DY 11: Statistics and Dynamics of/on Networks (joint session BP/DY/SOE)

Time: Tuesday 9:30–11:45 Location: H47

DY 11.1 Tue 9:30 H47

Chimera states in neural systems — •Iryna Omelchenko[1,2], Oleh Omel'chenko[3], Philipp Hövel[1,2,4], and Eckehard Schöll[1] — [1]Institut für Theoretische Physik, Technische Universität Berlin — [2]Bernstein Center for Computational Neuroscience, Humboldt-Universität zu Berlin — [3]Weierstrass Institute, Berlin — [4]Center for Complex Network Research, Northeastern University, Boston, USA

Chimera states are spatio-temporal patterns of synchrony and disorder observed in systems of nonlocally coupled identical elements. They are characterized by coexistence of spatial regions with regular synchronized and irregular incoherent motion. Initially discovered for phase oscillators, chimera states have been also found in systems of nonlocally coupled discrete maps [1], time-continuous chaotic systems [2], and have been recently realized in experiments [3].

We investigate the cooperative dynamics of nonlocally coupled neural populations modeled by FitzHugh-Nagumo systems, where each individual system displays oscillatory local dynamics, and demonstrate the existence of chimera states there. We analyse the stability of chimera states in the parameter space of the system and discuss mechanisms of transitions between different chimera types.

[1] I. Omelchenko, Yu. Maistrenko, P. Hövel, and E. Schöll, Phys. Rev. Lett. 106, 234102 (2011).

[2] I. Omelchenko, B. Riemenschneider, P. Hövel, Yu. Maistrenko, and E. Schöll. Phys. Rev. E 85, 026212 (2012).

[3] A.M. Hagerstrom, T.E. Murphy, R. Roy, P. Hövel, I. Omelchenko, and E. Schöll. Nature Physics 8, 658 (2012).

DY 11.2 Tue 9:45 H47

Scaling Laws in Critical Random Boolean Networks with General in- and out-Degree Distributions — •Marco Möller and Barbara Drossel — Institute for condensed matter physics, TU Darmstadt, Germany

We evaluate analytically and numerically the size of the frozen core and various scaling laws for critical Boolean networks that have a power-law in- and/or out-degree distribution. To this purpose, we generalize an efficient method that has previously been used for conventional random Boolean networks and for networks with power-law in-degree distributions. With this generalization, we can also deal with power-law out-degree distributions. When the power-law exponent is between 2 and 3, the second moment of a distribution changes, and the scaling exponent of the nonfrozen nodes depends on the degree distribution exponent.

Furthermore, the exponent depends also on the dependence of the cutoff of the degree distribution on the system size. Altogether, we obtain an impressive number of different scaling laws depending on the type of cutoff as well as on the exponents of the in- and out-degree distribution. We confirm our scaling arguments and analytical considerations by numerical investigations.

DY 11.3 Tue 10:00 H47

Small-World Network Spectra in Mean-Field Theory — •Carsten Grabow[1], Stefan Grosskinsky[2], and Marc Timme[3] — [1]Potsdam Institute for Climate Impact Research, Potsdam, Germany — [2]Mathematics Institute and Centre for Complexity Science, Warwick, UK — [3]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany

Collective dynamics on small-world networks emerge in a broad range of systems with their spectra characterizing fundamental asymptotic features. Here we derive analytic mean-field predictions for the spectra of small-world models that systematically interpolate between regular and random topologies by varying their randomness. These theoretical predictions agree well with the actual spectra (obtained by numerical diagonalization) for undirected and directed networks and from fully regular to strongly random topologies. These results may provide analytical insights to empirically found features of dynamics on small-world networks from various research fields, including biology, physics, engineering, and social science. (Based on Grabow, C., Grosskinsky, S. & Timme, M. Small-World Network Spectra in Mean-Field Theory. Phys. Rev. Lett 108, (2012).)

DY 11.4 Tue 10:15 H47

Robust large-scale properties in networks — •Tiago Peixoto and Stefan Bornholdt — Institut für Theoretische Physik, Universität Bremen, Hochschulring 18, D-28359 Bremen, Germany

Most network systems possess large- or mesoscale structures, which are not captured by local measures such as, e.g. degree and subgraph statistics. Many network models, as well as mean field analysis of dynamical processes on networks neglect such features. Here we include in a general fashion such large-scale properties in the the analysis of a paradigmatic percolation problem in networks with interdependence, as well as Boolean dynamics based on majority functions, meant to describe systems which are robust against noise, such as gene regulation.

A model for the evolution of such systems is proposed, where networks with more robust properties survive with greater probability. By mapping the evolutionary process into a statistical ensemble, the free energy of the system is minimized, and its equilibrium properties are obtained. The analysis reveals a topological phase transition at a specific value of selective pressure, where a core-periphery topology emerges, characterized by the existence of a smaller subset of nodes which regulate the entire system; a feature which is also found in many real systems.

T. P. Peixoto, S. Bornholdt, Phys. Rev. Lett. 109, 118703 (2012); T. P. Peixoto, Phys. Rev. E 85, 041908 (2012); T. P. Peixoto, Phys. Rev. E 85, 056122 (2012)

15 min. break.

DY 11.5 Tue 10:45 H47

High performance simulation and visualization of epidemics on complex networks — •Peter A. Kolski[1,2], Thomas Selhorst[1], Martin Clauss[3], and Jörn Hoffmann[3] — [1]Friedrich-Loeffler-Institut, Wusterhausen, Germany — [2]University of Potsdam, Germany — [3]University of Leipzig, Germany

Dynamical processes on complex networks are a growing field of interest. Performing simulations on large system of this kind demand a high computational power. To handle dynamics on networks the NetEvo C++ library can assign dynamical systems to edges and nodes. Furthermore it solves these ODEs via the ODEint library and can perform heuristic optimization. We introduce an extension to NetEvo using OpenCL on GPUs. With this approach we achieve an increase of computational performance up to a factor of 100, compared to an optimized C++ code on a modern CPU. Additionally we developed a framework to visualize intermediate results and to perform instantaneous visual analytics. The software will be applied in epidemiology, simulating disease spread on trade networks by solving the SIR model*s ODEs. The modification of parameter in real-time and the immediate access to simulation results leads to intuitive insights into the behavior of epidemics on large complex networks.

DY 11.6 Tue 11:00 H47

Diffusion processes and entropy prodcution in weakly coupled complex networks — Grzegorz Siudem and •Janusz Hołyst — Faculty of Physics, Center of Excellence of Complex Systems Research, Warsaw University of Technology, Poland

We consider diffusion phenomena on a pair of weakly coupled complex networks. Assuming that a density of internetwork connections is much lower than a density of intranetwork links we could make use of a time separation for processes taking place in and between the networks. As result we truncated the system dynamics to a simple Markov Chain and we received an equation corresponding to the Fick's First Law. We got an analytical form for internetwork diffusion coupling and estimated entropy production during the equilibration process.

DY 11.7 Tue 11:15 H47

A Network Generation Process for Temporal Graphs — •Peter A. Kolski[1,2], Thomas Selhorst[1], Markus Abel[2], and Arkady Pikovsky[2] — [1]Friedrich-Loeffler-Institut, Wusterhausen, Germany — [2]University of Potsdam, Germany

In this work we show a mechanism for creating Temporal Graphs inspired by real world trade transportation. In the last years complex networks have been in the focus of theoretical and applied research. Although networks like the power grid or water assets have continuos flow on the edges, trade networks are intrinsically discrete. We present a generic model for the generation and evolution of these Temporal Graphs: A continuous state is assigned to each node, described by a dynamical process. In our case we use an integrate-and-fire model. Once a threshold is exceeded, a node becomes "active" and, according to a cost function, selects another active node. This way an edge is temporarily established. Through these edges, nodes interact by resetting their states to zero. In addition, the cost function is modified in a way that the probability to reuse the edge is increased. We present first results on the analysis of this model by i) the degree distribution of the graph formed of the aggregated edges and ii) the degree distribution at a single time. In addition, we study the differences between a two-dimensional and a full graph. In particular we discuss details in the temporal evolution of the degree distribution, as one of the most important characteristics.

DY 11.8 Tue 11:30 H47

Transmission grid extensions during the build-up of a fully renewable European electricity supply — •Sarah Becker[1], Rolando A. Rodriguez[2], Gorm B. Andresen[2], Stefan Schramm[1], and Martin Greiner[2] — [1]Frankfurt Institute for Advanced Studies, Goethe-Universität Frankfurt — [2]Aarhus Department of Engineering and Department of Mathematics, Aarhus University, Denmark

Spatio-temporal generation patterns for wind and solar photovoltaic power in Europe are used to investigate the effect of an increasing penetration of these variable renewable energy sources (VRES) on the European electricity system, in particular on the required link capacities of the transmission grid. VRES growth predictions according to the official National Renewable Energy Action Plans of the EU countries are used and extrapolated logistically up to a fully VRES-supplied power system. It is examined how the need for transmission rises in the future. We find that quadrupling today's international net transfer capacities over the next forty years reduces the final need for backup energy by more than one third. The remaining backup energy is due to correlations in the generation patterns, and can thus not be reduced by transmission. Additionally, our results show how the optimal mix between wind and solar energy shifts from about 70% to 80% wind share as the transmission grid is enhanced. Finally, we exemplify how reinforced transmission affects the import and export opportunities of single countries during the VRES ramp-up and the coupled transmission grid extension.