DY 18: Networks II (with SOE)

Time: Wednesday 10:15–12:45 Location: H 0110

DY 18.1 Wed 10:15 H 0110

Diffusion on random networks with spatial constraints — •Thorsten Emmerich[1], Shlomo Havlin[2], and Armin Bunde[3] — [1]Institut für Theorethische Physik 3, Justus Liebig Universität Giessen, Giessen, Germany — [2]Minerva Center and Department of Physiks, Bar Ilan University, Ramat Gan, Israel — [3]Institut für Theorethische Physik 3, Justus Liebig Universität Giessen, Giessen, Germany

We consider random networks with spatial constraints. The networks are embedded in a linear chain or in a square lattice with embedding dimension $d_e = 1$ and 2, respectively. Each node has a fixed number of links. The length of the links are chosen with probability $p(r) \sim r^{-\delta}$, where r is the Euclidean distance between them. We show how the dimension of those networks can be determined and that it plays a basic role in determining the dynamical properties of the networks. The physical features are determined by δ: For $\delta < d_e$, the spatial constraints are irrelevant, while for $\delta > 2d_e$ the network behaves as a regular lattice. In between, for $d_e \leq \delta \leq 2d_e$ the network shows intermediate behavior and its dimension increases monotonically with decreasing δ.
We show that the dimension obtained from evaluating the structure of the networks appears also in the probability of return to the origin of a diffusing particle as well as in the survival properties of diffusing particles in the chemical reactions $A + A \to C$ und $A + B \to C$.

DY 18.2 Wed 10:30 H 0110

Topological properties of networks with spatial constraints — •Stefano Mattiello[1], Shlomo Havlin[2], and Armin Bunde[1] — [1]Institut für Theoretische Physik, Justus-Liebig-Universität Giessen, Giessen, Germany — [2]Minerva Center and Department of Physics, Bar-Ilan University, Ramat-Gan, Israel

We investigate the effects of spatial constraints on the topological properties of networks embedded in one or two dimensional space. The nodes are embedded in a linear chain or in a square lattice with embedding dimension $d_e = 1$ and $d_e = 2$, respectively. The length of the links are chosen with probability $p(r) \sim r^{-\delta}$, where r is the Euclidean distance between them. We consider Erdös -Rényi networks, where the distribution of the degrees of the nodes is Poissonian, as well as scale-free networks where the degree distribution follows a power law $P(k) \sim k^{-\gamma}$, with γ typically between two and three.

We study the mean topological distance l and the clustering coefficient C of both kind of networks. We focus on the dependence of these properties on the size of the system N and the exponent δ, in particular in the region $d_e \leq \delta \leq 2d_e$, where we expect an anomalous behavior.

DY 18.3 Wed 10:45 H 0110

Vaccine allocation in metapopulations — •Vitaly Belik — Massachusetts Institute of Technology, Cambridge, MA, USA — Max-Planck-Institut für Dynamik und Selbstorganization, Göttingen

Preparing for the 2009 H1N1 influenza pandemic, goverments of many countries acquired large stocks of vaccine or antivirals against this influenza strain. However due to low uptake of the vaccine in the population the governments needed to destroy the vaccine thus loosing many millions of dollars. This motivates the question addressed in this study - how to distribute the vaccine in the economically optimal way among different geographical regions. We propose an approximative method allowing with relatively little computational efforts to determine the optimal vaccination levels in real world systems for influenza-like diseases.

DY 18.4 Wed 11:00 H 0110

Interplay between epidemics and network topology in a growing population — •Güven Demirel[1] and Thilo Gross[2] — [1]Max Plax Institute for the Physics of Complex Systems, Dresden, Germany — [2]Merchant Venturers School of Engineering, University of Bristol, Bristol, UK

The structure of social contact networks strongly influences the dynamics of epidemic diseases. In particular the scale-free structure of real-world social networks allegedly allows unlikely diseases with low infection rates to spread and become endemic. However, in particular for potentially fatal diseases also the impact of the disease on the social structure should not be neglected. In this study, we consider the growth of a network by preferential attachment from which nodes are simultaneously removed due to an SIR epidemic. By comparison to network simulations we show that the interplay between topological evolution and epidemic dynamics can be captured by an analytical approximation. This reveals that increased infectivity increases the prevalence of the disease but also leads to the reemergence of an epidemic threshold by causing a transition from scale-free to exponential topology.

DY 18.5 Wed 11:15 H 0110

The vaccination dilemma with imperfect effectiveness — •Bin Wu[1,2], Feng Fu[1], and Long Wang[1] — [1]Center for Systems and Control, College of Engineering, Peking University, Beijing 100871, China — [2]Max-Planck-Institute for Evolutionary Biology, Plön 24306, Germany

Achieving widespread population immunity by voluntary vaccination poses a major challenge for public health administration [1]. The situation is complicated even more by imperfect vaccines. How the vaccine efficacy affects individuals' vaccination behavior has yet to be fully answered. To address this issue, we combine a game theoretical model of vaccination behavior with an epidemiological process. Our analysis shows that, in a population of self-interested individuals, the vaccine uptake level increases rapidly as the effectiveness of vaccination increases. Moreover, when the basic reproductive number exceeds a certain threshold, all individuals opt for vaccination for an intermediate region of vaccine efficacy. We further show that increasing effectiveness of vaccination always increases the number of effectively vaccinated individuals and therefore attenuates the epidemic strain. The results suggest that although increases in vaccination effectiveness lead to increased uptake level, it may drop due to free-riding effects. Nonethelss, the impact of the epidemic is mitigated by more effective vaccines [2].

[1] Rino Rappuoli, Science 316: 1287 (2007)
[2] Bin Wu, Feng Fu and Long Wang, PLoS ONE 6(6): e20577 (2011)

15 min. break

DY 18.6 Wed 11:45 H 0110

Cascading Failures on the Banking Network — •Maximilian Thess[1,2], Eckehard Schöll[2], and Sitabhra Sinha[1] — [1]Institute of Mathematical Sciences Chennai, India — [2]Institut für Theoretische Physik, Technische Universität Berlin, Germany

Following the recent financial crisis complex networks have been applied increasingly to study properties of the financial system. The interplay between topology and dynamics of networks is of current interest in systems ranging from physics and biology to the social sciences and economics. Dynamical and topological properties of the financial system are of crucial importance to its stability and an increased understanding can inform for example better regulatory policies.

In our contribution we study a simple model of cascading bank failures on the US interbank lending network. We characterize the network using measures from complex network theory and illustrate local and global stability. Through numerical simulations we study the impact of single-bank defaults on global system stability. To identify superspreader-banks based on their topological features we compare several ways of measuring their importance .

DY 18.7 Wed 12:00 H 0110

The informativeness of local constraints in the structure of the global trade network — •Tiziano Squartini[1], Giorgio Fagiolo[2], and Diego Garlaschelli[1] — [1]Lorentz Institute for Theoretical Physics, University of Leiden, Niels Bohrweg 2, NL-2333 CA Leiden, The Netherlands — [2]LEM, Sant'Anna School of Advanced Studies, Pisa, ITALY

The network of international trade relationships, or World Trade Web (WTW), has received renewed multidisciplinary interest due to recent advances in network theory. However, it is still unclear whether the network approach conveys additional, nontrivial information with respect to traditional international-economics analyses that describe world trade only in terms of local country-specific properties. In this work we use a recent randomization method to assess in detail the role that local structural properties have in shaping higher-order patterns

of the WTW in all its possible representations (binary/weighted, directed/undirected, aggregated/disaggregated) and across several years. We find that all higher-order properties observed in the binary description can be completely traced back to the degree sequence, which is therefore maximally informative. This implies that the degree sequence, which is currently neglected by economic models, should instead become among the focuses of theories. By contrast, the weighted patterns of the WTW cannot be completely explained by local properties, which are therefore of limited informativeness. Indirect weighted trade interactions are not simply combinations of direct ones, and can only be successfully captured by the network description of trade.

DY 18.8 Wed 12:15 H 0110

Networks of animal trade: from temporal paths to epidemic centrality — •Mario Konschake[1,3], Hartmut Lentz[1,2], Thomas Selhorst[1], Igor M. Sokolov[2], and Philipp Hövel[3] — [1]Friedrich-Loeffler-Institut, Wusterhausen — [2]Humboldt-Universität, Berlin — [3]Technische Universität, Berlin

Centrality of nodes is a major concept in network epidemiology which has been extensively studied. For temporal networks, however, a theoretical understanding is still in its infancy. In our case, a time-resolved topology arises from a series of static snapshots of the network taken at discrete time steps. The available animal-trade data has a temporal resolution of one day and includes 90.000 nodes.

We report on epidemiological relevant centrality measures based on the spread of an SIR-type disease. We analyse the robustness of the proposed measures under varying time of primary infection and under different infectious periods. We find the ranking of the nodes according to the measures sufficiently stable for different infectious periods, to be utilizable in the practical contexts of disease prevention and control. We thereby conclude that, for the analysed network, nodes with high epidemiological centrality can be identified independently of a specific disease.

We also find a threshold in the final size of the epidemic, so that diseases with an infectious period shorter than the intrinsic time constant of the network cannot propagate.

DY 18.9 Wed 12:30 H 0110

A comparison of probabilistic distribution for fitting the degree distribution of real-world social networks — •Faustino Prieto and Jose Maria Sarabia — University of Cantabria, Santander, Spain

In this paper, the degree distribution of social and information networks is analyzed. Several functional forms have been proposed in the network science literature, including the classical power law and many others. Now, six different probabilistic models are fitted in the entire range by maximum likelihood. The used models are Lognormal, Gamma, Weibull, power law and two special cases of the Pareto Positive Stable (PPS) distribution. The models are compared using the Akaike information criterion (AIC) and the Kolmorov-Smirnov (KS) statistic. A two-parameter PPS distribution is found to be the better choice in the whole range, to several social and information network datasets. Finally, the PPS model is validated graphically by using log-log rank-size plots and double log-log plots.