DY 29: Statistical physics of complex networks

Time: Friday 10:15–13:15 Location: ZEU 255

DY 29.1 Fri 10:15 ZEU 255

Automated moment closure and oscillations in adaptive networks — •Thilo Gross — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden, Germany

Adaptive networks combine topological evolution OF a network with dynamics ON the network. Recently a number of new phenomena that appear in this class of systems have been reported. One methods by which adaptive networks can be studied is the moment closure approximation, which yields a low-dimensional system of differential equations. In this talk I will first explain the conventional moment closure approach and then present automated moment closure (AMC) as an extension. In AMC appropriate closure terms are computed on-demand from short bursts individual-based simulation. Despite these micro-level simulations the system is analyzed directly on a macro-level, i.e., as a low-dimensional system of ordinary differential equations describing emergent system-level properties. This approach is used to find regions of oscillatory dynamics in an epidemiological susceptible-infected-susceptible model. Unlike oscillations on static network, the oscillatory dynamics on the adaptive network involves topological as well as local degrees of freedom.

DY 29.2 Fri 10:30 ZEU 255

The hierarchical system of PDE and a diffusive anomalous spread in media with multiscale connections — •Eugene Postnikov — Kursk State University, Kursk, Russia

Recently, there exists a large variety of real-world problems, which require mathematical methods for the modeling of diffusion in a strongly disordered complex environment. For example, description of human and animal mobility [González et al, 2008] as well as spread of information and diseases [Brockmann et al, 2006].

It has been shown [Naether, Postnikov, Sokolov, 2008] that realistic asymmetric Kendall waves of an SIR epidemic spread along a population with small mobility can be described with the PDE system, which contains the specific combination of infected individuals density and its Laplacian multiplied by the characteristic habitat size.

In the present contribution, the further development of this approach is presented. To model a spread in a hierarchical metapopulation, the unique "size coefficient" for diffusion term is replaced with the progressive set of values.

It has been shown that such an approach allows to reproduce the anomalous relaxation in the small world networks (with comparison with the direct simulation [Sokolov et al, 2000]) and some properties of anomalous human mobility patterns citied above.

DY 29.3 Fri 10:45 ZEU 255

Ergodic diffusion in network configuration space — •Sebastian Weber and Markus Porto — Institut für Festkörperphysik, Technische Universität Darmstadt, Germany

Virtually all real-world networks have evolved over time by stepwise alternation into their present structure. The patterns by which structural changes occur can be assumed to allow, in principle, for a free diffusion in the network configuration space. However, an ergodic exploration of the network configuration space by means of a generic process beyond single edge addition or removal is a subtle task as modification patterns are often bound to a particular class of networks [1]. We present an ansatz which uses only information of the current network in order to alter the network structure and evaluate the proposed schemes by driving, for instance, Erdős-Rényi type to two-point correlated scale-free type networks and back.

[1] S. Weber, and M. Porto, submitted

DY 29.4 Fri 11:00 ZEU 255

Critical Boolean networks with scale-free in-degree distribution — •Florian Greil — Institut für Festkörperphysik, Technische Universität Darmstadt, Germany

We investigate analytically and numerically critical Boolean networks with power-law in-degree distributions. When the exponent of the in-degree distribution is larger than 3, we obtain the same results as for networks with fixed in-degree, e.g., that the number of the non-frozen nodes scales as $N^{2/3}$ with the system size N. When the exponent of the distribution is between 2 and 3, the number of the non-frozen nodes increases as N^x, with x being between 0 and 2/3 and depending on the exponent and on the cutoff of the in-degree distribution. Our results explain various results obtained earlier by computer simulations.

DY 29.5 Fri 11:15 ZEU 255

The impact of clustering on the transport capacity of scale-free communication networks. — •Jan Scholz[1] and Martin Greiner[2] — [1]Frankfurt Institute for Advanced Studies, Goethe Universität Frankfurt, Ruth-Moufang-Str. 1, 60438 Frankfurt am Main, Germany — [2]Corporate Technology, Information & Communications, Siemens AG, 80200 München, Germany

The efficiency of communication networks can very effectively be enhanced by optimizing the routing metrics [1]. However, there is apparent discrepancy between the performance of null models (random scale-free networks) and measured Internet topology.

A key difference between these classes of networks is clustering, which is very abundant in the Internet data, while being suppressed in random scale-free networks.

Here we investigate the influence of clustering on the increase of communication performance by adaptive routing metrics and on the robustness of the resulting weighted networks.

[1] Jan Scholz, Wolfram Krause, and Martin Greiner. Decorrelation of networked communication flow via load-dependent routing weights. *Physica A — Statistical Mechanics and its Applications*, 387:2987–3000 (2008)

DY 29.6 Fri 11:30 ZEU 255

Complex dynamics on dissortative scale-free networks — •Jörg Menche, Angelo Valleriani, and Reinhard Lipowsky — Max-Planck-Institute of Colloids and Interfaces, Science Park Golm, 14424 Potsdam, Germany

Many biological and technological networks have been found to exhibit scale-free degree distributions together with dissortative mixing by degree. We study the properties of local majority rule dynamics on such networks. Networks without degree correlations only show two stable fixed points that correspond to the completely ordered states. In contrast, networks with degree correlations are found to exhibit a large number of additional attractors. Surprisingly, the number of attractors does not increase monotonously as a function of network size, but reaches a maximum for intermediate sizes. This can be explained by the reduction in the maximal dissortativity that can be achieved for scale-free networks in the limit of large network sizes.

15 min. break.

DY 29.7 Fri 12:00 ZEU 255

Fluctuating power flows in a future European power transmission network with a high share of wind and solar power production — •Dominik Heide[1], Clemens Hoffmann[2], Martin Greiner[2], Lüder von Bremen[3], Kaspar Knorr[3], Markus Speckmann[3], and Stefan Bofinger[3] — [1]Frankfurt Institute for Advanced Studies FIAS, Ruth-Moufang-Straße 1, 60438 Frankfurt am Main, Germany — [2]Siemens AG, Corporate Research and Technology, 81730 München, Germany — [3]Institut für Solare Energieversorgungstechnik ISET, Königstor 59, 34119 Kassel, Germany

We envision a future European transmission power network, which has only power production from renewable sources. With an 8-years-long numerical weather data set of 1h time resolution, the regional wind and solar power production across Europe is determined. This renewable power generation is confronted with the regional consumer loads and determines the fluctuating source/sink strengths of each region. The balancing of the sources and sinks determines the power flow. The latter is calculated within the DC flow approximation, which employs the Laplace matrix of the underlying geometric network, where node-like regions are connected by links. Due to the fluctuating source and sink strengths, the power flows across the links show strong fluctuations. Their characterization allows to roughly estimate the future investment needs into the European transmission power network.

In the second part of the presentation an abstracted network model will be presented, which is able to generically reproduce the results obtained from the weather-driven first part.

DY 29.8 Fri 12:15 ZEU 255

Counting Complex Disordered States by Efficient Pattern Matching: Chromatic Polynomials and Potts Partition Functions — •Marc Timme[1], Frank van Bussel[1], Denny Fliegner[2], Sebastian Stolzenberg[3], and Christoph Ehrlich[4] — [1]Network Dynamics Group, MPIDS Göttingen — [2]Dept. of Nonlinear Dynamics, MPIDS Göttingen — [3]Dept. of Physics, Cornell University, USA — [4]Dept. of Physics, TU Dresden

Counting problems, determining the number of possible states of a large system under certain constraints, play an important role in many areas of science. They naturally arise for complex disordered systems in physics and chemistry, in mathematical graph theory, and in computer science. Counting problems, however, are among the hardest problems to access computationally. Here we suggest a novel method to access a benchmark counting problem, finding chromatic polynomials of graphs. We develop a vertex-oriented symbolic pattern matching algorithm that exploits the equivalence between the chromatic polynomial and the zero-temperature partition function of the Potts antiferromagnet on the same graph. Implementing this bottom-up algorithm using appropriate computer algebra, the new method outperforms standard top-down methods by several orders of magnitude, already for moderately sized graphs. As a first application we compute chromatic polynomials of samples of the simple cubic lattice, for the first time computationally accessing three-dimensional lattices of physical relevance. The method offers straightforward generalizations to several other counting problems.

DY 29.9 Fri 12:30 ZEU 255

Deformed Gaussian Orthogonal Ensemble description of Small-World networks — •Josue Xavier de Carvalho[1], Sarika Jalan[1], and Mahir Saleh Hussein[1,2] — [1]MPIPKS, Dresden, Germany — [2]USP, Sao Paulo, Brazil

The study of spectral behaviour of networks has gained enthusiasm over the last few years. In particular, Random Matrix Theory concepts have proven to be useful. In discussing transitions from regular behaviour to fully chaotic behaviour it has been found that an extrapolation formula of the Brody type can be used. In the present paper we analyse the regular to chaotic behaviour of Small World networks using an extention of Wigner's Gaussian Orthogonal Ensemble. This RMT, coined the Deformed Gaussian Orthognal Ensemble, supplies a natural foundation of Brody's formula. The analysis performed in this paper proves the utility of the DGOE in network physics, as much as it has been useful in other physical systems.

DY 29.10 Fri 12:45 ZEU 255

Applying statistical complexity measures to networks — •Eckehard Olbrich, Thomas Kahle, Nils Bertschinger, and Jürgen Jost — Max Planck Institute for Mathematics in the Sciences, Leipzig, Germany

Statistical complexity measures such as the excess entropy are well established in the context of time series and were recently generalized to quantify the complexity of joint probability distributions in general. We discuss, how statistical complexity measures can be applied to quantify structural properties of graphs.

In particular, we propose the interaction complexity – a recently introduced vector valued complexity measure, whose components quantify the complexity in terms of k-th order statistical dependencies that cannot be explained by interactions between $k-1$ units – as a general and systematic framework for analyzing the subgraph (motif) statistics of complex networks.

DY 29.11 Fri 13:00 ZEU 255

Public transport networks under random failure and directed attack — Bertrand Berche[1], •Christian von Ferber[2,3], Taras Holovatch[1,2], and Yurij Holovatch[4,5] — [1]Laboratoire de Physique des Materiaux, Université Nancy, France — [2]Applied Mathematics Research Centre, Coventry University, UK — [3]Physikalisches Institut, Universität Freiburg — [4]ICPM National Academy of Sciences of Ukraine, Lviv — [5]Institut für Theoretische Physik, Universität Linz, Österreich

The behavior of complex networks under failure or attack depends strongly on the specific scenario. Of special interest are scale-free networks, which are usually seen as robust under random failure but appear to be especially vulnerable to targeted attacks. In a recent study of public transport networks of 14 major cities of the world we have shown that these systems when represented by appropriate graphs may exhibit scale-free behaviour [Physica A 380, 585 (2007)]. Our present analysis, focuses on the effects that defunct or removed nodes have on the properties of public transport networks. We confirm that the impact of random failure is weak and that for a moderate share of defunct nodes there is little to no change in the network behaviour. Simulating different directed attack strategies however, we derive vulnerability criteria that result in minimal strategies with high impact on these systems.