Working Group on Physics of Socio-economic Systems
Arbeitskreis Physik sozio-ökonomischer Systeme (AGSOE)

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Overview of Invited Talks and Sessions

(lecture rooms BAR 205, HSZ 403, HSZ 02, HSZ 01, and BAR SCHÖ; Poster P1B)

Invited Talks

AGSOE 2.1	Mon	9:30–10:15	BAR 205	**Anatomy of financial crashes: an agent based model of the leverage cycle** — •Stefan Thurner
AGSOE 7.1	Tue	9:30–10:15	BAR 205	**Growth, Innovation, Scaling, and the Pace of Life in Cities** — •Luis Bettencourt
AGSOE 10.1	Wed	9:30–10:15	BAR 205	**Cooperation supported by Darwinian selection of evolutionary rules** — •Gyorgy Szabo
AGSOE 16.1	Thu	9:30–10:15	BAR 205	**Group Path Formation in Physical and Abstract Spaces** — •Robert Goldstone

Award Ceremony of the Young Scientist Award for Socio- and Econophysics

AGSOE 13.1	Wed	16:15–17:00	HSZ 02	**The calculus of selfishness** — •Karl Sigmund
AGSOE 13.2	Wed	17:15–17:55	HSZ 02	**Using the Web to do Social Science** — •Duncan J. Watts

Public Evening Lecture (in German)

AGSOE 15.1	Wed	20:00–21:00	HSZ 01	**Wie Kooperation unter Egoisten entsteht** — •Martin Nowak

Session Overview

AGSOE 1.1–1.1	Sun	16:00–19:00	HSZ 403	**Tutorial**
AGSOE 2.1–2.1	Mon	9:30–10:15	BAR 205	**Financial Markets and Risk Management I**
AGSOE 3.1–3.7	Mon	10:15–12:45	BAR 205	**Financial Markets and Risk Management II**
AGSOE 4.1–4.5	Mon	14:00–16:00	BAR 205	**Financial Markets and Risk Management III**
AGSOE 5.1–5.5	Mon	16:00–17:45	BAR 205	**Social Systems, Opinion and Group Dynamics**
AGSOE 6	Mon	18:00–19:00	BAR 205	**Meeting of Members of AGSOE**
AGSOE 7.1–7.1	Tue	9:30–10:15	BAR 205	**Traffic Dynamics, Urban and Regional Systems I**
AGSOE 8.1–8.6	Tue	10:15–12:45	BAR 205	**Traffic Dynamics, Urban and Regional Systems II**
AGSOE 9.1–9.4	Tue	14:00–16:00	BAR 205	**Economic Models and Evolutionary Game Theory I**
AGSOE 10.1–10.1	Wed	9:30–10:15	BAR 205	**Economic Models and Evolutionary Game Theory II**
AGSOE 11.1–11.5	Wed	10:15–12:45	BAR 205	**Economic Models and Evolutionary Game Theory III**
AGSOE 12.1–12.4	Wed	14:00–16:00	BAR 205	**Economic Models and Evolutionary Game Theory IV**
AGSOE 13.1–13.2	Wed	16:15–18:00	HSZ 02	**Award Ceremony: Young Scientist Award for Socio- and Econophysics**
AGSOE 14.1–14.12	Wed	18:00–20:00	P1B	**Poster Session**
AGSOE 15.1–15.1	Wed	20:00–21:00	HSZ 01	**Public Evening Lecture**
AGSOE 16.1–16.1	Thu	9:30–10:15	BAR 205	**Networks: From Topology to Dynamics I**
AGSOE 17.1–17.5	Thu	10:15–12:45	BAR 205	**Networks: From Topology to Dynamics II**
AGSOE 18.1–18.4	Thu	14:00–16:00	BAR 205	**Networks: From Topology to Dynamics III**
AGSOE 19.1–19.4	Thu	16:00–18:00	BAR 205	**Networks: From Topology to Dynamics IV**

Symposium: Data Analysis in Complex Systems: From Data to Models

Friday: 10:15–13:30, BAR SCHÖ, See separate Program SYCS for datails.

"Maps of Science" Poster Exhibition by Katy Borner et al.

Monday–Friday 3rd floor in HSZ

Annual General Meeting Working Group on Physics of Socio-economic Systems

Monday 18:00–19:00 BAR 205

AGSOE 1: Tutorial

Time: Sunday 16:00–19:00 Location: HSZ 403

Tutorial AGSOE 1.1 Sun 16:00 HSZ 403

A General Theory of Traffic Flow — •Dirk Helbing — ETH Zurich, Universitätstr. 41, 8092 Zürich, Switzerland

The multi-disciplinary study of traffic and transport has revealed many interesting observations such as the existence of a large variety of different congested traffic states and counterintuitive effects such as the slower-is-faster effect. At the same time, great theoretical progress has been made, which is reflected by a large number of models aiming at the reproduction of empirical or experimental findings. However, many of these models have been standing side by side, and an integrative view has been missing to a large extent. This has its roots in the fact that traffic constitutes a complex, self-organizing system, and there is no general theory of complex systems, in contrast to many-particle systems close to equilibrium.

This tutorial will present elements of an integrative approach to traffic systems. Starting from simple car-following models, it will be shown how to derive consistent macroscopic, fluid-dynamic-like traffic models. It will be discussed how the linear and non-linear stability properties of these models can be analytically studied, and what kinds of congested traffic states can be derived from the related instability diagram. If time allows, further issues such as effects of multi-class multi-lane traffic will be studied, as well as network effects and elements of traffic signal control.

AGSOE 2: Financial Markets and Risk Management I

Time: Monday 9:30–10:15 Location: BAR 205

Invited Talk AGSOE 2.1 Mon 9:30 BAR 205

Anatomy of financial crashes: an agent based model of the leverage cycle — •Stefan Thurner — Complex Systems Research Group, Medical University of Vienna, Währinger Gürtel 18-20, A 1090 Vienna, Austria — Santa Fe Institute, Santa Fe, New Mexico, USA

Much of the recent financial crisis originates from the common practice of financial firms of making investments with large fractions of borrowed money (leverage). The collateral for these borrowed funds is usually put up in the form of financial assets, which are far from being 'solid' values. The dependence of the value of collateral on asset prices is often the heart of a credit crisis. In an agent based model we study an 'ecology' of essential financial players such as un-informed noise traders, hedge- or mutual funds, banks (as the providers of leverage) and investors to hedge funds. This model economy allows to identify the effects of leverage on the stability of the financial system. In particular it becomes possible to understand how minor random fluctuations can trigger a financial crisis, eventually leading to the collapse of the system. The main message is that simultaneous monitoring of a specific collection of indicators could be used to estimate the likelihood for the development of crisis. In terms of a physical classification, the model can be seen as a self organized critical system, which - as a side effect - produces realistic features of the associated price timeseries of financial assets, such as fat tailed return distributions and clustered volatility. It can be shown how details of these characteristics depend on actions of banks or regulators.

AGSOE 3: Financial Markets and Risk Management II

Time: Monday 10:15–12:45 Location: BAR 205

AGSOE 3.1 Mon 10:15 BAR 205

The instability of downside risk measures — Istvan Varga-Haszonits[1,2] and •Imre Kondor[1,3,4] — [1]Eötvös University, Budapest — [2]Analytics Department of Fixed Income Division, Morgan Stanley Hungary Analytics — [3]Collegium Budapest — [4]Parmenides Foundation, Munich

We study the feasibility and noise sensitivity of portfolio optimization under some downside risk measures (Value-at-Risk, Expected Shortfall, and semivariance) when they are estimated by fitting a parametric distribution on a finite sample of asset returns. We find that the existence of the optimum is a probabilistic issue, depending on the particular random sample, in all three cases. At a critical combination of the parameters of these problems we find an algorithmic phase transition, separating the phase where the optimization is feasible from the one where it is not. This transition is similar to the one discovered earlier for Expected Shortfall based on historical time series. We employ the replica method to compute the phase diagram, as well as to obtain the critical exponent of the estimation error that diverges at the critical point. A comparison of the historical and parametric estimators is given. The analytical results are corroborated by Monte Carlo simulations.

AGSOE 3.2 Mon 10:45 BAR 205

GPU Accelerated Fluctuation Analysis and Complex Pattern Formation — •Tobias Preis[1,2], Peter Virnau[1], Wolfgang Paul[1], and Johannes J. Schneider[1] — [1]Department of Physics, Mathematics and Computer Science, Johannes Gutenberg University of Mainz - Staudinger Weg 7, D-55099 Mainz, Germany — [2]Artemis Capital Asset Management GmbH, Gartenstr. 14, D-65558 Holzheim, Germany

The compute unified device architecture is a fundamentally new programming approach for managing computations on a graphics processing unit (GPU) as a data-parallel computing device. With continuously increasing number of cores in combination with a high memory bandwidth, a recent GPU offers incredible resources for computational physics. We apply this revolutionary new technology to methods of fluctuation analysis, which includes determination of the scaling behavior of a stochastic process and the equilibrium autocorrelation function. Additionally, the recently introduced pattern formation conformity [T. Preis et al , Europhys. Lett. 82, 68005 (2008)], which quantifies pattern-based complex short-time correlations of a time series, is calculated on a GPU and analyzed in detail. Results are obtained up to 84 times faster than on a current central processing unit core. When we apply this method to high-frequency time series of the German BUND future, we find significant pattern based correlations on short time scales. Furthermore, an anti-persistent behavior can be found on short time scales. Additionally, we compare the recent GPU generation, which provides a theoretical peak performance of up to roughly 1012 floating point operations per second with the previous one.

AGSOE 3.3 Mon 11:15 BAR 205

Collective firm bankruptcies and phase transition in rating dynamics — •Paweł Sieczka and Janusz Hołyst — Faculty of Physics, Center of Excellence for Complex Systems Research, Warsaw University of Technology, Koszykowa 75, PL-00-662 Warsaw, Poland

We present a simple model of firm rating evolution and resulting bankruptcies, taking into account two sources of defaults: individual dynamics of economic development and ordering interactions between firms. We show that such a defined model leads to phase transition, which results in collective defaults.

Two phases can be observed in the system: the paramagnetic phase of independent bankruptcies and the ferromagnetic phase of collective behavior. The mean interaction between firms decides which of these two scenarios is realized.

AGSOE 3.4 Mon 11:45 BAR 205

Measure of default risk in insurance companies: Do ratings fail? — •Christoph Hamer, Heiko Frings und Ralf Engelshove — Solcency Fabrik, Dürener Straße 295, 50935 Köln

Recent events on the financial markets indicate the need for a better understanding of certain systematic behaviour pattern in networks of risk spread.

Our approach focuses mainly on the relations between insurances and reinsurances, especially on the correlation of defaults on the probability of further default risks. This includes bilateral dependencies as well as external ratings. The aim of our work is to derive a realistic Boolean representation of these interactions. We study cascades of defaults depending on network topologies and seek to support our results by real world data.

AGSOE 3.5 Mon 12:00 BAR 205

Risk properties of structured financial securities offered to the general public — •Martin Treiber — TU Dresden, Germany

In the last years, a multitude of derivative financial products have been offered to the general investor. This includes not only call and put warrants but also more exotic investment vehicles such as reverse convertibles, discount calls and puts, so-called "bonus certificates" or "outperformance certificates", and structured notes that guarantee a certain return at expiration date.

In this contribution, I discuss the risk profile of such products in terms of the return distribution function and, particularly, the value at risk. As a main result, I show that the risk profiles depend strongly on the assumptions for the return profile of the underlying asset. For a lognormal distribution (Black-Scholes ansatz), analytic return profiles are derived even for some of the more exotic products. However, with the inclusion of stochastic volatility, the risk profiles change drastically. This is particularly true for the popular "bonus certificates" as many investors experienced at their own cost, recently.

AGSOE 3.6 Mon 12:15 BAR 205

Nonlinear stochastic modeling of Tsallis statistics with application to financial markets — •Bronislovas Kaulakys, Vygintas Gontis, Miglius Alaburda, and Julius Ruseckas — Institute of Theoretical Physics and Astronomy of Vilnius University, A. Gostauto 12, LT-01108 Vilnius, Lithuania

The financial observables may be related to the superstatistical and Tsallis' statistical approaches. Superstatistical processes generated by driven Poisson processes [1] are long-range with the power-law distributions and may be useful for analysis of traffic, financial and other systems. Here we derive nonlinear stochastic differential equations [2] generating processes with q-exponential and q-Gaussian distributions, with the long-range power-law autocorrelations and $1/f^{\beta}$ power spectral density. We analyze properties of solutions of these equations in relation with the nonextensive statistical mechanics framework and relevance of the generalized and adapted equations for modeling of the financial processes.

[1] V. Gontis, B. Kaulakys, and J. Ruseckas, Physica A **387**, 3891 (2008).

[2] B. Kaulakys and M. Alaburda, J. Stat. Mech., to be published (2009).

AGSOE 3.7 Mon 12:30 BAR 205

Prediction of financial time series with the technology of high-order Markov chains — Vladimir Soloviev[1], Vladimir Saptsin[2], and •Dmitry Chabanenko[1] — [1]Cherkassy National University, Cherkassy, Ukraine — [2]Kremenchuk State Polytechnical University, Kremenchuck, Ukraine

In this research the technology of complex Markov chains, i.e. Markov chains with a memory is applied to forecast the financial time-series. The high-order Markov chains can be simplified to first-order ones by generalizing the states in Markov chains. Considering the *generalized state* as the sequence of states makes a possibility to model high-order Markov chains like first-order ones. The adaptive method of defining the states is proposed, it is concerned with the statistic properties of price returns.

The algorithm of prediction includes the next steps: (1) Generate the hierarchical set of time discretizations; (2) Reducing the discretization of initial data and doing prediction at the every time-level (3) Recurrent conjunction of prediction series of different discretizations in a single time-series. The hierarchy of time discretizations gives a possibility to review long-memory properties of the series without increasing the order of the Markov chains, to make prediction on the different frequencies of the series.

The technology is tested on several time-series, including: EUR/USD Forex course, the World's indices, including Dow Jones, S&P 500, RTS, PFTS and other.

AGSOE 4: Financial Markets and Risk Management III

Time: Monday 14:00–16:00 Location: BAR 205

AGSOE 4.1 Mon 14:00 BAR 205

Reliable Quantification and Efficient Estimation of Credit Risk — •Jörn Dunkel[1] and Stefan Weber[2] — [1]Rudolf Peierls Centre for Theoretical Physics, University of Oxford, 1 Keble Road, Oxford OX1 3NP, United Kingdom — [2]School of Operations Research and Information Engineering, 279 Rhodes Hall, Cornell University, Ithaca, NY 14853, USA

The present crisis in the global financial markets requires a critical review of current regulatory practice. Substantial efforts are required to devise efficient quantitative methods for a more reliable estimation of financial risks in the future. These tools must be able to detect extreme loss scenarios that are unlikely to occur but whose impact may be dramatic as illustrated by the recent liquidity crisis of Lehman Brothers, Merrill Lynch, AIG, and others. We report here a novel Monte-Carlo approach for the efficient computation of improved, convex risk measures. Unlike the current industry standard Value-at-Risk, these new risk measures are sensitive to the tails of loss distributions. They can provide a basis for more sensible risk management policies and help to prevent future financial turmoil.

AGSOE 4.2 Mon 14:30 BAR 205

Double risks portfolio optimization problem for pension funds — •Uli Spreitzer[1] and Vladimir Reznik[2] — [1]Bonus Pensionskasse, 1060 Vienna, Austria — [2]Watson Wyatt, 65189 Wiesbaden, Germany

It is obvious, that an optimization with respect to minimize e.g. the downside- risk can effect an increase of the risk, that the rate of return is below a priori guarantied rate of return. And vice versa an optimization with minimization of the risk e.g. , that the rate of return is below a priori guarantied rate of return can result in, that the downside-risk is not optimized. We will show a theory of optimization of several combinations of two measures of risk, as competitiors risk, downside risks, guarantied rate risk.

AGSOE 4.3 Mon 15:00 BAR 205

Credit Risk and the limits of diversification — •Rudi Schäfer[1], Alexander Koivusalo[2], and Thomas Guhr[1] — [1]Fachbereich Physik, Universität Duisburg-Essen, Germany — [2]Mathematical Physics, LTH, Lund University, Sweden

In view of the current financial crises the modeling of credit risk is of great importance. We study a structural model which is based on a jump-diffusion process for the risk factors. In a portfolio of credit contracts, the correlations between the individual risk factors have a pronounced effect on the distribution of the portfolio losses. Even weak correlations lead to a heavy-tailed loss distribution and severely limit the benefits of diversification. We compare these findings to the predictions of reduced form models and discuss difficulties in measuring the correlations of defaults and recovery rates.

AGSOE 4.4 Mon 15:30 BAR 205

Time-dependent correlations in financial markets — •Michael Münnix, Rudi Schäfer, and Thomas Guhr — Fachbereich Physik, Universität Duisburg-Essen, Germany

Correlations between different financial assets are the crucial input for risk assessment and portfolio optimization. However, these correlations change with time. We show empirical results for the dynamics of the correlation structure in the S&P 500 stocks. Further, we use

Monte-Carlo simulations to investigate how noise reduction techniques can help to identify changes in the correlation structure.

AGSOE 4.5 Mon 15:45 BAR 205

A numerical analysis of eigenvalues and eigenvectors of covariance matrices — •Daniel Fulger[1,2], Enrico Scalas[1], Giulia Iori[3], Mauro Politi[2], and Guido Germano[2] — [1]Amedeo Avogadro University of East Piedmont, Alessandria, Italy — [2]Philipps-Universität Marburg, Germany — [3]City University, London, UK

Covariance matrices are related to similarity and dissimilarity matrices, which are often used as a starting point for classification purposes through clustering. We present numerical analyses of the eigenvalues and eigenvectors of covariance matrices built from independent or from correlated random variables for the cases $Q > 1$ or $Q < 1$, where $Q = T/N$ is the ratio of observations T to the number of random variables N. The former case, where there are more observations than variables, is common in physics and in finance, while the latter occurs typically for biological problems such as microarray analysis. We discuss how to compute covariance matrices from synchronous or asynchronous data, we compare the numerical eigenvalue spectra of independent or free independent random variables with analytical results of classical or free random matrix theory, and present several case studies with groups of correlated random variables in a noisy sea of independent random variables.

AGSOE 5: Social Systems, Opinion and Group Dynamics

Time: Monday 16:00–17:45 Location: BAR 205

AGSOE 5.1 Mon 16:00 BAR 205

Identification of the different ingredients governing the outcome of a soccer match — •Andreas Heuer, Christian Müller, and Oliver Rubner — Institut für Physikalische Chemie, WWU Münster

In previous work we have shown that during a *whole season* of the Bundesliga the quality of a team can be characterized by a single fitness value F. It can be estimated from the league table [1]. Here we analyse the three relevant ingredients, determining the outcome of a *single match* of teams A and B with fitness F_A and F_B, respectively.

1.) Which law determines the expectation for the average goal difference ΔG_{AB} of this match? From symmetry and self-consistency arguments the most general function $\Delta G_{AB}(F_A, F_B)$ can be identified. Comparison with the actual data allows one to adjust the parameters and to obtain a *unique* function. 2.) How important are fluctuations of the team fitness from match to match around its average value? Surprisingly, the effect of fitness fluctuations is very small. 3.) Given the average outcome of a match, what is the probability for a specific result? In contrast to a previous interpretation [2] the number of goals per team in a match can be extremely well described by a simple Poisson process (up to 8 goals).

In summary, soccer turns out to be a surprisingly simple match with respect to its statistical properties.

[1] A. Heuer, O. Rubner, Eur. J. Phys. B (in press).
[2] E. Bittner et al, Europhys. Lett. 78, 58002 (2007).

AGSOE 5.2 Mon 16:30 BAR 205

Anomaly interactions in network of Polish Football League — •Andrzej Jarynowski and Janusz Miskiewicz — Institute of Theoretical Physics, University of Wroclaw, pl.M.Borna 9, 50-204 Wroclaw, Poland

In recent years prosecution in Poland has been investigating several clubs, referees and players because of corruption procedures. We study the statistical properties of results in Polish League, looking for evidence of non-sport activity. We treat league as a complex system and we use tools from statistical physics to research some of its properties. Our analyse include: (1) comparing spectrum of correlation matrix with one of the *cleaner* national leagues-Bundesliga and random matrixes(from different distributions related to this type of data); (2) investigating system of ranked elements in time serie and finding which clubs play for anothers profits; (3) analysing statistical situation before and after matches, which were stated by the court as those in which a crime has been commited; (4) estimating parameters of Kopocinski model to predict propability of appearance of non-sport intervention in investigated match. This research is dedicated to release Polish Football from problem of corruption.

AGSOE 5.3 Mon 16:45 BAR 205

Cointegration of output, capital, labor, and energy — •Robert Stresing[1,2] and Reiner Kümmel[2] — [1]Institute of Physics, University of Oldenburg, Germany — [2]Institute of Theoretical Physics, University of Würzburg, Germany

Standard economic theory assumes that the markets of the production factors capital, labor, and energy operate in an equilibrium state, where the cost share of each production factor is equal to its output elasticity, which reflects its productive power. According to this assumption, the role of energy as a production factor is marginal, because it only accounts for five per cent of the total factor costs.

We apply cointegration analysis to the linear combinations of the time series of (the logarithms of) output, capital, labor, and energy for Germany, Japan, and the USA since 1960. The computed cointegration vectors represent the output elasticities of the aggregate energy-dependent Cobb-Douglas function. We find that they are for labor much smaller and for energy much larger than the cost shares of these factors. These findings disagree strongly with standard economic theory, but support results obtained with heterodox LINEX production functions.

Our results elucidate the forces behind the pressure towards increasing automation and unemployment, and question the concept of "neoclassical equilibrium" as well as influential analyses of the economic impacts of climate change based on standard economic theory.

Ref.: R. Stresing, D. Lindenberger, R. Kümmel, "Cointegration of output, capital, labor, and energy", Eur. Phys. J. B 66, 279-287 (2008)

AGSOE 5.4 Mon 17:15 BAR 205

A definite analytic relation between the unisex G7 life expectancy and the envelope of their annual output in goods and services — •Hans G Danielmeyer and Thomas Martinetz — Institut für Neuro- und Bioinformatik, Universität Lübeck, Ratzeburger Allee 160, Germany

The leading nation's mean unisex life expectancies are compared from 1850 to date with their annual output of goods and services per capita. Wars destroy analytic relations, but life insurers eliminate catastrophic losses, and the outputs have a well defined envelope representing the undisturbed existential condition. Both evolutions are S-functions with the same growth parameter of 62 years. This length bridging 3 generations and its constancy over 6 generations to date suggest epigenetic stabilization. For the first time it is seen that the mean life expectancy precedes the existential condition by constant 59 years and approaches an extrapolated age of 118. This precedence and the ratio 2 follow exactly when life integrates proportionally over existential conditions. There is no adjustable parameter. Individual life and technical progress seem to be guided by a coherent set of relevant knowledge. This supports our previous results that the industrial society's evolutionary pace is determined by our biologic nature as long as there is a sufficient buffer of relevant knowledge.

AGSOE 5.5 Mon 17:30 BAR 205

The Academic System and The Marketplace of Ideas — •Sabine Hossenfelder — Perimeter Institute for Theoretical Physics, Waterloo, Canada

The scientific community makes for an interesting case study for the emergence of social phenomena from individual interests. As a community of practice with only peripheral external interactions, researchers in academic institutions form an almost closed system, with over-averagely intelligent agents, whose activities are well documented.

In this talk, I want to examine the incentive structure in the academic system and the macro-trends that follows from the micro-behaviours of researchers. Most importantly, one can identify four pressures that result in the adaptation of strategies suitable to the environment: peer pressure, financial pressure, time pressure, and public pressure. I will further examine the question under which circumstances incentives for simplified secondary criteria can work against the primary goals of the community, and will argue that institutional-

izing measures for scientific success hinders the system's performance.

AGSOE 6: Meeting of Members of AGSOE

Time: Monday 18:00–19:00 Location: BAR 205

Details for the social evening with the invited speakers on Thursday evening will be announced during the meeting.

AGSOE 7: Traffic Dynamics, Urban and Regional Systems I

Time: Tuesday 9:30–10:15 Location: BAR 205

Invited Talk AGSOE 7.1 Tue 9:30 BAR 205

Growth, Innovation, Scaling, and the Pace of Life in Cities — •Luis Bettencourt — Theoretical Division, Los Alamos National Laboratory, Los Alamos NM 87545 — Santa Fe Institute, 1299 Hyde Park Rd, Santa Fe NM 87501

Humanity has just crossed a major landmark in its history with the majority of people now living in cities. The inexorable trend towards urbanization worldwide presents an urgent challenge for developing a predictive, quantitative theory of urban organization and sustainable development. We present empirical evidence indicating that the processes relating urbanization to economic development and knowledge creation are very general, being shared by all cities belonging to the same urban system and sustained across different nations and times.

Many diverse properties of cities from patent production and personal income to electrical cable length are shown to be power-law functions of population size with scaling exponents greater than unity (increasing returns) for quantities reflecting socio-economic processes (wealth creation, innovation, crime). Quantities accounting for infrastructure on the other hand are characterized by exponents smaller than one (economies of scale).

We explore the consequences of these relations for the pace of urban life and for the long term growth dynamics of urban agglomerations. We also show how the statistical properties of residuals from scaling fits lead to a new ranking of cities within an urban system that is population size independent and to simpler, more fundamental, models of urban systems.

AGSOE 8: Traffic Dynamics, Urban and Regional Systems II

Time: Tuesday 10:15–12:45 Location: BAR 205

AGSOE 8.1 Tue 10:15 BAR 205

New Laws of City Growth — •Diego Rybski[1], Hernan D. Rozenfeld[1], Jose S. Andrade Jr.[2], Michael Batty[3], H. Eugene Stanley[4], and Hernan A. Makse[1] — [1]Levich Institute and Physics Department, City College of New York, New York, NY 10031, USA — [2]Departamento de Fisica, Universidade Federal do Ceara, 60451-970 Fortaleza, Ceara, Brazil — [3]Centre for Advanced Spatial Analysis, University College London, 1-19 Torrington Place, London WC1E 6BT, UK — [4]Center for Polymer Studies and Physics Department, Boston University, Boston, MA 02215, USA

An important issue in the study of cities is defining a metropolitan area. A commonly employed method of defining a metropolitan area is the Metropolitan Statistical Areas (MSA), based on rules attempting to capture the notion of city as a functional economic region, and is constructed using experience. Here, we introduce a new method to designate metropolitan areas, denoted the "City Clustering Algorithm" (CCA). The CCA is based on spatial distributions of the population at a fine geographic scale, defining a city beyond the scope of its administrative boundaries. We use the CCA to examine Gibrat's law of proportional growth. We find that the mean growth rate of a cluster utilizing the CCA exhibits deviations from Gibrat's law, and that the standard deviation decreases as a power-law with respect to the city size. The CCA allows for the study of the underlying process leading to these deviations. These results have socio-political implications, such as those pertaining to the location of new economic development in cities of varied size.

AGSOE 8.2 Tue 10:45 BAR 205

Comparing fluctuations in traffic flow with thermal noise in physical pattern forming systems — •Martin Treiber — TU Dresden, Dresden, Germany

Thermal noise in physical pattern-forming fluid systems (such as Rayleigh-Benard convection or Taylor-Couette flow) increases in a characteristic way when approaching a linear stability threshold from below. This can be described quantitatively by generalizing the fluctuation-dissipation theorem to nonequilibrium systems.

In this contribution, I show that the same is true when (non-thermal) noise is applied to pattern-forming systems driven by nonphysical forces, with traffic flow being a prominent example. Sufficiently far away from threshold, many concepts of equilibrium thermodynamics carry over to the traffic system although neither energy nor momentum are conserved. Particularly, the fluctuations allow to determine a generalized "interaction potential" from the data.

Simulations show that, when approaching the linear stability, the fluctuations increase in the traffic system as well. Moreover, correlations appear that anticipate, in a way, the patterns of stop-and go traffic observed once above threshold. Both results could be described nearly quantitatively by analytical methods that have been successfully applied to the thermal fluctuations of the physical pattern-forming systems.

AGSOE 8.3 Tue 11:15 BAR 205

Spatiotemporal dynamics of supply network growth — •Karsten Peters — Institute for Traffic and Economis, TU Dresden

Supply networks are complex networks designed to fulfill certain functional requirements. Based on expansion data of a large grocery retailer network for more than 40 years we developped a model for the spatiotemporal expansion of supply networks, involving the setup of new stores an the coevolution of a distribution center network. Surprisingly the evolution of such networks reveals properties which are similar to the growth of tumors in tissues. Using this model, we where able to investigate the influence of different expansion strategies to the overall development, potential earnings and spatial coverage of such business structures. It turns out, that the tradeoff between large spatial expansion steps and optimal local coverage leads over the time to significant differences in the efficiency of different strategies. These results can be used to optimize the structure of retailer and supply networks but point also towards a new modelling paradigm for spatial economic growth, which uncovers the analogies with other, biological spatiotemporal expansion processes.

AGSOE 8.4 Tue 11:45 BAR 205

Universality in Geometric Properties of German Road Networks: Empirical Analysis and Modelling — •Sonic Chan[1], Reik Donner[1], Stefan Lämmer[1], and Dirk Helbing[2] — [1]TU Dresden, Andreas-Schubert-Str. 23, 01062 Dresden, Germany — [2]ETH Zürich, Universitätstr. 41, CH-8092 Zürich

In order to understand the development of urban road networks, we have investigated the structural properties of a variety of German cities. A considerable degree of universality is found in simple geometric features such as the distributions of link lengths, cell areas and

cell degrees. In particular, German cities are mainly characterized by perpendicular intersections and splittings of straight roads, deviations of the link angle distributions from the rectangular pattern follow in good approximation stretched exponential distributions.

It is shown that most empirical features of the studied road networks can be surprisingly well reproduced by a simple self-organizing evolving network model. For this purpose, we suggest a two-step procedure with a stochastic generation of new nodes in the presence of a sophisticated interaction potential, which is followed by the establishment of new links according to some deterministic rules. In this model, rectangular patterns naturally emerge due to basic economic considerations. It will be further discussed to which extent similar mechanisms do significantly contribute also in other technological or biological transportation networks.

AGSOE 8.5 Tue 12:15 BAR 205

The Pareto-positive stable distribution: a descriptive model for city size data — •Jose Maria Sarabia and Faustino Prieto — University of Cantabria, Santander, Spain

The Pareto-positive stable (PPS) distribution is introduced as a new model for describing city size data in several countries. The PPS distribution provides a flexible model for fitting all the range of a set of city size data, where zero and unimodality are possible, and the classical Pareto and Zipf distributions are included as a particular case.

The new model has a twofold origin. Initially, it can be obtained by mixing the shape parameter of a classical Pareto distribution with a positive stable distribution. In this way we can model the possible heterogeneity in the set of city sizes. The distribution obtained is also genuine by extending the range of the characteristic exponent in the stable law. PPS distribution can be also obtained from a monotonic transformation of the classical Weibull distribution.

Probabilistic properties are studied and several descriptive measures are obtained. Maximum likelihood estimators are proposed. Initial estimators of the parameters can be obtained using regression methods. A simple graphical method for studying the adequacy of the data to model is given.

Finally, we consider city size data for USA and Spain for several years, because they are the countries with highest migration shocks in recent years. Some classical distributions as well as PPS distribution are fitted, and we conclude that PPS distribution outperforms previous models.

AGSOE 8.6 Tue 12:30 BAR 205

Potential and Spatial Evolution of Location Patterns — •Yuri Yegorov — University of Vienna,, BWZ, Vienna, Austria

The spatial location of household and business represents a complex and evolving pattern that is driven by agglomeration and congestion forces. The origin of agglomeration forces is in scale economies, while congestion force is a cumulative negative externality. Since population and economy are growing, while technology is developing, the spatial structure is always evolving having only partial equilibrium at each time. The goal of this article is to develop a theory that can give some hint to equilibrium spatial structures and evolution of spatial patterns. The analysis starts from discrete case and then goes to continuous case. The analysis of interaction between two cities in discrete set up shows that market forces can either lead to dispersion or agglomeration, and polarized equilibrium is also possible. In the continuous static case the concept of potential of interaction between agent and CBD is introduced. Congestion function depends on population density. Interaction between these two forces can lead to heterogeneous spatial densities. Dynamics of spatial evolution depends of functional forms of potentials and can lead to different types of PDE equations of parabolic type.

AGSOE 9: Economic Models and Evolutionary Game Theory I

Time: Tuesday 14:00–16:00 Location: BAR 205

AGSOE 9.1 Tue 14:00 BAR 205

Predicting social systems — •Eckehard Olbrich, Nils Bertschinger, and Jürgen Jost — Max Planck Institute for Mathematics in the Sciences, Leipzig, Germany

Predicting social systems can, unlike in natural systems, evoke reactions that affect the predicted outcome. One well-known example are the so called "Self fulfilling prophecies". We analyze this phenomenon in a game theoretic setting. In a game with uncertainty an additional player is introduced who can ask the players before the actual game about their intentions and is interested in a prediction being as good as possible. We analyze under which conditions this modification introduce new equilibria to the game and discuss possible applications such as election polls or analyst forecasts.

Finally it is discussed to which extent the explanation of "self-fulfilling prophecies" has to take into account not only strategic interactions as it is formalized in the game theoretic approach, but also cognitive aspects, such as the framing of the situation.

AGSOE 9.2 Tue 14:30 BAR 205

Coarse-graining of evolutionary models — •Johannes Höfener — Biological Physics Section, Max-Planck Institut für Physik komplexer Systeme, Nöthnitzer Straße 38, 01187 Dresden, Germany

Analyzing complex evolutionary agent-based models by simulations can become prohibitively numerical demanding. Here we present a coarse-graining method, which uses only short burst of agent-based simulations to extract the information that is necessary to study the system directly on the level of trait distributions. We illustrate this approach by two examples from game theory. First, we show that it reproduces well-known results on the continuous snowdrift game, while numerical performance is increased by a factor of 1000. Then we consider a network snowdrift game, in which players can cut links to uncooperative neighbors. Here both the cooperative investment and the threshold for cutting links are treated as evolutionary traits. Our results show that this form of topological punishment can effectively enforce cooperation.

AGSOE 9.3 Tue 15:00 BAR 205

Fixation times in evolutionary games under weak selection — •Philipp M. Altrock and Arne Traulsen — Max-Planck-Institut für Evolutionsbiologie, Plön, Deutschland

In evolutionary game dynamics, reproductive success increases with the performance in an evolutionary game. If strategy A performs better than strategy B, strategy A will spread in the population. Under stochastic dynamics, a single mutant will sooner or later take over the entire population or go extinct. We analyze the mean exit times (or average fixation times) associated with this process [1].

We show analytically that these times depend on the payoff matrix of the game in an amazingly simple way under weak selection [2]: The payoff difference $\Delta\pi$ is a linear function of the number of A individuals i, $\Delta\pi = u\,i + v$. The unconditional mean exit time depends only on the constant term v. Given that a single A mutant takes over the population, the corresponding conditional mean exit time depends only on the density dependent term u. We demonstrate this finding for two commonly applied microscopic evolutionary processes.

[1] T. Antal and I. Scheuring. Fixation of strategies for an evolutionary game in finite populations. *Bull. Math. Biol.*, 36(12):1923–1944 2006.

[2] P. M. Altrock. and A. Traulsen. Fixation times in evolutionary games under weak selection. *New J. Physics*, in press 2008.

AGSOE 9.4 Tue 15:30 BAR 205

Simulation of the spread of highly allergenic ragweed in past and future — •Gero Vogl[1], Michael Leitner[1], Manfred Smolik[1], Lorenz-Mathias Stadler[1], Stefan Dullinger[2], Franz Essl[3], Ingrid Kleinbauer[4], and Johannes Peterseil[3] — [1]Fakultät für Physik der Universität Wien — [2]Fakultät für Lebenswissenschaften der Universität Wien — [3]Umweltbundesamt, Wien — [4]VINCA, Vienna Institute for Nature Conservation and Analyses

Modelling the spread of newcomers has traditionally been based on reaction-diffusion equations (Skellam 1951). However, these equations do not allow for explicit considering details of the environment (the habitat). Even by incorporating environmental heterogeneity by adjusting the model parameters to the habitat suitability (e.g. Kinezaki et al. 2002, 2006) the specific spatial habitat configurations cannot

be incorporated in detail. Spatially explicit modelling approaches are necessary for describing and predicting the spread of invasive species in real landscapes and as a function of changing climate.

In order to reconstruct by help of Monte Carlo simulations the recent spread of the highly allergenic invasive ragweed (Ambrosia artemisiifolia L.) across Austria we integrate habitat-based information on potential distributions and spatio-temporal range dynamics into a common framework. The result: invasion is not as fast as changing climate would permit, because spread is limited by the constraints of either short range diffusion or long range transport.

AGSOE 10: Economic Models and Evolutionary Game Theory II

Time: Wednesday 9:30–10:15 Location: BAR 205

Invited Talk AGSOE 10.1 Wed 9:30 BAR 205

Cooperation supported by Darwinian selection of evolutionary rules — •Gyorgy Szabo — Research Institute for Technical Physics and Materials Science, P.O. Box 49, H-1525 Budapest, Hungary

The evolutionary game theory provides a general mathematical framework for the investigation of multi-agent systems used widely in biology, economy and other social sciences. In these systems we have an extremely large freedom in the definition of models giving the set of strategies, the interaction, the connectivity structure, and dynamical rules. The introduction of co-evolutionary processes simplifies this problem by focusing our attention to those models which are themselves subjected to an evolutionary process.

We study co-evolutionary Prisoner's Dilemma games where each player can imitate both the strategy and imitation rule from a randomly chosen neighbor with a probability dependent on the payoff difference when the player's income is collected from games with the neighbors. The players, located on the sites of a lattice, follow unconditional cooperation or defection and use individual strategy adoption rule described by a parameter. If the system is started from a random initial state then the present co-evolutionary rule drives the system towards a state where only one evolutionary rule remains alive even in the coexistence of cooperative and defective behaviors. The final rule is related to the optimum providing the highest level of cooperation and affected by the connectivity structure.

AGSOE 11: Economic Models and Evolutionary Game Theory III

Time: Wednesday 10:15–12:45 Location: BAR 205

AGSOE 11.1 Wed 10:15 BAR 205

The Unexpected Birth of Cooperation in the Prisoner's Dilemma with Migration — •Dirk Helbing and Wenjian Yu — ETH Zurich, Universitätstr. 41, 8092 Zürich, Switzerland

The prisoner's dilemma models situations where it is risky to cooperate and tempting to defect (i.e. to free-ride or cheat). For this reason, it is often used to study conditions for the cooperation among selfish individuals. In the evolutionary prisoner's dilemma, the finally resulting fraction of cooperators is predicted to be zero. But what happens, if we consider effects of migration? The integration of game theoretical models and models of individual motion has recently led to agent-based models, which can describe various stylized facts in social, economic, and biological systems (such as agglomeration, segregation, turn-taking, class and niche formation). But how does migration influence the level of cooperation? We find that it can change the outcome dramatically! Directed (in contrast to random, diffusive) migration can support the formation of clusters and promote a higher level of cooperation, where conventional spatial games predict a decreasing level. We also study whether this finding is robust to varying parameters and noise. This reveals a new mechanism, how cooperators manage to resist attempts of defectors to invade cooperative clusters under various conditions. In a noisy world, success-driven migration can reach a majority of cooperators even when we assume no cooperators in the beginning and selfish behavior most of the time. This unexpected discovery shows that mobility could have been very crucial for the spontaneous birth of cooperation and (pro)social behavior.

AGSOE 11.2 Wed 10:45 BAR 205

Learning, migration and evolutionary games: a new paradigm in the study of cooperation — •Carlos P. Roca[1,2] and Dirk Helbing[1] — [1]Chair of Sociology, in particular of Modeling and Simulation, ETH Zurich, Swizterland — [2]GISC, Department of Mathematics, Universidad Carlos III de Madrid, Spain

The problem of the emergence and stability of cooperative behavior has attracted a great deal of attention during last decades, being one of the most prominent open questions in a variety of disciplines [1]. Evolutionary game theory has become one of the most fruitful frameworks to address this issue, by proposing stylized models based on social dilemmas and evolutionary dynamics [2]. Only very recently the importance of migration, understood as individuals' mobility, has started to be considered in depth [3]. On the other hand, whereas most studies introduce an evolutionary dynamics based on some sort of imitation, in this work we provide individuals with basic learning capabilities. We have found that the combined effect of learning and migration has a strong influence on cooperation, which nature stands in stark contrast to that of models based on other kind of dynamics. Our work suggests that the existence of particular cognitive abilities, as well as the possibility of mobility, may have been of crucial importance in the flourishing of cooperation.

[1] Pennisi E., Science 309, 2005.

[2] Maynard Smith J., Evolution and the Theory of Games, Cambridge University Press, 1982.

[3] Helbing D., Yu W., Adv. Complex Systems 11, 2008

AGSOE 11.3 Wed 11:15 BAR 205

Evolutionary dynamics in structured populations — •Corina Tarnita[1], Tibor Antal[1], Hisashi Ohtsuki[2], and Martin Nowak[1] — [1]Department of Mathematics and Program for Evolutionary Dynamics, Harvard University, Cambridge MA 02138, USA — [2]Department of Value and Decision Science, Tokyo Institute of Technology, Tokyo, 152-8552, Japan

Evolutionary dynamics are strongly affected by population structure. The outcome of an evolutionary process in a well-mixed population can be very different from that in a structured population. There have been many attempts to study the effect of population structure on evolutionary dynamics. These approaches include spatial models in ecology, spatial games and games on graphs. In most of these models, the underlying spatial structure or social network is given and does not change during the evolutionary process. Here I present a completely analytical theory for a class of models that use dynamical graphs. The interaction graph changes as a consequence of evolutionary updating. I obtain exact results for any evolutionary game including the evolution of cooperation. I present precise conditions for cooperators to be selected over defectors. Finally, I use the same mathematical tools to derive a general condition for strategy selection that holds for a large variety of structured population.

AGSOE 11.4 Wed 11:45 BAR 205

Efficiency based strategy spreading in the prisoner's dilemma game — •Sebastian Weber and Markus Porto — Institut für Festkörperphysik, Technische Universität Darmstadt, Germany

In contrast to well-mixed populations, discrete interaction patterns have been shown to support cooperation in the prisoner's dilemma game, and a scale-free network topology may even lead to a dominance of cooperation over defection. The majority of studies assumes a strategy adoption scheme based on accumulated payoffs. The use of accumulated payoffs, however, is incompatible with the integral property of the underlying replicator dynamics to be invariant un-

der a positive affine transformation of the payoff function. We show that using instead the payoff per interaction to determine the strategy spread, which has been suggested recently and recovers the required invariance, results in fundamentally different dynamical behavior [1]. Most notably, in such an efficiency based scenario the advantage of a scale-free network topology vanishes almost completely. We present a detailed explanation of the fundamentally altered dynamical behavior.
[1] S. Weber, and M. Porto, submitted

AGSOE 11.5 Wed 12:15 BAR 205

Measuring the evolution of socio-economical structure in an online game — •Michael Szell[1] and Stefan Thurner[1,2] — [1]Complex Systems Research Group; HNO; Medical University of Vienna; Währinger Gürtel 18-20; A-1090; Austria — [2]Santa Fe Institute; 1399 Hyde Park Road; Santa Fe; NM 87501; USA

The analysis of high-frequency log files of a massive multiplayer online game currently played by thousands of users allows to assess socio-economical dynamics over the past three years. We are able to relate social and economic behaviour of the players to a series of stylized facts known to exist in the real world. In particular, we analyze the evolution of underlying growing social networks such as constituted by friends and/or foes, private message communication networks, and measure their characteristic properties. Our data confirm the recently observed phenomena of shrinking diameters and growing average degrees. Clustering coefficients of friend-networks decay in time, while those of foes grow. Further, we study the evolution dynamics of social clusters (alliances in the game). We compare our findings with literature on real world data. With this setup we try to establish a "laboratory" for economical behaviour.

AGSOE 12: Economic Models and Evolutionary Game Theory IV

Time: Wednesday 14:00–16:00 Location: BAR 205

AGSOE 12.1 Wed 14:00 BAR 205

Evolutionary Dynamics with High Mutation Rates — •Arne Traulsen — Max-Planck-Institute for Evolutionary Biology, 24306 Plön, Germany

Evolutionary game theory describes systems in which successful strategies spread in a population. It is usually argued that it equally applies to genetical reproduction and to social imitation. However, while biological mutation rates are small, social mutation or exploration rates may be high. This can have a decisive impact on the evolution of cooperation and punishment [1]. Under weak selection, all strategies have similar abundance and one may argue that increasing the mutation rates does not change the strategy abundance. However, it can be shown that even for weak selection, different conditions for the abundance of strategies are obtained in $n \times n$ games for high and low mutation rates [2]. Only for 2×2 games, the condition under which one strategy is more abundant than the other does not depend on the mutation rate at all [3].
[1] A. Traulsen, C. Hauert, H. de Silva, M.A. Nowak, and K. Sigmund, PNAS, in press
[2] T. Antal, A. Traulsen, H. Ohtsuki, C. Tarnita, and M.A. Nowak, arXiv:0811.2009
[3] T. Antal, M.A. Nowak, and A. Traulsen, JTB, in press, arXiv:0809.2804

AGSOE 12.2 Wed 14:30 BAR 205

What is the effect of networks on cooperation? Lack of universality in evolutionary game theory on graphs. — Carlos P. Roca[1,2], Sergi Lozano[1], José A. Cuesta[2], Alex Arenas[3,4], and •Angel Sánchez[3,4,5] — [1]SOMS, ETH Zürich, Switzerland — [2]GISC, U. Carlos III, Madrid, Spain — [3]U. Rovira i Virgili, Tarragona, Spain — [4]BIFI, Zaragoza, Spain — [5]ICMAT, CSIC-UAM-UC3M-UCM, Madrid, Spain

In the past few years much work has been devoted to the study of the emergence of cooperation by considering evolutionary games among individuals whose interactions are governed by a network. This line of research has produced interesting and inspiring results; however, a complete picture of the observed phenomenology and the mechanisms behind it is lacking. In this talk, we provide evidence that such a complete picture can not be found because evolutionary game theory on graphs is highly non-universal. Extensive simulations allow us to conclude that the enhancement or inhibition of cooperation strongly depends on the type of network, the type of evolutionary dynamics and the social dilemma under study. Furthermore, the phenomenology observed in real social networks may be considerably different from the results of this kind of models. In particular, the existence of a mesoscopic level of organization can not be neglected. Our main conclusion is that modeling the emergence of cooperation in a sensible way requires looking at a wide range of social dilemmas and not at a particular one, and that this research should always have in mind a specific context for application because of the lack of universality.

AGSOE 12.3 Wed 15:00 BAR 205

Self-organization of scale free topologies in an adaptive network model of cooperation — •Gerd Zschaler and Thilo Gross — Max-Planck-Institut für Physik komplexer Systeme, Dresden, Germany

We study a model of cooperation on an adaptive network, where both the evolution of strategies and the dynamics of the network topology depend on the individuals' fitness. In our model, individuals adopting either strategy of cooperation or defection are represented by the nodes in a network and participate in a snowdrift game with each of their neighbors. We consider two mechanisms of the system's evolution: A player may adopt the strategy of a more successful neighbor (that receives a higher payoff) with a given probability. Additionally, a successful player can reshape its environment by cutting a link to a neighbor with lower payoff and rewiring to another randomly selected node.

Employing full simulations of the network and analytical approximation through moment-closure techniques, we show that sufficiently strong payoff-dependence in the linking dynamics leads to a higher fraction of cooperators in the stationary regime. As selective rewiring implies a "rich-stays-rich" mechanism in our model, the creation of high-degree nodes is observed. This results in the appearance of a power-law tail in the degree distribution.

AGSOE 12.4 Wed 15:30 BAR 205

Cycles of cooperation and defection in imperfect learning — •Tobias Galla — Theoretical Physics, School of Physics and Astronomy, The University of Manchester, Manchester M139PL, UK

In this talk we discuss the dynamics of agents learning to play a two-player game while subject to memory-loss. If players make an infinite number of observations (actions of their opponent) between adaptation events, the dynamics is deterministic and described by so-called Sato-Crutchfield equations, a modification of the standard replicator dynamics. In case of a finite number N of observations between two adaptation events, the learning dynamics becomes stochastic as the opponent's mixed strategy profile can no longer be sampled accurately.

We discuss the effects of the batch size N and the memory-loss rate for the specific example of the iterated prisoner's dilemma. The deterministic learning dynamics at non-zero memory-loss does here in general not converge to the Nash equilibrium describing full defection, but instead limit cycles or reactive fixed points can be found. The dynamics at finite batch sizes is seen to exhibit sustained stochastic oscillations between co-operation and defection, and the spectrum of these oscillations is obtained analytically within an expansion in the inverse batch size.

AGSOE 13: Award Ceremony: Young Scientist Award for Socio- and Econophysics

Time: Wednesday 16:15–18:00 Location: HSZ 02

Invited Talk AGSOE 13.1 Wed 16:15 HSZ 02
The calculus of selfishness — •Karl Sigmund — Faculty of mathematics, University of Vienna

This talk shows by means of simple examples how evolutionary game theory can deal with social dilemmas. In particular, it presents models helping to explain how cooperation emerges in a world of individuals guided by self-interest, and caught in a social trap.

Presentation of the Young Scientist Award for Socio- and Econophysics to Duncan J. Watts, Columbia University, New York

Prize Talk AGSOE 13.2 Wed 17:15 HSZ 02
Using the Web to do Social Science — •Duncan J. Watts — Columbia University, New York, USA

Social science is often concerned with the emergence of collective behavior out of the interactions of large numbers of individuals; but in this regard it has long suffered from a severe measurement problem - namely that interactions between people are hard to measure, especially at scale, over time, and at the same time as observing behavior. In this talk, I will argue that the technological revolution of the Internet is beginning to lift this constraint. To illustrate, I will describe three examples of research that would have been extremely difficult, or even impossible, to perform just a decade ago: (1) using email exchange to track social networks evolving in time; (2) using a web-based experiment to study the collective consequences of social influence on decision making; and (3) using a social networking site to study the difference between perceived and actual homogeneity of attitudes among friends; and (4) using Amazon's Mechanical Turk to study the incentives underlying "crowd sourcing". Although internet-based research still faces serious methodological and procedural obstacles, I propose that the ability to study truly "social" dynamics at individual-level resolution will have dramatic consequences for social science.

After the awardee's talk, there will be a social gathering with beer and pretzels around the poster area.

AGSOE 14: Poster Session

Time: Wednesday 18:00–20:00 Location: P1B

Note: Posters can and should be on display all day.

AGSOE 14.1 Wed 18:10 P1B
Extinction time of three-strategy cyclic coevolution in finite populations — •Markus Schütt[1] and Jens Christian Claussen[2,1] — [1]Theor. Phys. & Astrophys., CAU Kiel — [2]Neuro- und Bioinformatik, U zu Lübeck

In the limit of large populations, coevolutionary dynamics of interacting species (in biology) or strategies (of social individuals) is commonly described by the replicator equations of evolutionary game theory. In finite populations the microscopic dynamics however is a discrete stochastic process, based on such, fixation and extinction times of strategies can be calculated, see [1] for an introduction and overview. In finite populations, the $1/N$ corrections can be conveniently described by a Fokker-Planck equation which can lead to counterintuitive effects as a stability reversal ("drift reversal") in games between two populations [2]. In [3] we have shown analytically that such a drift reversal also is observed for a Rock-Papers-Scissors (RPS) game within one population, provided that the game is no longer zero-sum: *if the bank looses in the play, biodiversity of strategies is stabilized even in a well-mixed (nonspatial) population.* Here we investigate the extinction time for the non zero-sum RPS game. Its scaling with N changes between exponential (positive-sum RPS) and polynomial (zero-sum and negative-sum RPS) scaling, and is consistent with the results from the drift reversal picture.
[1] Martin Nowak, Evolutionary Dynamics, Harvard (2007).
[2] A Traulsen JC Claussen C Hauert, PRL 95, 238701 (2005)
[3] JC Claussen A Traulsen PRL 100, 058104 (2008)

AGSOE 14.2 Wed 18:10 P1B
Three-site cluster approximation for the evolution of adoption rules in Prisoner's Dilemma games — •Jeromos Vukov, Attila Szolnoki, and György Szabó — Research Institute for Technical Physics and Materials Science, P.O. Box 49, H-1525 Budapest, Hungary

We study spatial Prisoner's Dilemma games where the distribution of both the strategies and strategy adoption rules can evolve depending on the payoff differences between neighboring players. Players are located on the sites of a kagome lattice where the overlapping triangles support the spreading of cooperation. Choosing between unconditional cooperation and defection, the players gain their payoff from games with their neighbors. Each individual strategy adoption rule is characterized by a single (temperature-like) parameter describing how strongly the adoptions depend on the payoff-difference. If we start the system from a random strategy distribution with many adoption rules, the co-evolution of strategies and adoption rules drives the system to a final state where only one adoption rule remains. This adoption rule is in good agreement with the parameter value associated to the highest cooperativity in the region where cooperators and defectors coexist. The predictions of the three-site approximation agree very well with the results of Monte Carlo simulations. In this poster, we give a thorough overview about the method of this type of approximation.

AGSOE 14.3 Wed 18:10 P1B
Dynamics of supply chains under mixed production strategies — •Reik Donner[1], Kathrin Padberg[1], Johannes Höfener[2], and Dirk Helbing[3] — [1]TU Dresden, Andreas-Schubert-Str. 23, 01062 Dresden, Germany — [2]MPI-PKS, Nöthnitzer Str. 38, 01187 Dresden — [3]ETH Zürich, Universitätstr. 41, CH-8092 Zürich

We study the dynamics of material flows in supply chains under pull, push and mixed production strategies. For this purpose, a mathematical input-output model of commodity flows is generalized and analyzed in some detail for the case of linear supply chains. In particular, it is investigated under which conditions the effect of instabilities like the Bullwhip effect can be minimized. The presented results allow some new insight into the dynamics of manufacturing systems, which will be of importance for the development of new approaches for production planning and control.

AGSOE 14.4 Wed 18:10 P1B
Time series processing via independent component analysis and financial asset allocation — •Sergio Rojas — Physics Department, Universidad Simón Bolívar, Valle de Sartenejas, Edo. Miranda, Venezuela

A fundamental problem in time series analysis is to find suitable representation of the signals in terms of basis that could help in extracting useful information from the data and/or to provide a better appropriate representation of the observed signals for further analysis. Linear methods widely used for this purpose include the Fourier, Haar, and cosine transformations. In this work we will examine the implementation of the relatively new technique known as Independent Component Analysis, which is intended to find non gaussian statistically independent representations of time series. By means of synthetic data that reflect some of the structural features of financial time series (like stock prices) we will show the robustness and appropriateness of the aforementioned technique for analyzing noise, incomplete and irregularly sampled time series. After that, we will address the suitability of the technique to building diversified investment financial portfolios and its applications to risk management tasks.

AGSOE 14.5 Wed 18:10 P1B
Time Symmetric Monetary Systems — •Braun Dieter — Sys-

tems Biophysics, LMU München, Germany

With the current credit crisis, the problems of bank money creation is back in focus. We discuss criteria towards establishing monetary systems without money creation which still allow creditary dynamics. The ultimate aim is to develop a monetary system with an inherent mechanism of defining units of account.

The guiding principles will be the Noether theorem, linking the quantity of money with the time symmetry of monetary transactions, based on a physically inspired mapping between space-time and bookkeeping [1][2].

We propose a symmetric approach of balancing assets/liabilities of credits and assets/liabilities of deposits with a floating exchange rate. We show that under random transfer between agents, this system is stable and converges to a two-sided exponential distribution.

References:
[1] Physica A, 369, 714-722 (2006)
[2] Physica A 324, 266-271 (2003)

AGSOE 14.6 Wed 18:10 P1B

Car park management and train position monitoring based on magnetic imaging of vehicles — •Haibin Gao[1], Stefan Voit[2], and Uwe Hartmann[1] — [1]Physics Department, Saarland University, Campus, 66123 Saarbruecken, Germany — [2]Votronic GmbH, Saarbruecker Str. 8, 66386 St. Ingbert, Germany

Increasing traffic volume needs optimized traffic management for both economy and safety reasons. A car park guiding system is based on providing the real-time occupation of each parking lot. Efficient railway marshalling requires the actual train positions. Magnetic field detectors can be employed for vehicle position monitoring by means of magnetic profile measurement. Magnetoresistive sensors utilize the earth*s magnetic field as a bias field for detecting the presence of ferromagnetic objects, i.e., components of a vehicle. The passive method of sensing requires no energy to be emitted, thus minimizing both energy consumption and risk of electromagnetic interference. Furthermore, the compact size of the magnetoresistive sensors allows for versatile placement options. A car park employed with more than 100 magnetic detectors in each parking lot is used to demonstrate the application of magnetic detectors. Customers can obtain the unoccupied lots* positions via a large LED display. Other information like local news, time and commercial information can be presented simultaneously. Detectors were used to detect the actual train positions during railway marshalling process. They were buried underneath tracks to obtain magnetic profiles of passing locomotive and carriages. The results shows magnetic detectors can be applied in this field as well.

AGSOE 14.7 Wed 18:10 P1B

Synchronization in material flow networks with biologically inspired self-organized control — •Reik Donner[1], Stefan Lämmer[1], and Dirk Helbing[2] — [1]TU Dresden, Andreas-Schubert-Str. 23, 01062 Dresden, Germany — [2]ETH Zürich, Universitätstr. 41, CH-8092 Zürich

The efficient operation of material flows in traffic or production networks is a subject of broad economic interest. Traditional centralized as well as decentralized approaches to operating material flow networks are known to have severe disadvantages. As an alternative approach that may help to overcome these problems, we propose a simple self-organization mechanism of conflicting flows that is inspired by oscillatory phenomena of pedestrian or animal counter-flows at bottlenecks. As a result, one may observe a synchronization of the switching dynamics at different intersections in the network. For regular grid topologies, we find different synchronization regimes depending on the inertia of the switching from one service state to the next one.

In order to test the robustness of our corresponding observations, we study how the detailed properties of the network as well as dynamic feedbacks between the relevant state variables affect the degree of achievable synchronization and the resulting performance of the network. Our results yield an improved understanding of the conditions that have to be present for efficiently operating material flow networks by a decentralized control, which is of paramount importance for future implementations in real-world traffic or production systems.

AGSOE 14.8 Wed 18:10 P1B

Spontaneous ordering against external mass media in social systems — •Juan Carlos Gonzalez-Avella[1], Mario G. Cosenza[2], Victor M. Eguiluz[1], and Maxi San Miguel[1] — [1]IFISC (CSIC-UIB), Instituto de Física Interdisciplinar y Sistemas Complejos, Campus Universitat Illes Balears, E-07122 Palma de Mallorca, Spain. — [2]Centro de Física Fundamental, Universidad de Los Andes, Mérida, Mérida 5251, Venezuela.

We study the collective behavior of nonequilibrium systems subject to an external field modeled as mass media or propaganda with a dynamics characterized by the existence of non-interacting states. Aiming at exploring the generality of the results, we consider two types of models according to the nature of their state variables: (i) a vector model, where interactions are proportional to the overlap between the states, and (ii) a scalar model, where interaction depends on the distance between states. In both cases the system displays three phases: two ordered phases, one parallel to the field, and another orthogonal to the field; and a disordered phase. The phase space is numerically characterized for each model in a fully connected network. By placing the particles on a small-world network, we show that, while a regular lattice favors the alignment with the field, the presence of long-range interactions promotes the formation of the ordered phase orthogonal to the field.

AGSOE 14.9 Wed 18:10 P1B

Dominance in cooperation networks — •Marcus John[1], Miloš Jovanović[1,2], and Stefan Reschke[1] — [1]Fraunhofer Institut für Naturwissenschaftlich-Technische Trendanalysen, Euskirchen — [2]Heinrich-Heine-Universität, Düsseldorf

Cooperation between various partners (e.g. scientists, institutes or countries) is an important and characteristic attribute of the scientific community. It can be viewed in terms of a weighted network. In such a network some partners may be more dominant than others either due to their cooperation activity, scientific output, excellence or because of political and/or social processes. In this contribution we utilise a cooperation matrix C, where each element C_{ij} is the number of cooperation between two distinct partners i and j, for representing this network. The matrix is constructed by means of a bibliometric approach by analysing the publications of a set of partners. We derive and discuss various quantities, which we call *dominance factors*, for measuring the dominance within such a cooperation network. We further give some real world applications as examples and demonstrate that an appropriately chosen dominance factor is indeed able to mirror e.g. social or political processes, which affect a cooperation network and the dominance of its members.

AGSOE 14.10 Wed 18:10 P1B

Investigation of opinion poll data and election results in Germany and Great Britain — •Johannes Josef Schneider[1] and Christian Hirtreiter[2] — [1]Department of Physics, Mathematics, and Computer Science, Johannes Gutenberg University of Mainz, Staudinger Weg 7, 55099 Mainz, Germany — [2]Faculty of Physics, University of Regensburg, Universitätsstr. 31, 93053 Regensburg, Germany

Since many years, the Allensbach institute in Germany and a related institute in Great Britain performs an opinion poll each week, asking at least 1000 people the question "Which party would you vote for if there was an election next Sunday?"

We investigate these opinion poll data by means of time series analysis. The most prominent results for the German data are fat tails in the return distributions of the time series. Furthermore, we find that the election results for the Green party cannot be predicted at all by opinion polls. For the conservative and the social democratic party, we find that the opinion poll data agree the more with the election results, the closer the date of the opinion poll is to the election date [1]. Thus, the question arises whether an opinion poll long before an election provides any useful information at all. In this talk, we compare the results we found in Germany with corresponding data from Great Britain and focus on similarities with the time developments of price changes of assets traded at financial markets.

[1] J.J. Schneider and Ch. Hirtreiter, Int. J. Mod. Phys. C **19**, 441, 2008.

AGSOE 14.11 Wed 18:10 P1B

Distributing students optimally to universities — •Christian Hirtreiter[1], Johannes Josef Schneider[2], and Ingo Morgenstern[1] — [1]Faculty of Physics, University of Regensburg, Universitätsstr. 31, 93053 Regensburg, Germany — [2]Department of Physics, Mathematics, and Computer Science, Johannes Gutenberg University of Mainz, Staudinger Weg 7, 55099 Mainz, Germany

Since many years, the problem of how to distribute students to the various universities in Germany according to the preferences of the

students remains unsolved. In a nowadays widely used approach, students apply for a place at various universities. The best students get then several acceptances, whereas some worse students fail everywhere. In the next step, the best students choose a place at their preferred university, such that places suddenly become free for students, who received a rejection in the first step and who now get an acceptance. This scheme is iterated several times, each time takes some weeks. Then the semester has already started before some students get the acceptance letter. But for some subjects, like medical science, students can lose a whole year by this way. The former way of distributing students was to apply for a place at some preferred universities at a central agency called ZVS (Zentralstelle für die Vergabe von Studienplätzen). However, due to a strange rule set, many students ended up at universities which were not in their preference list. In this talk, we show how the rules for distributing students could be changed easily in order to increase the fraction of satisfied students.

AGSOE 14.12 Wed 18:10 P1B

Epidemic dynamics on spatio-temporal networks: The Dengue fever host-vector bipartite network model — •Alejandro Mora[1,2], Jose Daniel Munoz[2], Fabio Correa[2], and Harish Padmanabha[3] — [1]Max-Planck Institute for the Physics of Complex Systems, Nöthnitzer Straße 38, 01187 Dresden Germany — [2]Simulation of Physical Systems Group, Departamento de Física, Universidad Nacional de Colombia, Cra 30 45-03, Ed. 404, Of. 348, Bogotá D.C., Colombia — [3]Florida Medical Entomology Laboratory, University of Florida, Florida, USA

Dengue Fever is a human arboviral disease which is transmitted by the domestic mosquito *Aedes aegypti* and constitutes one of the most widespread tropical diseases around the globe. The only way dengue fever virus can spread is the transmission from human to human via the mosquito. We present a *host-vector bipartite network* model for the spreading of the Dengue fever epidemics in urban areas. The simulated spatiotemporal system reveals rich dynamical behavior with epidemic thresholds, classes of phase transitions, and synchronization properties. The model is extended to include disease control/immunization strategies and analyzed within the adaptive networks conceptual framework. Validation of the model with field epidemiological data is discussed.

AGSOE 15: Public Evening Lecture

Time: Wednesday 20:00–21:00 Location: HSZ 01

Evening Talk AGSOE 15.1 Wed 20:00 HSZ 01

Wie Kooperation unter Egoisten entsteht — •Martin Nowak — Harvard University, Boston, USA

Menschen sind Weltmeister, wenn es um Kooperation (und Betrug) geht. Sie haben kooperative Unternehmungen gegründet, die den gesamten Globus umspannen. Aber wir helfen anderen auch, wenn es mit Kosten für uns verbunden ist. Solches altruistisches Verhalten ist im Gegensatz zu dem, was man aufgrund des Prinzips der natürlichen Auslese erwarten würde. Warum sollten wir potenziellen Konkurrenten helfen?

Ich werde fünf Mechanismen vorstellen, die zur Entstehung von Kooperation führen: genetische Verwandtschaft, direkte und indirekte Gegenseitigkeit, Vernetzung, und Konkurrenz zwischen Gruppen. Direkte Gegenseitigkeit meint Situationen, in denen dieselben Individuen mehrmals miteinander interagieren und wo das eigene Verhalten davon abhängt, wie sich die anderen einem gegenüber verhalten haben. Indirekte Gegenseitigkeit betrifft Situationen mit wiederholten Interaktionen, wo das eigene Verhalten auch davon abhängt, wie sich jemand gegenüber anderen verhalten hat, also von seiner Reputation. Direkte und indirekte Gegenseitigkeit sind die Schlüsselmechanismen für das Verständnis sozialen Verhaltens unter Menschen. Indirekte Gegenseitigkeit hat insbesondere den Selektionsdruck erzeugt, der die Evolution sozialer Intelligenz und der menschlichen Sprache bedingt hat. Ich werde ausserdem ausführen, dass Bestrafung kein effizienter Mechanismus ist, um die Entstehung von Kooperation unter Egoisten zu erreichen.

The emergence of cooperation:
Humans are the world champions of cooperation (and defection). We help others even if costs are involved. We have established cooperative enterprises that span the entire globe. Such "altruistic behavior" should be at variance with natural selection. Why should we help potential competitors? I will present five mechanisms for the evolution of cooperation: kin selection, group selection, graph selection, direct reciprocity and indirect reciprocity. Direct reciprocity means there are repeated interactions between the same two individuals and my behavior towards you depends on what you have done to me. Indirect reciprocity means there are repeated interactions within a group and my behavior towards you also depends on what you have done to others. Direct and indirect reciprocity are the key mechanisms for understanding any pro-social behavior among humans. Indirect reciprocity has provided the selection pressure for the evolution of social intelligence and human language. I will also show that costly punishment is not an efficient mechanism for the evolution of cooperation.

Literatur/Further Reading:
Dreber A, DG Rand, D Fudenberg, MA Nowak (2008): *Winners don't punish*, Nature 452: 348-351
Nowak MA (2006). *Five rules for the evolution of cooperation.* Science 314: 1560-1563
Nowak MA (2006): *Evolutionary Dynamics*, Harvard University Press

AGSOE 16: Networks: From Topology to Dynamics I

Time: Thursday 9:30–10:15 Location: BAR 205

Invited Talk AGSOE 16.1 Thu 9:30 BAR 205

Group Path Formation in Physical and Abstract Spaces — •Robert Goldstone — Indiana University, Bloomington, Indiana, USA

Just as ants interact to form elaborate colonies and neurons interact to create structured thought, groups of people interact to create emergent organizations that the individuals may not understand or even perceive. One important class of collective behavior is self-organized path formation in situations where people are motivated to take advantage of the paths forged by others. We have developed two experimental scenarios for studying path formation using an internet-based experimental platform that allows groups of 2-200 people to interact with each other in real time on networked computers (http://groups.psych.indiana.edu/). The first scenario is physical, spatial path formation in which travelers earn points by moving between randomly selected destinations, while leaving trails that facilitate travel for subsequent travelers. The second scenario investigates abstract paths in a problem space in which participants choose between exploring their own solutions or following the paths found by neighbors in their imposed social network. Agent-based computational models provide useful accounts of the experimental results. Both scenarios reveal tradeoffs between exploration and exploitation, compromises between individuals using their own strategies and strategies obtained from their peers, and bridging relations between individuals' local decisions and group's ability to find globally good problem solutions.

Also: Note the Joint Symposium of DY, BP and AGSOE: Data Analysis in Complex Systems: From Data to Models. Details can be found in the program under SYCS or under www.daics09.de.

AGSOE 17: Networks: From Topology to Dynamics II

Time: Thursday 10:15–12:45 Location: BAR 205

AGSOE 17.1 Thu 10:15 BAR 205

Universality and the lack of it in multiscale human mobility networks — •Rafael Brune[1,2], Christian Thiemann[1,2], and Dirk Brockmann[1] — [1]Northwestern University, Evanston IL, USA — [2]Georg-August-Universität, Göttingen, Germany

Although significant research effort is currently devoted to the understanding of complex human mobility and transportation networks, their statistical features are still poorly understood. Specifically, to what extent geographical scales impose structure on these networks is largely unknown. In particular, in light of the use of human mobility models in the development of quantitative theories for spatial disease dynamics, a comprehensive understanding of their structure is of fundamental importance. The large majority of statistical properties (degree distributions, centrality measures, clustering, etc.) of these networks have been obtained either for large scale networks or on small scale systems, indicating significant yet poorly understood deviations. We will present the first investigation of multiscale and multi-national mobility networks, covering length scales of a few to a few thousand kilometers. We will report that certain properties such as mobility flux distribution are universal and independent of length scale, whereas others vary systematically with scale. In particular, controversial properties such as scale-free degree distributions lose their heavy tails in small to intermediate length-scale windows.

AGSOE 17.2 Thu 10:45 BAR 205

About human activity, long-term memory, and Gibrat's law — •Diego Rybski[1], Sergey V. Buldyrev[2], Shlomo Havlin[3], Fredrik Liljeros[4], and Hernan A. Makse[1] — [1]Levich Institute and Physics Department, City College of New York, New York, NY 10031, USA — [2]Department of Physics, Yeshiva University, New York, NY 10033, USA — [3]Department of Physics, Bar-Ilan University, Ramat-Gan 52900, Israel — [4]Department of Sociology, Stockholm University, S-10691 Stockholm, Sweden

A central research question in the social sciences for several centuries has been whether any law like patterns in the unintended outcomes of human action exist. Here we investigate the existence of scaling laws in the human activity of communication, considering the number of messages sent by individuals as a growth process in time. We analyze millions of messages sent in two social online communities and uncover power-law relations between fluctuations in the growth rate and the activity of the members. We attribute this scaling law to a long-term persistence of human activity beyond daily or weekly cycles holding up to more than a year. Based on such an underlying long-term correlated dynamics, we elaborate a consistent framework for the empirical evidences, establishing a missing link between the scaling behavior in the growth and long-term persistence. Our results indicate that large fluctuations in communication activity can be expected as an unintended consequence of human interaction. This finding is of importance for both designing communication systems and for understanding the dynamics of social systems.

AGSOE 17.3 Thu 11:15 BAR 205

Patterns of cooperation — •Anne-Ly Do and Thilo Gross — Max Planck Institute for the Physics of Complex Systems, Dresden

We propose a simple model for the formation of cooperation networks among self-interested agents. It bases on the continuous snowdrift game, a paradigmatic approach to cooperation studied by different disciplines, but replaces non-directional cooperativeness by the ability of humans to maintain different levels of cooperation with different, self-chosen partners. The model reproduces and provides a rationale for well known phenomena from biology, anthropology, sociology, politics, and economics. Its twofold nature opens rich potentialities for the analytical treatment: The underlying differential equations allow for a stability analysis by means of dynamical systems theory. The discrete nature of the evolving network enable the application of graph theoretical tools. All told makes the model a promising candidate for a unified framework for phenomena from several disciplines.

AGSOE 17.4 Thu 11:45 BAR 205

Dynamics of a SIRS epidemic model on an adaptive network — •Alejandro Mora[1,2], Gerd Zschaler[1], and Thilo Gross[1] — [1]Max-Planck Institute for the Physics of Complex Systems, Nöthnitzer Straße 38, 01187 Dresden Germany — [2]Simulation of Physical Systems Group, Departamento de Física, Universidad Nacional de Colombia, Cra 30 45-03, Ed. 404, Of. 348, Bogotá D.C., Colombia

The study of epidemic spreading on adaptive networks combine tools from the classical epidemiology, statistical physics, and dynamical systems theory. Adaptive evolution of the network topology depending on the local state of the nodes provides a more realistic approach to the propagation of contagious diseases. We investigate the dynamics of a *susceptible-infected-recovered-susceptible* (SIRS) epidemiological process on an adaptive network. The recovered state is proposed to represent either temporal immunity or susceptible population turnover. In the latter case, a node in the recovered state loses its links at a fast rate, while new links are permanently created and destroyed between nodes in the other epidemiological states. We analyze the system behavior with extended mean-field equations that include links between nodes as dynamical variables and a moment closure that approximates higher order correlations between nodes. The numerical solutions of such correlation equations show the emergence of discontinuous transitions, bifurcations, and oscillations of the disease prevalence. Then comparisons are performed with analogous results of intensive agent-based simulations on networks. Finally, we discuss application to real epidemics.

AGSOE 17.5 Thu 12:15 BAR 205

Optimization of AS Internet Robustness to Malicious Attack — •Christian M. Schneider[1], Andre A. Moreira[2], Jose S. Andrade Jr.[2], Shlomo Havlin[3], and Hans J. Herrmann[1,2] — [1]Computational Physics, IfB, ETH-Hönggerberg, Schafmattstrasse 6, 8093 Zürich, Switzerland — [2]Departamento de Física, Universidade Federal do Ceará, 60451-970 Fortaleza, Ceará, Brazil — [3]Minerva Center and Department of Physics, Bar-Ilan University, 52900 Ramat-Gan, Israel

We develop a method that substantially improves the robustness of complex networks against malicious attacks. This technique is successfully applied for the Internet at the level of autonomous system and other scale-free networks. As malicious attack we choose the dynamic degree-based attack and we numerically optimize the network under the condition that the degree distribution remains invariant. We also study three different types of scale-free network models and compare the results with the real network.

AGSOE 18: Networks: From Topology to Dynamics III

Time: Thursday 14:00–16:00 Location: BAR 205

AGSOE 18.1 Thu 14:00 BAR 205

Synchronization in complex networks — •Albert Diaz-Guilera — Universitat de Barcelona — Potsdam University

Synchronization processes in populations of locally interacting elements are in the focus of intense research in physical, biological, chemical, technological and social systems. The many efforts devoted to understand synchronization phenomena in natural systems take now advantage of the recent theory of complex networks. We report the advances in the comprehension of synchronization phenomena when oscillating elements are constrained to interact in a complex network topology. We also overview the new emergent features coming out from the interplay between the structure and the function of the underlying pattern of connections. Extensive numerical work as well as analytical approaches to the problem are presented. Finally, we review several applications of synchronization in complex networks to different disciplines: biological systems and neuroscience, engineering and computer science, and economy and social sciences.

AGSOE 18.2 Thu 14:30 BAR 205

Extracting Dynamics from System Topology by Generalized Modeling — •Thilo Gross — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden

In several disciplines, ranging from biology to sociology and psychology, the topology of the network of interactions between system components is often either clear or suspected. By contrast the dynamical laws governing the interplay between these components are hard to derive, prohibiting a detailed mathematical analysis. For instance in ecology it is often known who-eats-who, but it is difficult to restrict these interactions to specific mathematical functions and parameter values. Therefore the term model is often used to refer to a diagrammatic representation of a system rather than a set of equations. In this talk I will show how generalized modeling can be used to investigate the local dynamics around all steady states of all potential systems of differential equations that are consistent with a given diagrammatic representations. In this way we can: identify important parameters for the local dynamical stability of the system; identify bifurcation points at which the stability is lost; and draw further conclusions on local and global dynamics from bifurcation analysis. The numerical performance of generalized models is so favorable that it can be used to statistically explore systems with thousands of unknown parameters. The approach will be illustrated by several examples from psychology and sociology.

AGSOE 18.3 Thu 15:00 BAR 205

Tour de Sys: The traveler's view of a network — •Christian Thiemann[1,2], Daniel Grady[1], and Dirk Brockmann[1] — [1]Northwestern University, Evanston IL, USA — [2]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany

The plight of the Flatlander is imperfect information about a high-dimensional object. Yet even so, the clever inhabitant of a low-dimensional world can gain a great deal of information about such an object by examining it from many perspectives. We analyze complex transportation networks by using shortest-path trees to measure universal network properties from different locations. Furthermore, by defining a measure of a node's geographical access area we give a more realistic characterization of the centrality or remoteness of a location. The network topology indicates a clear distinction between the center and edge of a network, but we find that examining the weights of links is crucial, as the distinction in the weighted network for some quantities is even more pronounced. Often prior research has not focused on the weightedness of transportation networks, in spite of the fact that this property has an obvious bearing on how the networks are actually used. We show that measuring networks with weighted edges significantly affects their statistics. Our analysis indicates dynamical processes occurring on these networks should behave in a manner very different than what is predicted by considering topology alone.

AGSOE 18.4 Thu 15:30 BAR 205

A novel approach in the filtering of information from complex systems: The overlapping Tree Network — •Antonios Garas and Panos Argyrakis — Department of Physics, Aristotle University of Thessaloniki, 54124 Thessaloniki Greece.

We present a novel filtering technique that is able to extract information from various complex systems. To use this technique we first map the complex system into a network by representing its elements with nodes and the interactions among its elements with links connecting the nodes. Then we make use of the established Minimum Spanning Tree technique, in such a way that it allows us to create a subgraph that retains the strongest links of the original complex network, but it has considerably smaller amount of total links. The resulting subgraph is not a tree, and therefore it can contain loops. This way we are able to extract more information for the investigated system, in comparison to the information we can extract by direct implementation of the Minimum Spanning Tree technique. We apply this method into various different networks, and we discuss the results.

AGSOE 19: Networks: From Topology to Dynamics IV

Time: Thursday 16:00–18:00 Location: BAR 205

AGSOE 19.1 Thu 16:00 BAR 205

Statistical Mechanics and Homology of Neighborhod Complexes — •Danijela Horak[1], Slobodan Maletic[2], and Milan Rajkovic[2] — [1]Max Planck Institute for Mathematics in the Natural Sciences, Leipzig — [2]Institute of Nuclear Sciences Vinca, Belgrade

Complex networks are encoded into simplicial complexes (neighborhood complexes) and analyzed from alegbraic, combinatorial and topological aspect. Certian topological invariants are shown to have distinct statistical properties and in analogy to statistical mechanics of networks we develop a statistical mechanics of simplicial complexes. Long lived topological features, considered as topological signal, are distinguished from short lived ones, considered as topological noise. A new topological invariant, persistent homology, is determined and presented as a parametrized version of a Betti number. Complex networks with distinct degree distributions exhibit distinct persistent topological features. Persistent toplogical attributes, shown to be related to robust quality of networks, also reflect defficiency in certain connectivity properites of networks. Random networks, networks with exponential conectivity distribution and scale-free networks are considered for homological persistency analysis. Furthermore, the advantages of such an approach and new results are illustrated in applications to economic and social models on networks (e.g. Axelrod model and its variants).

AGSOE 19.2 Thu 16:30 BAR 205

Networks of monetary transactions as signals of growth or decay in production chains — Marco Lamieri[1], •Volker Nannen[1], and Guy Kelman[2] — [1]Fondazione ISI, Torino, Italy — [2]Hebrew University, Jerusalem, Israel

While numerous publications have acknowledged the fact that businesses form a network and that the nature of this network has significant consequences for the economic dynamics, to the best of our knowledge no attempt has so far been made to extract this network from transaction records.

Here we use the database of economic transactions (bank transfers and financial factoring among Italian firms) provided by Intesa Sanpaolo s.p.a., the biggest Italian commercial bank group. The available sample covers 80% of Italian firms and represents about 25% of the total value of Italian financial transactions. The sample is representative both at the sector level and at the geographical level.

We aggregate the raw data into a comprehensive dynamic transaction network where the nodes are firms, characterized by turnover and risk level, and the links are transactions. We present the statistical properties of this network like the dynamics of the connectivity and monetary flow. Special attention is given to the effects of the current financial crisis.

AGSOE 19.3 Thu 17:00 BAR 205

Delays in Train Networks — •Christoph Fretter[1], Marc-Thorsten Hütt[2], Lachezar Krumov[3], Matthias Müller-Hannemann[1], and Karsten Weihe[3] — [1]Martin Luther Universität Halle — [2]Jacobs Universy Bremen — [3]Technische Universität Darmstadt

In cooperation with Deutsche Bahn AG, we study the propagation of delays in railway networks. In case of a train delay, a waiting policy determines whether a connecting train has to wait. Depending on these decisions passengers miss or reach their connection. Letting trains wait for others introduces a delay cascade.

We investigate delay response functions derived from real passenger data of the current train schedule, and discuss several models which give insight into the connection between topology and dynamics.

AGSOE 19.4 Thu 17:30 BAR 205

Public Transport Routes and Self-avoiding Walks — •Christian von Ferber[1,2], Taras Holovatch[1,3], Yurij Holovatch[4,5], and Vasyl Palchykov[4] — [1]Applied Mathematics Research Centre, Coventry University, UK — [2]Physikalisches Institut, Universität Freiburg — [3]Laboratoire de Physique des Materiaux, Université Nancy, France — [4]ICPM National Academy of Sciences of Ukraine, Lviv — [5]Institut für Theoretische Physik, Universität Linz, Österreich

We explore the fractal dimensions of public transport routes of different cities with the finding that their fractal behaviour is close to that of self-avoiding walks. Self-avoiding walks, apart from observing the constraint of non-self-intersection evolve randomly. The fact that PT routes appear to display a similar scaling symmetry is quite unexpected. In particular, this behavior seems to be at odds with the requirement of minimizing passengers traveling time between origin to destination. The latter argument, however, ignores the time passengers spend walking to the initial and from the final stations. Including these, one understands the need for the routes to cover larger areas by meandering through neighborhoods. Given the requirements for a PTN to cover a metropolitan area with a limited number of routes while simultaneously offering fast transport across the city routes scaling like SAWs may present an optimal solution.

On Thursday evening, there will be social get-together with all invited speakers from the AGSOE program and the SYCS Symposium. Details are announced during the member's meeting on Monday, 18:00-19:00.