are roles different from communities and from equivalences (from sociology)? What are the applications in which these discovered roles can be effectively used? In this talk, we address these questions, provide unsupervised and supervised algorithms for role discovery, and discuss various applications such as sense-making, transfer learning, re-identification, and minimizing dissemination on networks.

• **Sinan Aral**
Massachusetts Institute of Technology
Fri June 6, 11-11:30am
TBA