DY 10 Statistical Physics of Complex Networks I

Time: Monday 09:30–11:00 Room: HÜL 186

Invited Talk DY 10.1 Mon 09:30 HÜL 186

Networks in Physics — •Maya Paczuski — Complexity Science Group, Department of Physics and Astronomy, University of Calgary, Canada

A fundamental problem in the physics of complex systems is to understand how qualitatively new behavior emerges from nonlinear interactions between large collections of constituents – be they particles, grains in a sand pile, species in a food chain, regulatory genes, or parts of the Earth's crust. Recently complex networks have been recognized as cogent descriptions for social, biological and technological phenomena. Here I point out that they also play an important role in constructing sparse descriptions of ordinary physical systems, where the main degrees of freedom are nodes and their relevant interactions appear as links. These networks may self-organize into a complex critical state, with avalanches of all sizes. The specific examples I discuss here include our discovery of the scale free magnetic network in the solar corona, a SOC model for complex networks of interacting (magnetic flux) loops, and a network description of seismicity that uses only relations between events rather than properties of individual earthquakes to uncover the underlying spatiotemporal structure of seismicity.

DY 10.2 Mon 10:00 HÜL 186

Transient times and avalanche size distribution in the Olami-Feder-Christensen earthquake model — •Felix Wissel and Barbara Drossel — Institut f. Festkoerperphysik, Hochschulstrasse 8, 64287 Darmstadt

We present analytical and numerical results for the earthquake model by Olami, Feder and Christensen (OFC). First we discuss the transient time until the system is in the stationary state. By introducing the concept of effective sites and using a mean field ansatz for the toppling profile we explain the numerical data as function of the system size N and the coupling parameter α. In the limit $\alpha \to 0$, our calculation and our simulation data suggest that the transient time diverges as $T(N, \alpha) \sim \alpha^{-\nu} N^{\alpha^{-\mu}}$ with exponents $\nu \simeq 0.5$ and $\mu > 0.5$. By analyzing the correlation function, we then find that the pattern of "patches"(i.e., areas of similar force value) shows scaling behavior, and based on this result we argue that the avalanche size distribution in the thermodynamic limit of infinite system size is either a power law with α-dependent exponent τ or no power law at all. In any case, almost all topplings occur in the thermodynamic limit in avalanches of size one.

DY 10.3 Mon 10:15 HÜL 186

Emergence of Hierarchical Structures in a Stochastic Network Model — •Michael Koenig, Stefano Battiston, and Frank Schweitzer — Chair of Systems Design,ETH Zurich,CH-8092 Zurich, Switzerland

We investigate a network model governed by processes on two different time scales: The short time scale describes the eigendynamics of the nodes, a feature often neglected in network models. The long time scale describes the change of the network structure itself which represents the interactions between the nodes. Each node is characterized by a scalar variable, representing for example "size" or "output", in a stochastic equation with auto-catalytic and hetero-catalytic growth terms. For the dynamics of the network, we consider different sets of rules for rewiring the links according to the output of the nodes. For example, a rewiring of any link between two nodes is accepted iff this increases the output of both nodes. Starting from a random graph, the dynamics leads to a saturated state characterized by an optimized output of the system (Nash equilibrium). We find that this equilibrium structure corresponds to a hierarchy in the output distribution. Averaging over different network realizations, we further obtain power-law like behavior for other network variables, such as the distribution of links, clustering coefficients and the number and length of cycles in the network.

DY 10.4 Mon 10:30 HÜL 186

Maximum flow and topological structure of complex networks — •Deok-Sun Lee and Heiko Rieger — Theoretische Physik, Universität des Saarlandes, 66041 Saarbrücken, Germany

The problem of sending the maximum amount of flow q between two arbitrary nodes s and t of complex networks along links with unit capacity is studied, which is equivalent to determining the number of link-disjoint paths between s and t. The average of q over all node pairs with smaller degree $k_{\min}$ is $\langle q \rangle_{k_{\min}} \simeq c\, k_{\min}$ for large $k_{\min}$ with c a constant implying that the statistics of q is related to the degree distribution of the network. The disjoint paths between hub nodes are found to be distributed among the edge-biconnected links, and q can be estimated by the number of pairs of edge-biconnected links incident to the start and terminal node. The relative size of the giant edge-biconnected component of a network approximates to the coefficient c. The applicability of our results to real world networks is tested for the Internet at the autonomous system level.

DY 10.5 Mon 10:45 HÜL 186

Metropolis Public Transport: Network Topology and Vulnerability — •Christian von Ferber[1,2], Yurij Holovatch[3,4], Taras Holovatch[4], and Vasyl Palchykov[4] — [1]Physikalisches Institut, Freiburg University — [2]Complex Systems Research, Jagellonian University, Krakow — [3]Institute for Condensed Matter Physics, Lviv, Ukraine — [4]Ivan Franko National University of Lviv, Ukraine

We analyse the public transport (PT) networks of a number of major cities of the world. While the primary network topology is defined by a set of routes each servicing an ordered series of given stations, a number of different neighborhood relations may be defined both for the routes and the stations. E.g. one either defines two stations as neighbors whenever they are serviced by a common route or only if one station is the succesor of the other in the series serviced by this route. The networks defined in this way display a number of distinguishing properties, the most striking being that often several routes proceed in parallel for a sequence of stations [1]. While other networks with real-world links like cables or neurons embedded in two or three dimensions often show similar features, these can be studied in detail in our present case. Previous studies of PT have mostly been restricted to much smaller networks and did not observe scale free behavior for which we find clear indications in the larger of the networks that we analyze. Our findings for the statistics as well as for relations between the topology and vunerability of these networks are supported by simulations of an evolutionary model of PT networks that we propose. [1] C. von Ferber, Yu. Holovatch, and V. Palchykov, Condens. Matter Phys.8:225(2005)cond-mat/0501296