DY 22: Statistical physics of complex networks II

Time: Wednesday 16:45–18:30 Location: MA 004

DY 22.1 Wed 16:45 MA 004

Thermodynamic forces, flows, and Onsager coefficients in complex networks — Agata Fronczak, Piotr Fronczak, and •Janusz Holyst — Faculty of Physics, Warsaw University of Technology, Koszykowa 75, 00-662 Warsaw, Poland

We present Onsager formalism applied to random networks with arbitrary degree distribution. Using the well-known methods of non-equilibrium thermodynamics we identify thermodynamic forces and their conjugated flows induced in networks as a result of single node degree perturbation. The forces and the flows can be understood as a response of the system to events, such as random removal of nodes or intentional attacks on them. Finally, we show that cross effects (such as thermodiffusion, or thermoelectric phenomena), in which one force may not only give rise to its own corresponding flow, but to many other flows, can be observed also in complex networks.

DY 22.2 Wed 17:00 MA 004

Dynamical Clustering in Reaction-Dispersal Processes on Complex Networks — •Vincent David[1], Marc Timme[1,4], Theo Geisel[1,2,4], and Dirk Brockmann[1,3] — [1]Max-Planck-Institute for Dynamics and Self-Organization, Göttingen — [2]Georg-August-Universität, Göttingen — [3]Northwestern University, Evanston — [4]Bernstein Center for Computational Neuroscience, Göttingen

We investigate nonlinear annihilation processes (e.g., $A + A \rightarrow \emptyset$) of particles that perform random walks on complex networks. In well mixed populations (mean field) this process exhibits t^{-1} decay behavior in the total number of particles. Additional dispersal of particles adds a second time scale and drastically changes the decay behavior.

Here we study these changes for two types of hopping processes. First, if particles independently select one of the possible exit channels at each node their exit rates are given by the sum of all outgoing weights such that the waiting times are degree-dependent. We compare this to the popular ansatz of a uniform waiting time process.

Derived mean field equations show that for large numbers of particles per node both processes exhibit nearly identical relaxation properties. However, below a critical particle number the processes deviate not only from mean field predictions but, more importantly, by orders of magnitude from one another. We attribute this to dynamical clustering effects in the uniform waiting time model, that is absent in the independent channel dynamics. We conclude that the prediction of dynamical properties of reaction-diffusion processes on complex networks drastically depend on the appropriate choice of model.

DY 22.3 Wed 17:15 MA 004

Pattern Formation and Efficiency of Reaction-Diffusion Processes on Complex Networks — •Sebastian Weber[1], Marc-Thorsten Hütt[2], and Markus Porto[1] — [1]Institut für Festkörperphysik, Technische Universität Darmstadt, Germany — [2]Computational Systems Biology, School of Engineering and Science, Jacobs University Bremen, Germany

To understand how the topology of a network influences a given dynamic taking place on it, is a major challenge in many fields of science. We address part of this challenge by studying the impact of topological correlations in complex networks on the pattern formation and the efficiency of the reaction-diffusion process $A + B \rightarrow \emptyset$ [1], the latter serving as a generic dynamic capturing the essentials of many real world examples. We show how to properly compare the states of the dynamics taken place on different ensembles of networks, which allows us to isolate the impact of topological correlations from other effects. The major result is that (i) the pattern formation can by characterized by a single scalar observable directly related to the amount of topological correlations and that (ii) a large amount of pattern formation does not necessarily mean a small efficiency, in contrast to regular d dimensional lattices.

[1] S. Weber, M.-Th. Hütt, and M. Porto, submitted

DY 22.4 Wed 17:30 MA 004

Decorrelation of networked communication flow via load-dependent routing weights — •Jan Scholz[1] and Martin Greiner[2] — [1]Frankfurt Institute for Advanced Studies, Johann Wolfgang Goethe Universität, Frankfurt am Main, Germany — [2]Corporate Research and Technology, Information & Communications, Siemens AG, München, Germany

Clever assignments of link weights are able to change the routes in communication networks in such a way that loads are distributed almost evenly across the network. This is achieved by weight assignments based on link load. As demonstrated for scale-free as well as synthetic Internet networks they decorrelate the loads of the nodes and links from the network structure and increase the transport capacity of the network. For various Internet scans the increase of transport capacity amounts to a factor of around five when compared to shortest-path routing.

DY 22.5 Wed 17:45 MA 004

Effects of load fluctuations on the robustness of networks — •Dominik Heide[1], Mirko Schäfer[1], and Martin Greiner[2] — [1]Frankfurt Institute for Advanced Studies (FIAS), Ruth-Moufang-Str. 1, 60438 Frankfurt am Main — [2]Corporate Technology, Information Communications, Siemens AG, 81730 München

On previously studied heterogeneously loaded networks [1], we analyze the effect of load fluctuations on the network's robustness. We find that on each vertex the distribution of the resulting load can be described using parameters analytically derived from the network flow paths. Based on this analysis, we propose a capacity layout where the probabilities for the number of overloaded vertices due to load fluctuations is known. Furthermore, we analyze the robustness of the network against cascades of overload failures. The findings are of relevance for critical infrastructures like communication, transportation, and power networks.

[1] A. Motter, and Y.C. Lai, Phys. Rev. E **66**, 065102(R) (2002)

DY 22.6 Wed 18:00 MA 004

Frustration from Fat Graphs — •Martin Weigel[1] and Des Johnston[2] — [1]Institut für Physik, KOMET 331, Johannes-Gutenberg-Universität* Mainz, Staudinger Weg 7, 55099 Mainz, Germany — [2]Department of Mathematics and the Maxwell Institute for Mathematical Sciences, Heriot-Watt University, Edinburgh, EH14 4AS, UK

We consider the effect of geometric frustration induced by the random distribution of loop lengths in the “fat” graphs of the dynamical triangulations model on coupled antiferromagnets. While the influence of such connectivity disorder is rather mild for ferromagnets in that an ordered phase persists and only the properties of the phase transition are substantially changed in some cases, any finite-temperature transition is wiped out due to frustration for some of the antiferromagnetic models. A wealth of different phenomena is observed: while for the annealed average of quantum gravity some graphs can adapt dynamically to allow the emergence of a Néel ordered phase, this is not possible for the quenched average, where a zero-temperature spin-glass phase appears instead. We relate the latter to the behaviour of conventional spin-glass models coupled to random graphs.

[1] M. Weigel and D. Johnston, Phys. Rev. B **76** (2007) 054408.

DY 22.7 Wed 18:15 MA 004

Spin Dynamics on Complex Networks — Filippo Radicchi[1], Yong-Yeol Ahn[2], and •Hildegard Meyer-Ortmanns[3] — [1]CNNL., ISI Foundation, 10133 Torino, Italy — [2]Korea Adv.Inst.Science and Technology, Daejeon 305-701, Korea — [3]SES, Jacobs University, 28725 Bremen, Germany

In the first part we consider Ising spin dynamics as it can be used to describe the approach to a state of social balance. We shall map this dynamics along with the associated algorithm to the process of solving a satisfiability problem of computer science. The network is varied from an all-to-all topology, to a random one with different degrees of dilution, and to regular topologies. As it turns out, the stationary states and the time of finding a solution depend on the topology as well as on the dilution parameter and the propensity parameter which characterizes the tendency to reduce frustration in the system. Even if an optimal solution exists it depends on the parameter choice whether the local stochastic algorithm is able to find it. In the second part we systematically interpolate between synchronous and asynchronous update of a chain of Ising spins. As a function of the interpolation parameter we identify a phase transition between the stationary states that belongs to the universality class of parity conservation. For fully synchronous update of the ferromagnetic Ising chain the stationary state becomes antiferromagnetic. Moreover, strongly asynchronous update for Boolean threshold dynamics considerably changes the phase space that is supposed to model the yeast cell cycle.