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Fachverband Physik sozio-ökonomischer Systeme (SOE)

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Overview of Invited Talks and Sessions

(Lecture rooms: MA 001, H 0104, A 151, BH-N 243, BH-N 333, and BH-N 128; Posters: E (close to MA 001))

Plenary Talk related to SOE

PV XXV	Thu	14:00–14:45	H 0104	**Collective Motion, Collective Decision-making, and Collective Action: From Microbes to Societies** — •Simon Levin

Invited Talks

SOE 7.1	Mon	16:00–16:45	MA 001	**Computational Social Science: Exciting Progress and Future Challenges** — •Duncan Watts
SOE 9.1	Tue	9:30–10:15	MA 001	**The Universality of Cities as Complex Network Systems** — •Luis Bettencourt

Prize Talk of the Young Scientist Award for Socio- and Ecconophyics (YSA)

SOE 7.2	Mon	17:00–17:45	MA 001	**For cooperation please add: Carrots, sticks, both, or neither?** — •Matjaz Perc

Topical Talks

SOE 10.1	Tue	10:15–10:45	MA 001	**Micro dynamics of social interactions** — •Sune Lehmann
SOE 10.6	Tue	11:45–12:15	MA 001	**Containing epidemics using limited resources and information** — •Olivia Woolley-Meza
SOE 15.1	Wed	16:45–17:15	MA 001	**The Industrial Society's natural Sustainability** — •Hans G. Danielmeyer, Thomas Martinetz
SOE 23.1	Thu	17:00–17:30	MA 001	**Critical Transitions in Socio-econo-ecological Systems—A Global Adaptive Model of the Regional Transitions to Agriculture 8000 BC to AD 500** — •Carsten Lemmen, Kai W. Wirtz

Invited Tutorial Talks

SOE 1.1	Sun	16:00–16:50	H 0104	**Economics in a nutshell, for physicists** — •Sylvie Geisendorf
SOE 1.2	Sun	16:50–17:40	H 0104	**Connecting microscopic behavioral economics to macroscopic financial market models** — •Sebastian M. Krause
SOE 1.3	Sun	17:40–18:30	H 0104	**You are a young and aspiring physicist. Is working at the interface with economics a good idea?** — •Tobias Galla

Invited talks of the joint symposium SYPS

See SYPS for the full program of the symposium.

SYPS 1.1	Wed	9:30–10:00	H 0105	**Anticipating and avoiding tipping points** — •Timothy M. Lenton
SYPS 1.2	Wed	10:00–10:30	H 0105	**Climate investment under uncertainty: the two degree target and the desire for dynamic consistency** — •Hermann Held, Delf Neubersch

SYPS 1.3	Wed	10:30–11:00	H 0105	**What are the resources required to fulfil human needs?** — •Julia Steinberger
SYPS 1.4	Wed	11:15–11:45	H 0105	**Design of Sustainable Supply Chains for Sustainable Cities** — •Anna Nagurney
SYPS 1.5	Wed	11:45–12:15	H 0105	**Ecological econophysics for degrowth** — •Salvador Pueyo

Sessions

SOE 1.1–1.3	Sun	16:00–18:30	H 0104	**Tutorial: From spin models to macroeconomics (SOE, DY, jDPG)**
SOE 2.1–2.1	Mon	9:30–10:00	MA 001	**Future Visions of Socio- and Econophysics**
SOE 3.1–3.3	Mon	10:00–10:45	MA 001	**Evolutionary Dynamics of Social Systems**
SOE 4.1–4.6	Mon	10:45–12:15	MA 001	**Financial Markets and Risk Management**
SOE 5.1–5.4	Mon	12:15–13:15	MA 001	**Networks: From Topology to Dynamics I (joint session SOE / DY / BP)**
SOE 6.1–6.3	Mon	15:00–15:45	MA 001	**Evolutionary Game Theory I (joint session SOE / BP / DY)**
SOE 7.1–7.2	Mon	16:00–17:45	MA 001	**Prize Session: Young Scientist Award for Socio- and Econophysics (YSA)**
SOE 8.1–8.31	Mon	18:00–20:00	Poster E	**Poster**
SOE 9.1–9.1	Tue	9:30–10:15	MA 001	**Urban Systems - Dynamics and Complexity of Cities (Invited Talk Luis Bettencourt)**
SOE 10.1–10.10	Tue	10:15–13:15	MA 001	**Focus Session: Complex Contagion Phenmomena (joint session SOE / DY / BP)**
SOE 11.1–11.9	Tue	14:00–16:15	MA 001	**Evolutionary Game Theory II (joint session BP / SOE / DY)**
SOE 12.1–12.5	Wed	9:30–12:15	H 0105	**Physics of Sustainability and Human-Nature Interactions (Symposium SYPS)**
SOE 13.1–13.6	Wed	15:00–16:30	MA 001	**Opinion Formation, Segregation, and Language Dynamics**
SOE 14.1–14.5	Wed	15:00–16:30	A 151	**Fluctuating Electricity Supply: Modelling of Generation, Backup and Storage (joint session AKE / DY / SOE)**
SOE 15.1–15.6	Wed	16:45–18:30	MA 001	**Physics of Sustainability and Human-Nature Interactions I (joint with DY, jDPG, BP, AKE) - session accompanying the sympoisum SYPS**
SOE 16	Wed	18:35–19:30	MA 001	**Annual Member's Assembly**
SOE 17.1–17.6	Thu	9:30–11:15	MA 001	**Social Systems, Opinion and Group Dynamics**
SOE 18.1–18.3	Thu	11:15–12:00	MA 001	**Social Networks**
SOE 19.1–19.5	Thu	12:00–13:15	MA 001	**Networks: From Topology to Dynamics II (joint session SOE / DY / BP)**
SOE 20.1–20.12	Thu	9:30–12:45	BH-N 243	**Energy Systems (joint session DY/ AK Energy / SOE)**
SOE 21.1–21.1	Thu	14:00–14:45	H 0104	**Plenary Talk Simon Levin**
SOE 22.1–22.7	Thu	15:00–17:00	MA 001	**Economic Models**
SOE 23.1–23.5	Thu	17:00–18:30	MA 001	**Physics of Sustainability and Human-Nature Interactions II (joint with DY, jDPG, BP) - session accompanying the symposium SYPS**
SOE 24.1–24.7	Thu	15:00–17:00	BH-N 243	**Extreme Events (joint session DY / SOE)**
SOE 25.1–25.12	Fri	9:30–12:45	BH-N 128	**Networks: From Topology to Dynamics III (joint session DY / SOE / BP)**

Annual General Meeting of the Physics of Socio-economic Systems Division

Wednesday 18:35–19:30 MA 001

- Report on activities. Announcement of conferences and workshops.
- Report by Benjamin Lux on www.uni-ulm.de/physics_meets_finance (5.-7. March 2015).
- Discussion of future symposia and focus session suggestions & Miscellaneous.

SOE 1: Tutorial: From spin models to macroeconomics (SOE, DY, jDPG)

Formulated as a minimal model of ferromagnets, the Lenz-Ising model received a recent renaissance serving as paradigmatic basis for the formulation and analysis of models of social and economic behaviour. Prominent examples are microscopic market and price formation models incorporating herding behaviour of the economic agents and leading to nonlinear and nonequilibrium macroeconomic dynamics. The Sznajd-Weron opinion formation model introduced spin models with outflow kinetics into quantitative social modeling. Finally, the macroscopic (replicator) equations of evolutionary game theory again can be based on microscopic (Glauber-like) reaction kinetics for discretized behavioral states, whereby the payoffs from the neighborhood resemble a local meanfield. This series of tutorial lectures shows that methods adapted from statistical phyics can serve as concepts in quantitative social and economic theories and are worth the effort of bridging the disciplines, which includes properly connecting to economic frameworks. (Session compiled by Jens Christian Claussen.)

Time: Sunday 16:00–18:30 Location: H 0104

Tutorial SOE 1.1 Sun 16:00 H 0104

Economics in a nutshell, for physicists — •Sylvie Geisendorf — ESCP Europe Berlin

The talk explains why and how the economic mainstream, the theory of neoclassical economics, is based on the idea of Newtonian physics. It also discusses why a real Newtonism would probably have been a good idea and where economists deviate from it.

Although modern economists rarely refer to physics, economic theory is based on Newtons idea of universal gravity. Following Newtons discovery, physics became an exact science with rigorous mathematical descriptions. In physics, Newton marked the beginning of the era of rational mechanics. Society was fascinated by Newtons insights and economists based their theory on classical mechanics with the explicit aim to make economics a rational science as well. But instead of adopting Newtons laws of motion they employed the simplified principle of general maximization. Whereas the laws of motion name the forces acting in a system, optimization calculus only deduces the final outcome. Even in physics, the realization of global minima or maxima is only possible under specific conditions. In economics, where actions of bounded rational agents have to be considered, these conditions are even rarer. The talk argues that a real Newtonian approach could have moderated the current lack of contact with reality, economic theory displays, and could have facilitated the necessary transition to an evolutionary theory of the economy.

Tutorial SOE 1.2 Sun 16:50 H 0104

Connecting microscopic behavioral economics to macroscopic financial market models — •Sebastian M. Krause — Rudjer Boskovic Institute, Zagreb, Croatia

Time series of prices show the stylized facts of broadly distributed price jumps which occur clustered. This has serious implications for the accumulation of risk. Macroscopic price evolution models for estimating risk are commonly used. They extend the random walk by including auxiliary volatility variables to model time dependent volatility. On the other hand, agent based models that include behavioral insights are used to enlighten the mechanisms behind stylized facts. This could help to predict crashes and to improve market regulation.

After briefly illustrating this background, I discuss a way of interconnecting these two strands of research. Using an agent based model with herding, I exemplify a general recipe for finding macroscopic models numerically: A macroscopic variable which might control volatility is identified; The stochastic process ruling this volatility variable is measured, using the numeric evolution of the microscopic model. This procedure is suitable for models with puzzling emergent behavior, as well as for complicated models with many parameters. The resulting macroscopic price evolution model can be much simpler, allowing for proceeding investigations. Therefore, the field of agent based modeling profits from a macroscopic description. Another advantage is the microfoundation of macroscopic financial market models which are so far pure phenomenological. The auxiliary volatility variable can inherit a clear behavioral meaning from the microscopic model.

Tutorial SOE 1.3 Sun 17:40 H 0104

You are a young and aspiring physicist. Is working at the interface with economics a good idea? — •Tobias Galla — Theoretical Physics, School of Physics and Astronomy, The University of Manchester, Manchester M13 9PL, UK

The terms econophysics and sociophysics describe research in which physicists apply their ideas and methods to problems in economics and the social sciences. What do you have to know about the field to find your own answer to the question in the title? Well, one way is to talk to as many 'older' physicists as possible who have worked in this area, and then to form your own opinion. In this tutorial I will give you my personal assessment of what physicists can contribute to the field of economics, and comment on why they cannot contribute as easily as it may seem. We will discuss the main achievements of physicists, for example the detection of non-Gaussian features and long-range correlations in financial data, theories of market impact, non-equilibrium ideas and bottom-up models of game theory, decision making and market microstructure. At the same time you will hear about the things physicists have not achieved (despite occasional claims to the contrary). I will then present some of our own work on chaotic dynamics in the learning of complicated games and discuss the potential consequences this has for agent-based market models, and the limitations of our work. In the final part of the tutorial I will comment on the potential hurdles young physicists moving into this area might want to be aware of, and I will highlight the potentials and benefits of working in this field.

SOE 2: Future Visions of Socio- and Econophysics

Time: Monday 9:30–10:00 Location: MA 001

SOE 2.1 Mon 9:30 MA 001

A Planetary Nervous System to Measure and Understand Our Society — •Dirk Helbing — ETH Zurich, Clausiusstrasse 50, CH-8092 Zurich

The Planetary Nervous System is a large-scale distributed research platform that will provide real-time social mining services as a public good. Existing Big Data systems threaten social cohesion as they are designed to be closed, proprietary, privacy-intrusive and discriminatory. In contrast, the Planetary Nervous System is an open, privacy-preserving and participatory platform designed to be collectively built by citizens and for citizens. The Planetary Nervous System is enabled by Internet of Things technologies and aims at seamlessly interconnecting a large number of different pervasive devices, e.g. mobile phones, smart sensors, etc. For this purpose, several universal state-of-the-art protocols and communication means are introduced. A novel social mining paradigm shift is enabled: Users are provided with freedom and incentives to share, collect and, at the same time, protect data of their digital environment in real-time. In this way, social mining turns into a knowledge extraction service for public good. The social mining services of the Planetary Nervous System can be publicly used to build novel innovative applications. Whether you would like to detect an earthquake, perform a secure evacuation or discover the hot spots of a highly frequented city, the Planetary Nervous system makes this possible by collectively mining social activities of participatory citizens.

SOE 3: Evolutionary Dynamics of Social Systems

Time: Monday 10:00–10:45 Location: MA 001

SOE 3.1 Mon 10:00 MA 001

Evolution and Ecology of the Digital World — •Kaj Kolja Kleineberg and Marian Boguna — Departament de Física Fonamental, Universitat de Barcelona, Martí Franquès 1, 08028 Barcelona, Spain

The overwhelming success of Web 2.0, within which online social networks are key actors, has induced a paradigm shift in the nature of human interactions. The user-driven character of Web 2.0 services has allowed researchers to quantify large-scale social patterns for the first time. However, the mechanisms that determine the fate of networks at the system level are still poorly understood. For instance, the simultaneous existence of multiple digital services naturally raises questions concerning which conditions these services can coexist under. Analogously to the case of population dynamics, the digital world forms a complex ecosystem of interacting networks. The fitness of each network depends on its capacity to attract and maintain users' attention, which constitutes a limited resource. Here, we introduce an ecological theory of the digital world which exhibits stable coexistence of several networks as well as the dominance of an individual one, in contrast to the competitive exclusion principle. Interestingly, our theory also predicts that the most probable outcome is the coexistence of a moderate number of services, in agreement with empirical observations.

SOE 3.2 Mon 10:15 MA 001

The Expert Game - Emergence of trust, social capital and exploitation protection in an impersonal environment — •Florian Uekermann — Niels Bohr Institute, Copenhagen, Denmark

We present the Expert Game, a simple socio-economic experiment, which mimics professional communication and collaboration in an impersonal environment (using standardized electronic messages).

In the Expert Game, each subject is assigned a task and an expertise. The tasks and expertises are assigned such that each subjects task matches another subjects expertise. The goal for each subjects is to find their expert and receive help from him. Finding this expert can be accelerated by receiving a referral to the expert from a third person. In each round the subjects can choose between asking someone for help or replying to such a request by sending a referral or helping with a task. The subjects face a dilemma: Replies are detrimental to their immediate performance, but nobody can achieve his goal without help.

Our experiments show that in a session of repeated games with 16 subjects, mutual preferential treatment emerges, indicating a mutual trust relationship. We also measure a higher winning efficiency compared to a control with hidden identities.

In simulations using a simple model of the participants behavior, we show how individual reputations lead to exploitation protection and emergence of measurable social capital. We give a generally applicable quantitative definition of social capital and describe how it can be measured.

SOE 3.3 Mon 10:30 MA 001

Traveling waves in evolutionary dynamics — •Reinhard Mahnke[1], Jevgenijs Kaupuzs[2], Martins Brics[1], Hans Weber[3], and Sebastian Rosmej[1] — [1]Rostock University, Institute of Physics, D-18051 Rostock, Germany — [2]University of Latvia, LV-1459 Riga, Latvia — [3]Lulea University of Technology, S-97187 Lulea, Sweden

Here we consider models based on certain evolutionary dynamics written as Fisher-Eigen equation. Each species has its own fitness. We investigate the probability density as function of time for the evolution of a population of different species.

This reaction-diffusion (also called adoption-exploration) dynamics shows traveling waves soltions relevant for evolutionaly biology as well as in social systems.

In the context of the Fisher equation we explore the expansion and evolution of patterns or trends as an important example.

SOE 4: Financial Markets and Risk Management

Time: Monday 10:45–12:15 Location: MA 001

SOE 4.1 Mon 10:45 MA 001

Markets, herding and response to external information — •Adrián Carro, Raúl Toral, and Maxi San Miguel — Instituto de Física Interdisciplinar y Sistemas Complejos, IFISC (UIB-CSIC), Universitat de les Illes Balears, Palma de Mallorca, Spain

We focus on the influence of external sources of information upon financial markets. In particular, we develop a stochastic agent-based market model characterized by a certain herding behavior as well as allowing traders to be influenced by an external dynamic signal of information. This signal can be interpreted as a time-varying advertising, public perception or rumor, in favor or against one of two possible trading behaviors, thus breaking the symmetry of the system and acting as a continuously varying exogenous shock. As an illustration, we use a well-known German *Indicator of Economic Sentiment* as information input and compare our results with Germany's leading stock market index, the DAX, in order to calibrate some of the model parameters. We study the conditions for the ensemble of agents to more accurately follow the information input signal. The response of the system to the external information is maximal for an intermediate range of values of a market parameter, suggesting the existence of three different market regimes: amplification, precise assimilation and undervaluation of incoming information.

SOE 4.2 Mon 11:00 MA 001

Stylized Dynamics from Efficient Pricing — •Felix Patzelt and Klaus Pawelzik — Institute for Theoretical Physics, University of Bremen, Germany

Mainstream economic theories describe financial markets as systems that transform available information into prices. This view is consistent with the finding that price changes are hard to predict. It has, however, proven difficult to reconcile with the excessive movements of real prices.

The origins of empirical "stylized facts" of price time series, on the other hand, are often investigated using multi-agent models. Difficulties to coordinate the agent's strategies can lead to slowly shifting market imbalances that modulate the market's volatility due to nonlinearities.

Here we combine these seemingly opposing views in a minimal and analytically fully tractable model. We first show that simple efficient bidding processes where prices follow a martingale inevitably form "bubbles". We furthermore consider a simple non-linearity for the generation of prices that arises naturally from the imbalance of supply and demand. It amplifies the modulation the price volatility similar to much more complicated models. This model quantitatively reproduces the empirical scaling laws of the distributions and temporal correlations of (logarithmic) price-change magnitudes independent of parameters. It can be mapped to an equivalent diffusion process which might be used to estimate market imbalances underlying real price time series and more complex models.

SOE 4.3 Mon 11:15 MA 001

Influence of response time on traders' performances: a double-auction model analysis — •Guanghao Liu[1], Yu Chen[2], Fujio Toriumi[1], and Hirotada Ohashi[1] — [1]Department of Systems Innovation, the University of Tokyo, Japan — [2]Department of Human and Engineered Environmental Studies, the University of Tokyo, Japan

The influence of the response time of traders on their performances is investigated by using a multi-agent continuous double auction model. In this model, every agent can access the same information. They make decisions with the same type of strategy, but the decisions are not identical because of the random coefficients in the strategy at every time step. A time delay, referred to in this study as "the response time", is used to describe the time interval between the time one agents accesses the information and the time he sends an order. Orders will be executed on their arrival according to their price. We check the model by obtaining several stylized facts of financial markets such as the so-called fat-tail distributions and volatility clustering. The simulation results show that the agents with the shortest response time could not always get the highest wealth. To clarify the influence of the response time of an agent on his wealth in different conditions, several investment strategies and market rules are investigated.

SOE 4.4 Mon 11:30 MA 001

Analysis of German Interest Rates according to Standard Models and beyond. — •Magda Schiegl — Hochschule Landshut, Am Lurzenhof 1, D-84036 Landshut

Over the last years interest rates decreased continuously in Germany. The short period interest rates even decline to negative values. This development is very crucial and especially demanding for companies dealing with long term investments.

For the risk management of interest-rate-sensitive investments stochastic models are used. The standard interest rate models, the CIR (Cox, Ingersoll, Ross) and the Vasicek model (Ornstein-Uhlenbeck-Process) are Langevin type models. They consist of a mean reverting drift part and a volatility part. The models differ in this second part concerning the volatility dependence on the interest rate's size. The mean reverting ansatz reflects the idea of an "equilibrium" interest rate to be achieved as a stable state in the long run attracting the fluctuating interest rate.

We analyse the German interest data according to these standard models and ask for their relevance. Various methods are applied to analyse for instance: The time series, the interest rate cdfs and the time scaling behaviour of the volatility. We compare the results of the empirical data with theoretical and Monte Carlo results of the standard models.

SOE 4.5 Mon 11:45 MA 001

Solcency II directive and stability of financial markets — •Daniil Osipov and Zere Toleuberdi — KBTU, Almaty, Kazakhstan

We propose a model of financial instability based on the Lotka-Volterra equations with specific attention given to the international regulatory accords (Basel II, Basel III for banks, and Solvency II Directive for insurance companies). The model describes the relationship between industry and financial sector, and it helps to understand and to measure the counter-cyclicality effect of Solvency II regulation.

SOE 4.6 Mon 12:00 MA 001

Dynamics of multi-asset artificial markets considering inter-market transactions of two types of traders: risk-seekers and risk avoiders — •Hidenori Mabe[1], Yu Chen[2], Fujio Toriumi[1], and Hirotada Ohashi[1] — [1]Department of Systems Innovation, the University of Tokyo, Japan — [2]Department of Human and Engineered Environmental Studies, the University of Tokyo, Japan

Most studies of artificial financial markets focused on dynamics of a single asset in a single market. However, there is no independent market in reality, and all markets all over the world are connected in some ways. Market participants move repeatedly their investment capitals from one asset to another crossing various markets. We construct a multi-asset artificial market model to investigate dynamics of interacting markets. The model is composed of several assets and two types of agents. One type corresponds to risk-avoiders who invest based on values of fundamentals, which depend on a time series of exchange rates. The other corresponds to risk-seekers who tend to invest in highly volatile assets. The resulting dynamics becomes complex because of the interactions between agents' behavior and price changes of assets. Some stylized facts such as fat-tail distributions and volatility clustering are observed. We investigate the spread of influences of price changes among assets. Price fluctuations of an asset caused by risk-seekers lead to those of others in which risk-avoiders mainly participate. Negative correlations between returns and volatility are observed and, we think, this represents a phenomenon called volatility anomaly, which is contrary to the conventional wisdom in financial engineering.

SOE 5: Networks: From Topology to Dynamics I (joint session SOE / DY / BP)

Time: Monday 12:15–13:15 Location: MA 001

SOE 5.1 Mon 12:15 MA 001

How mutational networks shape evolutionary processes — •Henning Siemen, Benjamin Maier, and Dirk Brockmann — Robert Koch-Institut, Berlin

Dynamic processes on complex networks have attracted a lot of attention in the past. The majority of the studies focus on understanding how topological network features shape dynamics. Several interesting results have been obtained in the context of epidemics and contagion phenomena recently, for instance the absence of epidemic thresholds in scale free networks, or the context of synchronization phenomena where certain network topologies can sustain chimera states. However, evolutionary processes on networks received comparatively little attention. It is largely unresolved how network topologies influence mutation and selection dynamics. Here, we investigate a network system of genetic strains in which each node represents a strain and links represent possible mutational pathways. We compare generic network topologies ranging from ordinary lattices and Erdos-Renyi networks to small world and scale free networks. We find that network topologies can have a substantial impact on equilibrium strain distributions. We show that locally clustered networks such as small world and lattice topologies tend to generate local maxima composed of communities with high fitness. Furthermore, we find that scale free topologies as opposed to ER networks are more likely to exhibit a lower error threshold.

SOE 5.2 Mon 12:30 MA 001

Possible Origin of Stagnation and Variability of Earth's Biodiversity — •Jan Nagler[1], Theo Geisel[2], and Frank Stollmeier[2] — [1]ETH Zurich — [2]MPI DS, Göttingen

The magnitude and variability of Earth's biodiversity have puzzled scientists ever since paleontologic fossil databases became available. We identify and study a model of interdependent species where both endogenous and exogenous impacts determine the nonstationary extinction dynamics. The framework provides an explanation for the qualitative difference of marine and continental biodiversity growth. In particular, the stagnation of marine biodiversity may result from a global transition from an imbalanced to a balanced state of the species dependency network. The predictions of our framework are in agreement with paleontologic databases.

[1] Stollmeier, Geisel, Nagler, Phys. Rev. Lett. 112, 228101 (2014)

SOE 5.3 Mon 12:45 MA 001

Excitable dynamics and cellular automata dynamics on loop-free networks — •Anne-Wiebke Harder[1,2] and Jens Christian Claussen[2,1] — [1]Institut für Neuro- und Bioinformatik, Universität zu Lübeck — [2]Computational Systems Biology Lab, Jacobs University Bremen

Spreading dynamics on graphs or networks have attracted considerable attention in the context of pattern formation and infection dynamics [1]. Here we investigate patterns generated by excitable dynamics [2] comprised by the states of susceptible - excitable - recovered, as well as cellular automata dynamics started from a localized seed on lattices and loop-free graphs [3]. The latter type of dynamics exhibits interesting characteristics as 1/f type spectra [4] and relates to new integer sequences [5]. Finally we investigate cellular-automata (CA) like limiting cases of the SER dynamics.

[1] C. Kamp PLoS Comput Biol 6 e1000984 (2010)
[2] M. Müller-Linow, C. Marr, M.-T. Hütt, Phys. Rev. E 74 026112 (2006)
[3] J.C. Claussen, J. Math. Phys. 49 062701 (2009)
[4] J. Nagler and J.C. Claussen Phys. Rev. E 71 067103 (2005)
[5] J.C. Claussen, in: Online Encyclopedia of Integer Sequences, entries http://oeis.org/A138276 and http://oeis.org/A138277 (2008)

SOE 5.4 Mon 13:00 MA 001

Noise in Coevolving Networks — •Marina Diakonova, Victor Eguiluz, and Maxi San Miguel — Instituto de Física Interdisciplinar y Sistemas Complejos IFISC (CSIC-UIB), E07122 Palma de Mallorca, Spain

Coupling dynamics of the states of the nodes of a network to the dynamics of the network topology leads to generic absorbing and fragmentation transitions. The coevolving voter model is a typical system that exhibits such transitions at some critical rewiring. We study the robustness of these transitions under two distinct ways of introducing noise. Noise affecting all the nodes destroys the absorbing-fragmentation transition, giving rise in finite-size systems to two additional regimes: bimodal magnetisation and dynamic fragmentation. Noise Targeting a fraction of nodes preserves the transitions but introduces shattered fragmentation with its characteristic fraction of isolated nodes and one or two giant components. Both the lack of absorbing state for homogenous noise and the shift in the absorbing transition to higher rewiring for targeted noise are supported by analytical approximations.

SOE 6: Evolutionary Game Theory I (joint session SOE / BP / DY)

Time: Monday 15:00–15:45 Location: MA 001

SOE 6.1 Mon 15:00 MA 001

Dynamics of human behaviour in prisoner dilemma games — •Martin Spanknebel and Klaus Pawelzik — Institute for Theoretical Physics, University of Bremen, Germany

When playing simple games humans sometimes fail to achieve maximally possible earnings, which is often considered to reflect 'irrationality'. Such behaviour has been attributed to accessory objectives or emotional biases. For instance, recently humans were found to cooperate far less than required for optimizing mean payoff when playing prisoner dilemma games against extortion strategies. But against generous strategies humans performed to optimise their behaviour properly. Here we propose an alternative explanation based on preference shifts towards choices that proved more rewarding in the immediate past. This 'melioration' is found to account for human behaviour in prisoner dilemma games with opponents exhibiting different degrees of extortion and generosity. In particular, melioration explains reduced cooperation in extortion and high cooperation in generous games and reproduces the broad distributions of choice rates in ensembles of players. These results indicate that the alleged irrationality of human behaviour could be the consequence of elementary learning mechanisms and not necessarily involves auxiliary motives.

SOE 6.2 Mon 15:15 MA 001

When do microscopic assumptions determine the outcome in evolutionary game dynamics? — •Bin Wu[1], Bebedikt Bauer[1], Tobias Galla[2], and Arne Traulsen[1] — [1]Department of Evolutionary Theory, Max Planck Institute for Evolutionary Biology, Ploen, Germany — [2]Theoretical Physics, School of Physics and Astronomy, The University of Manchester, Manchester M13 9PL, United Kingdom

The modelling of evolutionary game dynamics in finite populations requires microscopic processes that determine how strategies spread. The exact details of these processes are often chosen without much further consideration. Different types of microscopic models, including in particular fitness-based selection rules and imitation-based dynamics, are often used as if they were interchangeable. We challenge this view and investigate how robust these choices on the micro-level really are. Focusing on a key macroscopic quantity, the probability for a single mutant to take over a population of wild-type individuals, we show that there is a unique pair of a fitness- based process and an imitation process leading to identical outcomes for arbitrary games and for all intensities of selection. This highlights the perils of making arbitrary choices at the micro-level without regard of the consequences at the macro-level.

SOE 6.3 Mon 15:30 MA 001

Social particles. On the common roots of aggression, al-

truism, co-operation and grouping — •Karl Kalveram — Tu Darmstadt and Uni Duesseldorf

We are accustomed of the strange outcome of the interaction of particles: particles that annihilate if meeting each other and/or re-emerge from vacuum. Some attract and some refute others. Their overall demeanor, however, is, temporal stationarity presumed, only describable statistically, and governed by equations proposed by Schroedinger or Heisenberg. Now we look at another type of particles interacting, too, with randomly varying outcomes. Their properties, however, can change over time, some rules of which being formulated first by Darwin. Here I present a mathematical formalism describing behavior and evolution of a selection called 'social particles'.

The formalism considers population dynamics as dependent on the particles' average birth and death rate, the average outcome of social interactions as influencing this ratio, and the reproduction ratio (birth rate/death rate) as fitness. A special 'gene setting' passed to offspring determines a particle's behavior in encounters. Following Dawkins, particles sharing the same gene setting (here called gene-relatives) should favor each other or exempt from harm in an encounter, but type one and type two errors hamper a correct behavioural decision. Inserting pay-off matrices characterizing aggression, altruism, co-operation or grouping into the formalism reveals, how the respective social particles' frequency develops in domains with limited resources.

SOE 7: Prize Session: Young Scientist Award for Socio- and Econophysics (YSA)

Time: Monday 16:00–17:45 Location: MA 001

Invited Talk SOE 7.1 Mon 16:00 MA 001

Computational Social Science: Exciting Progress and Future Challenges — •Duncan Watts — Microsoft Research, 641 Avenue of the Americas, 7th Floor, New York, NY 10011, USA

The past 15 years have witnessed a remarkable increase in both the scale and scope of social and behavioral data available to researchers, leading some to herald the emergence of a new field: *computational social science.* Against these exciting developments stands a stubborn fact: that in spite of many thousands of published papers, there has been surprisingly little progress on the *big* questions that motivated the field in the first place*questions concerning systemic risk in financial systems, problem solving in complex organizations, and the dynamics of epidemics or social movements, among others. In this talk I highlight some examples of research that would not have been possible just a handful of years ago and that illustrate the promise of CSS. At the same time, they illustrate its limitations. I then conclude with some thoughts on how CSS can bridge the gap between its current state and its potential.

Presentation of the YSA Award to the Awardee

Prize Talk SOE 7.2 Mon 17:00 MA 001

For cooperation please add: Carrots, sticks, both, or neither? — •Matjaz Perc — Faculty of Natural Sciences and Mathematics, University of Maribor, Slovenia

Widespread cooperation among unrelated individuals distinguishes humans markedly from other species. The origins of our remarkable other-regarding abilities have been associated with rearing offspring that survived, which was a pressing challenge during the Paleolithic age that could not be met by individual efforts alone. But in the absence of such a challenge, what keeps us cooperating? Reciprocity is long considered an important piece of the puzzle. If someone is kind to us, we are kind in return. We reward cooperation. On the other hand, if someone is unfair or exploitative, we tend to retaliate. We punish defection. And according to the strong reciprocity hypothesis, positive and negative reciprocity are correlated to give us optimal evolutionary predispositions for the successful evolution of cooperation. But is this really true? Should we reward and punish, or should we do just one of the two, or maybe neither? Recent economic experiments reject the strong reciprocity hypothesis, and everyday experience also leaves us with the impression that people and institutions will either reward cooperation or punish defection, but seldom will they do both. I will show how methods of statistical physics might contribute to the resolution of the stick versus carrot dilemma.

SOE 8: Poster

Poster boards are in A0 portrait format. Posters can and should be on display on whole Monday.

Time: Monday 18:00–20:00 Location: Poster E

SOE 8.1 Mon 18:00 Poster E

Sustainable Monetary Agency — •Stephen I. Ternyik — POB. 201 D-82043 Munich

We may like it or not, ours is a monetary civilization, since ~ 5000 years. The last 250 years saw the rise of the monetary production economy, with the latest consequence that all human needs are now reduced to the need for money. This technical 'simplification' of economic complexity comes with a high price, concerning the physical sustainability of the human-nature-capital interplay. Money (m) has become physical access to all types of energy (e), drives the temporal (t) length (l) of economic production (p) cycles and determines the 'speed' of the human economy. The cybernetic wave circuit reads: m/quantizes/e=e/quantizes/t=t/quantizes/p. Every economic wave length (l) is quantitatively proportional to the liquidity frequency (f); the greater the monetary volume (x) in a wave, the higher is f (l=f (x/r); r (reserve requirement) is the decisive factor in this equation. The temporal (t) acceleration of p (e.g. machine operating time, logistics) is a result of x in demand for e (p=t (x/e); every customer payment finalizes p. As a result, the economic behavior of gradual monetary excess increases the exponential need for energy and causes the temporal acceleration of economic wave cycles (crises). Only an efficient monetary technique of narrow reserve banking can lead to more economic systems sustainability.

SOE 8.2 Mon 18:00 Poster E

Aspiration–Based Full Cooperation in Finite Systems of Players — •Tadeusz Platkowski — Department of Mathematics, Informatics and Mechanics, University of Warsaw, Warsaw, Poland

We propose a mathematical model of evolution of a finite well–mixed population of players who change their behavior if the payoff obtained from Prisoner's Dilemma based interactions is smaller than a threshold (aspiration level). The threshold can be a fixed constant or a dynamical variable, which depends on some overall dynamically changing characteristics of the system. We investigate the dependence of full cooperation on the group size, game payoffs, aspiration level, and heterogeneity of the system. For endogenous aspirations we find analytically conditions which guarantee full cooperation in the long run for all initial configurations and group sizes. The result is robust to a stochastic choice of strategies by the heterogeneous players, as documented by numerical simulations [1].

[1] T. Platkowski, to appear in Applied Mathematics and Computations (2015)

SOE 8.3 Mon 18:00 Poster E

Hidden scaling patterns and universality in written communication — •Marco Formentin[1], Alberto Lovison[2], Amos Maritan[3], and Giovanni Zanzotto[4] — [1]UTIA, Czech Accademy of Sciences, Prague, Czech Republic — [2]University of Padova, Padova, Italy — [3]University of Padova, Padova, Italy — [4]University of Padova, Padova, Italy

The temporal statistics exhibited by written correspondence appear to be media dependent, with features which have so far proven difficult

to characterize. We explain the origin of these difficulties by disentangling the role of spontaneous activity from decision-based prioritizing processes in human dynamics, clocking all waiting times through each agent's "proper time" measured by activity. This unveils the same fundamental patterns in written communication across all media (letters, email, sms), with response times displaying truncated power-law behavior and average exponents near -3/2. When standard time is used, the response time probabilities are theoretically predicted to exhibit a bi-modal character, which is empirically borne out by our new years-long data on email. These novel perspectives on the temporal dynamics of human correspondence should aid in the analysis of interaction phenomena in general, including resource management, optimal pricing and routing, information sharing, emergency handling.

SOE 8.4 Mon 18:00 Poster E

Constrained Dynamic Models (CD-Models) in Economics as a missing link of commonly used Economic Models — •Erhard Glötzl — Karl-Kautsky-Weg 26, A-4040 Linz, Austria

Constrained dynamics are well known from classical Mechanics. Identifying *economical forces* with physical forces, *economical power* with the reziproke value of mass and realizing that economical constraints mostly are given by accounting identities one can transform the concept of constraint dynamics to economic models. It can be shown, that commonly used economic models such as Classic, Neoclassic, GE, DSGE, Keynesian, Post-Keynesian, ABM and SFC models can be interpreted as special cases of CD-Models. CD-Models provide the basis for a variety of different closures of economic models, which are ultimately the result of different assumptions about the power relations between economic agents.

SOE 8.5 Mon 18:00 Poster E

Structural characterization of complex networks based on edge-to-edge relations from failure-induced flow redistributions — Michael T. Schaub[1], •Jörg Lehmann[2], Sophia N. Yaliraki[1], and Mauricio Barahona[1] — [1]Imperial College London, U.K. — [2]ABB Switzerland Ltd, Corporate Research, Baden-Dättwil, Switzerland

The structural analysis of complex networks mostly focuses on nodes and their relations, e.g., in node communities. However, for many dynamical processes on networks, in particular those related to the flow of energy or information, edges are at least as important as the nodes and an analysis based on relations between edges is more appropriate. Here, we put forward a corresponding approach, which is based on the flow redistribution induced by edge failures [1]. We find that there is a potential long-range interaction between edges, which can reveal interesting non-local edge-communities. Furthermore, we introduce the concept of an edge embeddedness, which reflects the importance of an edge in weighted cuts of the network. We exemplify the significance of our approach with analyses of the Iberian power grid, traffic flows in road networks and the C. elegans neuronal network.
[1] M. T. Schaub et al., Network Science **2**, 66 (2014).

SOE 8.6 Mon 18:00 Poster E

Secure message passing on networks with insecure classes of nodes — •Sebastian M. Krause[1], Michael M. Danziger[2], and Vinco Zlatic[1] — [1]Rudjer Boskovic Institute, Zagreb, Croatia — [2]Bar Ilan University, Ramat Gan, Israel

Nodes in a network such as the Internet may be able to communicate even if many connecting nodes fail. If instead of failing, the nodes manipulate or intercept messages silently, such nodes have to be avoided in advance. This is possible if the message is split into parts which are only useful together, and the parts are sent over independent paths. It is an open question, if this is possible on realistic large scale networks, where whole classes of nodes need to be avoided at the same time due to software bugs.

Here we consider the case of a network partitioned into sets of nodes (each labeled with one color) with the assumption that no single subset can be trusted. This corresponds, for example, to routers running different software versions or controlled by different entities. For transmitting the parts of a message, we ask whether sufficient paths exist, such that no color of nodes is needed to transmit all message parts. We develop a new mathematical framework based on percolation theory. With analytic solutions for Poisson and scale-free graph ensembles, we discuss a new kind of critical phenomena in which the critical exponent is determined by the number of colors. We also present a numerical algorithm which is suitable for analyzing real world networks. Applied to the Internet on the level of autonomous systems, we find that a large fraction of servers would be able to securely communicate.

SOE 8.7 Mon 18:00 Poster E

Empirical analysis of the order book and order flow of a Bitcoin marketplace and comparison with traditional markets — •Alexander Eckrot, Jan Jurczyk, and Ingo Morgenstern — University of Regensburg, Germany

Bitcoin marketplaces have some features that distinguish them from traditional marketplaces. Examples of this features are: Very high transparency, low trading volumes, 24 hours of trading a day without free days. Especially the high trading transparency makes this marketplaces a good resource for collecting data about the order book and order flow. We collected about 1,2 Million snapshots of order books for a Bitcoin marketplace from June to September 2014. The snapshots have a time interval of 7 seconds, which is small enough to reconstruct the order flow. We analyze these order books and compare our results with traditional stock markets.

SOE 8.8 Mon 18:00 Poster E

Effects of microscopic limit order book structure on price formation — •Winfried Sebastian Reimann, Hannes Blut, and Stephan Eule — Max-Planck-Institut für Dynamik und Selbstorganisation, Goettingen, Deutschland

Most modern financial markets nowadays employ limit order books to manage the priority of unexecuted limit orders. Analysis of large amounts of historical order book data in continuous double auction markets have discovered the dynamics to be influenced by a number of observables:

(i) Structural properties such as imbalance of orders and gap size;

(ii) order flow statistics, e.g. limit order placement and cancellation rates;

(iii) price determining quantities including spread size, and price jump distributions.

Especially the third group of observables is recognized for its essential role in execution strategies and risk estimation. Whereas past modeling has mainly aimed for reproducing the properties of prices by investigating the order flow, we focus on the effects of price gaps. These and other structural properties of the order book are expected to have a large influence on the book's dynamics, in particular in high volatility markets. We extend the standard double auction model by Mike and Farmer[1] to make predictions about the relation between gaps and price statistics and compare these to real data.

[1]Mike, S., Farmer, J. D., 2008. An empirical behavioral model of liquidity and volatility. J. Econ. Dyn. Control 32 (1), 200-234.

SOE 8.9 Mon 18:00 Poster E

How multiplex affects the Abrams-Strogatz model — •Roberta Amato, Nikos Kouvaris, and Albert Diaz-Guilera — departament de fisica fonamental, universitat de barcelona, marti franques 1, 08028 barcelona, spain

The Abrams-Strogatz model studies the competition between two languages or, more in general, two states, in a given society. each individual starts with a random language and, during the time, can choose to change his language according to: the prestige of both languages in his society and the most spoken language by his friends. if the individuals live on a random network almost fully connected, and we consider just the first neighbours interaction, at some point all the people will speak the same language.

In agreement with reality, the people interact to each others in different situations or environments like the work, the family, the pub, etc... to represent these different interaction situations we can use multiplex. In a multiplex each situation is as a network on a layer, and the layers are connected by connecting a node and his counterpart in the other layer. The new question we place is: can multilayer human interaction ensure the lives of both languages? We introduce a new parameter that controls, for each individual, how the language spoken in a layer influence the language spoken in the other layer. In this new situation an individual may choose to change his language in a layer also in according to: his language in the other layer. What we find is that, for some values of the parameter a metastable state of two language consistence exists.

SOE 8.10 Mon 18:00 Poster E

The network of inter-organizational movements in the Stockholm region, 1990-2003 — •Hernan Mondani[1], Petter Holme[2,3,1,4], and Fredrik Liljeros[1,4] — [1]Department of Sociology, Stockholm University, 10691 Stockholm, Sweden — [2]Department

of Energy Science, Sungkyunkwan University, 440-746 Suwon, Korea — [3]IceLab, Department of Physics, Umeå University, 90187 Umeå, Sweden — [4]Institute for Futures Studies, Box 591, 10131 Stockholm, Sweden

This study uses Swedish register data to bring a network perspective into the statistical analysis of organizational growth. The data is a unique individual-level longitudinal database on organizational membership for all workers in the Stockholm region, during the period 1990-2003. We can keep track of organizations and individuals over time, and people's movements between organizations can be known on a yearly basis.

We construct a network where the nodes are organizations, and the links are movements of people between them, during a given year. Firstly, we study the network properties of a collapsed network for the whole time period, and compute probability distributions for the main connectivity and centrality statistics. Secondly, we look at the time evolution of network measures and flows of people between organizations. We explore the scaling of network properties with company size, as well as differences in the statistics for the public and private sectors.

Keywords: complex networks, sociophysics, organizational growth process, scaling.

SOE 8.11 Mon 18:00 Poster E

Impact of Meta Orders on Continuous Double Auction Order Book Dynamics with Inhomogeneous Placement and Cancellation Rates — •Hannes Blut, Winfried Sebastian Reimann, and Stephan Eule — Max-Planck-Institut für Dynamik und Selbstorganisation, Am Faßberg 17, D-37077 Göttingen, Deutschland

Most modern financial markets nowadays employ limit order books to manage the priority of unexecuted limit orders. Analyses of large amounts of historical order book data in continuous double auction markets have discovered the dynamics to be influenced by a number of observables: (i) Structural properties such as imbalance of orders and gap size; (ii) order flow statistics, e.g. limit order placement and cancellation rates; (iii) price determining quantities including spread size, and price jump distributions. Especially the third group of observables is recognized for its essential role in execution strategies and risk estimation. On the basis of such analyses, models for the microscopic dynamics of order books have been developed and tested by means of simulation. Here, existing models are extended. The modified models aim to include inhomogeneous order placement and cancellation rates, which have been detected in data analyses. Furthermore, long-term correlations in order signs are applied to account for meta orders.

SOE 8.12 Mon 18:00 Poster E

On commonalities between computational economics and computational neuroscience — •Bernhard A. Kaplan — Department of Computational Biology, Royal Institute of Technology, KTH, Stockholm, Sweden

Numerical simulations of mathematical models have become a valuable tool in all fields of science. However, there is rather little exchange between different disciplines regarding the challenges that are faced, e.g. the development of software tools for simulations or the descriptions of models. This contribution aims to show commonalities between two different disciplines, neuroscience and socio-economic modeling, and highlights perspectives for a beneficial exchange regarding modeling and simulation methods. Both disciplines deal with highly complex, temporally evolving systems, and scientists face similar challenges when it comes to building models that simultaneously cover multiple levels of detail and different temporal scales. An exchange of the ideas and best practices regarding software and methodology used in this endeavour could be highly beneficial for both disciplines. One of the major challenges in computational neuroscience includes the integration of experimental data, the development of models and the simulation of multi-scale models that are supposed to cover many levels of complexity. I will present some of the ideas and approaches in use and will argue for the benefits of using similar methods in the field of socio-economics and agent-based economic modeling.

SOE 8.13 Mon 18:00 Poster E

Extending the efficient frontier of the mean variance model and value at risk model by utilizing groundstate behavior of portfolios — •Jan Jurczyk — University of Regensburg, Regensburg, Germany

The cornerstone of portfolio investments is the analysis of the efficient frontier and its development in time. We extend this approach by investigating the behavior of the connected optimal portfolios and its physical observables, connected to the mean variance model and value at risk model. For finding the optimal solutions for a certain time frame, we use an algorithm based on simulated annealing. This approach leads to a measure, which is able to represent the overall market behavior.

SOE 8.14 Mon 18:00 Poster E

Search space approximation for multi-objective optimization problems — •Thorsten Rehberg — University of Regensburg

A parallel optimization strategy based on simulated annealing and a machine learning approach is used for the approximation of cost functions. This approach is exemplary applied to the portfolio selection problem for developing an efficient cost-function. For this purpose stock data from DAX, MDAX and S&P500 is used for training and validating the results.

SOE 8.15 Mon 18:00 Poster E

Effects of price transparency in a self organized cartel-formation model — •Philipp C. Böttcher, Tiago P. Peixoto, and Stefan Bornholdt — Institut für Theoretische Physik, Universität Bremen, Hochschulring 18, D-28359 Bremen

Fuel prices vary strongly over short time periods, often to the disadvantage of customers. It is commonly hypothesized that this might be a consequence of collusion among gas companies. A recent measure to counteract this in Germany is to force gas stations to list their prices, so that buyers can more easily choose the best option, in the spirit of an improved competition.
However, it has been shown recently that explicit collusion is not a necessary ingredient of cartel-like behavior. In a simple market model [T. Peixoto and S. Bornholdt, Phys. Rev. Lett. 108, 218702 (2012)], where buyers freely choose the seller, and the sellers adapt their prices without colluding, a cartel-like dynamics arises spontaneously. The parameter which controls the onset of the cartel-like dynamics is the relative speed with which the sellers update their strategies compared to the buyers.
We modify the original market model by placing the buyers and sellers in a two-dimensional lattice, and we include a portion of buyers which have access to a global list of prices. By varying this fraction, we can probe the effect of this particular measure in diminishing the typical prices and their fluctuations. We find that price transparency does indeed produce the intended effect in some situations while it can even intensify cartel-like behavior in others.

SOE 8.16 Mon 18:00 Poster E

Urbanization and Path Dependence in Urban Form — •Steffen Lohrey, Felix Creutzig, and Malte Roedl — Mercator Research Institute on Global Commons and Climate Change (MCC)

Urbanization trends forecast a tripling of urbanized areas by 2030. Impacts include loss of arable land and biodiversity, but also a strong increase of both urban energy consumption and CO2 emissions. To a large part, these stem from urban transport. Transport emissions are known to be strongly influenced by urban form. A naive proxy of urban form, population density, is known to influence GHG emissions via the distance driven and modal shares. Urban form inhibits strong inertia, sudden change to a city*s layout is unlikely. Thus, the growth of today*s cities seems to determine tomorrow*s emissions with a high lock-in potential. In our work, we are assessing urban growth using non-linear modelling techniques, to assess whether path dependence is a pertinent concept to describe a possible carbon lock-in of urban transport systems. Techniques developed could help assess path dependence and help mitigate it. We here apply agent-based modeling motivated by urban economic concepts. Our results outline which parameters have crucial impact on potential lock-in, but also lock-out developments. We also tentatively suggest development strategies for different types of human settlements worldwide.

SOE 8.17 Mon 18:00 Poster E

Emergence of asynchronous local clocks in excitable media — Richard Gerum, •Achim Schilling, Ben Fabry, and Claus Metzner — Department of Physics, Friedrich-Alexander University Erlangen-Nürnberg (FAU), Germany

Excitable media such as the myocardium or the brain consist of arrays of coupled excitable elements, in which the local excitation of a single element can propagate to its neighbors in the form of a nonlinear autowave. Since each element has to pass through a refractory

period immediately after excitation, the frequency of autowaves is self-limiting. In this work, we consider the case where each element is spontaneously excited at a fixed average rate and thereby initiates a new autowave. Although these spontaneous self-excitation events are modelled as independent Poisson point processes with exponentially distributed waiting times, the travelling autowaves lead collectively to a non-exponential, unimodal waiting time distribution for the individual elements. With increasing system size, a global 'clock' period T emerges as the most probable waiting time for each element, which fluctuates around T with an increasingly small but non-zero variance. This apparent synchronization between asynchronous, temporally uncorrelated point processes differs from synchronization effects between perfect oscillators interacting in a phase-aligning manner. Finally, we demonstrate that asynchronous local clocks also emerge in non-homogeneous systems in which the rates of self-excitation are different for all individuals, suggesting that this novel synchronization mechanism can occur in a wide range of excitable media.

SOE 8.18 Mon 18:00 Poster E

Agent based model based on socio-physics and evolutionary economics to describe changes in technological regimes — •Florian Senger — Fraunhofer ISI, Breslauer Str. 48, 76139 Karlsruhe

The work presented here is part of an ongoing PhD thesis, where I combined methods from physics of social systems with methods from evolutionary economics to develop an agent-based model to mimic the dynamics of regime changes in socio-technical systems. I therefore modelled the demand side as consumer agents according to a distribution of endowments and needs, connected to each other in a social network, influencing each other in a voter-model-like manner and the supply side as explicit company agents consisting of genes in an evolutionary sense, producing a technology in a quality depending on their particular fitness, taking influence on particular areas of the consumer network via marketing and changing the alleles of their genes by a process of imitating and stochastically innovating, getting feedback on their fitness by the degree of success with the consumers. In this presentation I will show results for the phase behaviour of the system and how different properties of the network and the company agents yield different scenarios of metastable technological regimes and technological regime changes as observed in reality.

SOE 8.19 Mon 18:00 Poster E

A Bayesian model for the propagation of social norms and identity formation — •Leonhard Horstmeyer[1], Francesca Lipari[2], Alireza Goudarzi[3], and Brais Alvarez[4] — [1]MPI for Mathematics in the Sciences — [2]University of Pennsylvania — [3]University of New Mexico — [4]European University Institute

We develop a dynamical agent-based model for identity formation in the presence of descriptive norms in order to address questions of social mobility.

Agents are endowed with a social identity and beliefs thereon, subjected to updating rules. We introduce a social payoff function as a map from the identity space to a discrete valued payoff space. Agents form beliefs about these functions, modelled as probability distributions. Each agent observes other agents' identities as a proxy for their beliefs and updates its own belief via a Bayesian rule. They assume a new identiy whenever it is accessible and the expected social payoff gain succeeds a threshold τ. Agents are also subjected to an external source, modelled as a probability distribution over the social payoff functions. These are then integrated into the updating process through a convex combination with parameter λ. We study social mobility on the (τ, λ)-parameter space and find that a linear relation separates a mobile and an immobile phase.

SOE 8.20 Mon 18:00 Poster E

Estimating Social Networks of Killer-Whales — •Sarah Hallerberg[1], Yvonne Radstake[1], Heike Vester[2], and Marc Timme[1] — [1]Network Dynamics, Max Planck Institute for Dynamics and Self-Organization, 37077 Göttingen — [2]Ocean Sounds, Sauoya 01, 8312 Henningsvaer, Norway

Estimating social networks of animals becomes a challenging task if the animals under study are living in the wild and are visuable only for very short moments. We estimate the social network of a group of killer whales based on a database of pictures, taken while the animals breach the ocean surface for breathing. We are especially interested in identifying leader-follower relationships between individual whales.

SOE 8.21 Mon 18:00 Poster E

Discontinuous phase transition via cooperation of spreading agents — Weiran Cai[1], •Li Chen[2], Fakhteh Ghanbarnejad[3], and Peter Grassberger[4] — [1]Medical Faculty Carl Gustav Carus, Technische Universität Dresden, 01307 Dresden, Germany — [2]Robert Koch-Institute, 13353 Berlin, Germany — [3]Max-Planck Institute for the Physics of Complex Systems, 01187 Dresden, Germany — [4]Forschungszentrum Jülich, 52425 Jülich, Germany

Spreading of infective agents like pathogens, computer viruses, fashions, or political opinions can exhibit a percolation transition that separates small outbreaks from giant ones which reach a non-zero fraction of the population. Typically, such transitions are continuous (second order), but recently possible discontinuous (first order) transitions (DTs) have aroused huge interest. Here we present a model involving cooperativity between two different types of spreading agents: the presence of one facilitates the spreading of the other, and vice versa. We show that this mechanism can lead to DTs or to continuous ones, depending on the chosen order parameter, the topology of the underlying network, and on seemingly minor details of the implementation. Moreover, all DTs are also accompanied by various non-trivial power laws, which blurs the fundamental distinction between first and second order transitions.

SOE 8.22 Mon 18:00 Poster E

Long memory in a minimal trading model. — •Philipp Heyken, Felix Patzelt, and Klaus Pawelzik — Institute for Theoretical Physics, University of Bremen, Germany

In economics, markets are commonly assumed to absorb available information such that only previously unknown information states lead to price changes. How such 'learning' might be realized in real markets, however, is unknown. It was shown in a minimal multi-agent model, that the redistribution of assets can serve as a learning mechanism [1].

In particular, we find that information states which are presented frequently lead to decreasing price-change magnitudes over time. Detailed analysis shows how information is stored via imprints in the asset distribution. The memory capacity depends on the size of the system and is characterized by a phase transition. Beyond the critical point the system stores information states incrementally without any forgetting. At the critical point of the system size, forgetting exhibits power-law-behavior over time such that once presented information states still leave permanent traces.

[1] F. Patzelt and K. Pawelzik: An Inherent Instability of Efficient Markets, Scientific Reports 3, 2784 (2013)

SOE 8.23 Mon 18:00 Poster E

Heterogeneity in synchronizing networks of mobile particles — •Jorge P. Rodríguez and Víctor M. Eguíluz — Institute for Cross-Disciplinary Physics and Complex Systems IFISC (UIB-CSIC), Universitat de les Illes Balears, E-07122 Palma de Mallorca, Spain

The Kuramoto model of synchronization proposes an interaction between particles which, in the case of every particle having the same natural frequency, makes their phases approach. We will explore the Fujiwara model, which considers that the particles move diffusively in a square, and they only interact via a Kuramoto update with the particles that are located within their circular zone of influence. Hence, we have a temporal random geometric graph, as the motion of particles modifies the topology of the spatial network.

First of all, we analyse the synchronization process if there is a fraction p of slow particles ($1-p$ of fast). Comparing this process with that of a set of particles moving with the same homogeneous average velocity, we find that the heterogeneous case is slightly slower than the homogeneous. In order to characterize the role of heterogeneity, we consider a system with a Gaussian distribution of particle velocities, and analyze the characteristic synchronization time as a function of the distribution width. We find that the heterogeneity modifies the average relative velocity between particles, which is related with the average link time duration, influencing the characteristic synchronization time.

Finally, we consider that faster particles have a bigger zone of interaction. Links will be directed, and we will find a threshold for the width above which there is no global synchronization.

SOE 8.24 Mon 18:00 Poster E

Modeling the evolution of science in scientific space — •Jan Moritz Joseph[1] und Jens Christian Claussen[2,3] — [1]Institut für Technische Informatik, Universität zu Lübeck, Germany — [2]Computational Systems Biology Lab, Research II, Jacobs University

Bremen, Germany — [3]INB, Universität zu Lübeck, Germany

How does the topological space of science emerge? Scientific disciplines form clusters and topical sub-clusters, overlap through interdisciplinary research, and dynamically emerge and grow over time. Inspired by the concept of mapping scientific topics to a scientific space [1], we introduce a dynamical process of authors collaborating and publishing papers [2]. The model fosters novelty and multidisciplinary of new papers, as well as a retirement mechanism which prevents large groups to dominate topics forever. We demonstrate that our model can generate a nontrivial topological structure comparable to [1]. We quantifiy the time-evolution of the spatial structure and discuss the influence of inhomogeneity. Exploring further properties of the dynamics, we examine special and structural characteristics by measuring the fractal dimension. Furthermore, we compare the topology with real data given by the UCSD Map of Science [3].

[1] K.W. Boyack, R. Klavans and K. Börner, Mapping the backbone of Science, Scientometrics 64, 351 (2005)
[2] J.M. Joseph and J.C. Claussen, arXiv.org/abs/1407.8422
[3] K. Börner et al., Plos One 7, e39464 (2012)

SOE 8.25 Mon 18:00 Poster E

Conditional fixation in N-individual Hawk-Dove games in finite and infinite populations — Binghui Fan[1], Xinsheng Liu[1,3], •Jens Christian Claussen[2,3], and Wanlin Guo[1] — [1]Nanjing University, China — [2]Computational Systems Biology Lab, Jacobs University Bremen, Germany — [3]INB, Universität zu Lübeck, Germany

Evolutionary game theory usually describes contests between two individuals, but in reality, interactions can be more complex and involve more than two individuals. Here we present an N-individual generalization of the well-known Hawk-Dove game by considering the possible existence of a threshold of the frequency of Hawks in the interacting group above which the Doves get nothing and the Hawks fight for the total resource. When the frequency of Hawks is less than the threshold, the Doves can share a portion of the resource and the hawks fight for the remaining portion. Besides, as the frequency of Hawks increases, the portion of the resource that the Doves can gain decreases sharply according to a nonlinear function. Then we discuss evolutionary dynamics of the N-individual Hawk-Dove games with variation of reasonable range of some significant parameters in both infinite and finite populations. Specially, as for infinite populations, the system will always end up either in full Hawk or in a stable equilibrium where Hawks and Doves coexist. We discuss fixation probabilities and fixation times in finite populations by analytic and numerical methods. We find that the conditional fixation time exhibits a maximum with respect to the group size or the value-to-cost ratio.

SOE 8.26 Mon 18:00 Poster E

Evolutionary Dynamics for Persistent Cooperation in Structured Populations — Yan Li[1], Xinsheng Liu[1], •Jens Christian Claussen[2], and Wanlin Guo[1] — [1]Nanjing University, China — [2]Computational Systems Biology Lab, Jacobs University Bremen

In a public goods game, the total resulting payoff is divided equally among all participants. This still leads to the dominance of defection without substantially magnifying the public good by a multiplying factor. To explain the evolution of cooperative strategies, in a recent model only a portion of the total benefit is shared by all the players through introducing a new strategy named persistent cooperation. A persistent cooperator is a contributor who is willing to pay a second cost to retrieve the remaining portion of the payoff contributed by themselves. In a previous study, this model was analyzed in the framework of well-mixed populations. This paper focuses on discussing the persistent cooperation in lattice-structured populations. The evolutionary dynamics of the structured populations consisting of three types of competing players (pure cooperators, defectors and persistent cooperators) are revealed by theoretical analysis and numerical simulations. In particular, the approximate expressions of fixation probabilities for strategies are derived on one-dimensional lattices. The phase diagrams of stationary states, the evolution of frequencies and spatial patterns for strategies are illustrated on both one-dimensional and square lattices. We find that the existence of persistent cooperators greatly suppresses the spreading of defectors under more relaxed conditions in structured populations compared to well-mixed populations.

SOE 8.27 Mon 18:00 Poster E

Effect of heterogeneity on scaling laws in a stochastic macroeconomic model — •Cornelia Metzig — Department of Infectious Disease Epidemiology, Imperial College London, UK

Fat-tailed distributions in economic systems are typically explained by multiplicative noise, preferential attachment or similar stochastic models. A stochastic firm growth model introduced previously exhibits such scaling for several quantities, such as firm size and size fluctuations (both temporal and for the ensemble of firms at one time point). Here, the effect of introduction of heterogeneity is studied, i.e. of firms which differ in profitability. This introduces replicator dynamics in which more profitable forms outperform less profitable ones. Besides making the model easier to interpret in the context of macroeconomic agent-based models, heterogeneity affects both nature and exponents of certain scaling laws, which has been studied theoretically and numerically.

SOE 8.28 Mon 18:00 Poster E

Prediction of lane changes with a mathematical model using steering wheel angle and velocity — •Kim Schmidt[1], Stefan Pichelmann[2], Matthias Beggiato[2], Karl Heinz Hoffmann[1], and Josef F. Krems[2] — [1]TU Chemnitz, Institut für Physik, D-09107 Chemnitz — [2]TU Chemnitz, Institut für Psychologie, Allgemeine & Arbeitspsychologie, D-09107 Chemnitz

To get adapted assistance of advanced driver assistance systems we want to predict lane changes. Therefore, we evaluate the quality of our previously developed mathematical model for prediction using steering wheel angle. We also focus on possible improvements. Hence, we developed two different approaches based on velocity.

SOE 8.29 Mon 18:00 Poster E

Study of the Ecology of Multi-Assets Stock Market: An Agent-Based Model Approach — •YowKeong Lew and Yu Chen — Graduate School of Frontier Sciences, The University of Tokyo, 5-1-5 Kashiwanoha, Kashiwa City, Chiba Province, Japan

We use an agent-based model for multi-assets stock market to study the ecology of random and mean-variance traders, in particular on the mechanism of price formation and the origin of cross-correlations between the assets. Furthermore, we will evaluate the market impact of mean variance optimized trading on the volatility and cross-correlation structure of the multi-asset stock market. As a preliminary result, the constructed model is able to reproduce related important stylized-facts of univariate and multivariate price processes. We show that mean-variance optimized trading make the market more efficient in terms of cross-correlation but, on the other hand, more volatile.

SOE 8.30 Mon 18:00 Poster E

Finite populations evolving in fluctuating environments — •Peter Ashcroft[1], Philipp M. Altrock[2,3,4], and Tobias Galla[1] — [1]The University of Manchester, Manchester, UK — [2]Program for Evolutionary Dynamics, Harvard University, Cambridge, MA, USA — [3]Harvard School of Public Health, Boston, MA, USA — [4]Dana Farber Cancer Institute, Boston, MA, USA

We have shown that a mutant invading a finite population can exploit environmental noise. This noise modifies the payoff structure of the evolutionary game. A dynamic environment that randomly switches between two states can lead to a probability of fixation that is higher than in any of the individual environmental states. We provide an intuitive interpretation of this surprising effect. We develop a general theory to describe the fixation of a mutant in a population of wild-types in an environment that randomly switches between an arbitrary number of states. We also investigate stationary distributions when mutations are present in the dynamics. In this regime, we find two approximations of the stationary measure. One works well for rapid switching, the other for slowly fluctuating environments.

[1] Ashcroft, Altrock & Galla (2014) J. R. Soc. Interface 11: 20140663.

SOE 8.31 Mon 18:00 Poster E

Transformation in range expansion assays — •Robert Zöllner, Enno Oldewurtel, Nadzeya Kouzel, and Berenike Maier — Universität zu Köln, Department of Physics, Germany

Numerous bacterial species generate biofilms that cause a decreased response to antibiotics. Biofilms are complex and dynamic communities of bacteria that are embedded in an extracellular matrix. For many species including the human pathogen Neisseria gonorrhoeae, extracellular DNA (eDNA) is an essential structural element of the biofilm. Here, we use a model biofilm to test the role of eDNA in development and spreading of multi-drug resistance in biofilms through

transformation. The spatial expansion of densely growing bacteria on agar, also known as range expansion, provides an effectively two dimensional model for a biofilm. Using different fluorescence markers for different antibiotic resistance genes, horizontal gene transfer was directly visualized. The rate of generation of multi-resistant transformants and their spreading rate were measured at varying selection pressures set by the antibiotics.

SOE 9: Urban Systems - Dynamics and Complexity of Cities (Invited Talk Luis Bettencourt)

Time: Tuesday 9:30–10:15 Location: MA 001

Invited Talk SOE 9.1 Tue 9:30 MA 001

The Universality of Cities as Complex Network Systems — •Luis Bettencourt — Santa Fe Institute, Santa Fe NM, USA

Cities are perhaps among the most complex systems on the planet. For an increasing majority of people on the planet they are the dominant physical and socioeconomic environment affecting their lives. The development and growth of urban environments is also intimately connected to processes of economic growth, human development and challenges of environmental sustainability.

In this talk I will discuss some of the universal quantitative properties of cities and urban systems in terms of interacting social and infrastructural networks embedded in space and subject to energetic and cognitive constraints. I will show how new theory describes the metrics of thousands of cities worldwide, both past and present. I will also describe how this new knowledge is both revealing of large scale human sociality and is useful for policy.

Finally, I will also show how to establish a formal connection between what is particular and what is general to people, neighborhoods and cities and how to bridge scales in terms of theory, from strong variations at the local an individual level to universality at the urban level. In this way I will attempt to unify description of cities across scientific disciplines, from physics to the social sciences.

SOE 10: Focus Session: Complex Contagion Phenmomena (joint session SOE / DY / BP)

Complex contagion is the phenomenon in nature in which multiple factors are required for an agent in order to adopt or/and change of a behavior. Generically pathogens, information, opinions, new technologies that spread and proliferate on networks (e.g. contact networks between individuals in single populations or in networks of populations that are coupled by means of transportation, etc) interact, coexist and coevolve. These can effectively change simple dynamical processes to complex contagion phenomena. This session addresses the theoretical approaches as well as empirical studies dealing with these phenomena. (Session compiled and chaired by Fakhteh Ghanbarnejad and Dirk Brockmann.)

Time: Tuesday 10:15–13:15 Location: MA 001

Topical Talk SOE 10.1 Tue 10:15 MA 001

Micro dynamics of social interactions — •Sune Lehmann — Technical University of Denmark, Kgs Lyngby, Denmark

Over the past decade, we have made tremendous progress in understanding the complex networks in the world around us. In terms of social systems, we have recently developed the technological ability to measure the dynamics such networks with unprecedented accuracy, using smartphones as sensors.

For the past two years, my group has worked towards creating a dataset of unparalleled quality and size. We use smartphones as measurement devices to capture the complete network (face-to-face, telecommunication, online social networks, geolocation, etc) in a group of approximately 1000 individuals. In terms of size, this increases the number of study participants by a full order of magnitude compared to similar studies in the field.

I'll give an overview of our ongoing work with a particular focus on spreading processes as well as communities in face-to-face networks.

SOE 10.2 Tue 10:45 MA 001

Cooperative SIS epidemics can lead to abrupt outbreaks — •Fakhteh Ghanbarnejad[1], Li Chen[2], Weiran Cai[3], and Peter Grassberger[4] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]Robert Koch- Institute, 13353 Berlin, Germany — [3]TU Dresden, Germany — [4]JSC, FZ Jülich, D-52425 Jülich, Germany

In this paper, we study spreading of two cooperative SIS epidemics in mean field approximations and also within an agent based framework. Therefore we investigate dynamics on different topologies like Erdos-Renyi networks and regular lattices. We show that cooperativity of two diseases can lead to strongly first order outbreaks, while the dynamics still might present some scaling laws typical for second order phase transitions. We argue how topological network features might be related to this interesting hybrid behaviors.

SOE 10.3 Tue 11:00 MA 001

How to quantify the strength of factors in a contagion phenomena? — Fakhteh Ghanbarnejad, Martin Gerlach, Jose M. Miotto, and •Eduardo G. Altmann — Max Planck Institute for the Physics of Complex Systems, Dresden

Different factors contribute to the spreading of a process through a population. For instance, the adoption of an innovation may depend on factors such as peer pressure, agent specific believes, and the intrinsic fitness of the innovation. In this talk we (i) introduce a measure of the contribution of a factor to the overall spreading; (ii) show how this measure depends on the spreading dynamics (e.g., Bass or Threshold) and network topology; and (iii) propose methods to estimate the strength of factors from data.

[1] F. Ghanbarnejad, M. Gerlach, J. M. Miotto, and E. G. Altmann, "Extracting information from S-curves of language change", J. R. Soc. Interface 11, 20141044 (2014)

SOE 10.4 Tue 11:15 MA 001

Competitive percolation: How cooperation can strengthen competitors — li chen[1,2] and •dirk brockmann[1,2] — [1]Robert-Koch Institute, Berlin, Germany — [2]Humboldt University, Berlin, Germany

Competition and cooperation are ubiquitous in natural and social systems. Typically, both concepts are considered as antagonistic and mutually exclusive dynamic forces that typically enter systems as independent degrees of freedom with opposite signs. Direct interactions of both concepts, e.g. the benefit of cooperation among competitors and vice versa, is less well understood. Here we investigate a network system, in which two choices initially compete with for individual agents in a susceptible population. Cooperation enters the system by enhanced recruitment in a secondary contagion process for those individuals that recovered from the first reaction. A mean-field analysis supplemented with agent-based simulations shows that these systems can exhibit a discontinuous transition for the contagion process for strong cooperativity. We also show that one "infection" only survives in the presence of the other. Our model can shed light on the dynamics of systems in socio-economic contexts, sports and stability of fashion traits.

SOE 10.5 Tue 11:30 MA 001

The good, the bad and the optimal: allocation of resources during emergent infectious diseases — •Olga Baranov[1] and

Dirk Brockmann[1,2] — [1]Robert Koch Institut, Berlin — [2]HU Berlin

The growing complexity of global mobility is a key challenge for the understanding of the worldwide spread of emergent infectious diseases and the design of effective containment strategies. Despite global connectivity, containment policies are based on national, regional and 'egocentric' assessments of outbreak situations that are no longer effective or meaningful in the development of efficient containment strategies. This was recently demonstrated by 2014 Ebola outbreak in West Africa where months passed before a concerted effort followed. Despite the importance of the matter, optimal strategies are poorly understood. We investigate a model for the optimal deployment of mitigation resources in a network of interacting countries. Each node can exercise a limited amount of resources among all nodes in the network to mitigate an outbreak. At each node costs are a combination of invested resources and effective susceptibility to import a disease. We treat the problem game theoretically and show that, contrary to common belief, purely selfish and cooperative actions do not differ considerably in a single outbreak scenario. Purely selfish behavior tends to invest resources at the outbreak location. However, in a scenario with multiple outbreak locations we find that resource allocation can follow more complex patterns and nodes can fall back on egocentric resource allocations. We will report on preliminary results obtained for a system when disease dynamics and resource allocation are modelled explicitly.

Topical Talk SOE 10.6 Tue 11:45 MA 001

Containing epidemics using limited resources and information — •Olivia Woolley-Meza — Computational Social Science, ETH Zurich, Clausiusstrasse 37, CLD C6

Every action taken to contain disease spread carries a potential payoff but also a cost. Can we successfully contain epidemic spreading when resources are limited, and decisions on how to allocate these resources are based on imperfect information? I will discuss two cases where the interaction of economic constraints with disease spread transforms the spreading dynamics, usually making it harder to contain the disease. However, I will show that some constraints can work to our advantage. I first consider the dynamics of an epidemic when the recovery of sick individuals depends on the availability of healing resources that are generated by the healthy population. Epidemics spiral out of control into "explosive" spread if the cost of recovery is above a critical cost. The transition to this explosive regime is discontinuous – once there are signs of a transition it can no longer be prevented. In the second case I will show you how the information resolution available to individuals determines the effectiveness of voluntary vaccination decisions. Although an epidemic cannot be contained when individuals use global information, the successful eradication of a disease can occur in an intermediate region of information resolution between the local and the global.

SOE 10.7 Tue 12:15 MA 001

Virus transmission on a network of injecting drug users — •Cornelia Metzig and Peter White — Department of Infectious Disease Epidemiology, Imperial Collge London, UK

The Hepatitis C virus (HCV) is a virus that is most prevalent among injecting drug users, who transmit the virus by sharing their injecting equipment, a problem that receives much attention from healthcare providers. Several studies investigate the topology of drug injecting partners via snowball sampling methods with the goal of describing a static network. Typical networks are reported to be highy clustered, assortive and heavy-tailed in degree distribution. Transmission dynamics of the virus can be described by SIR or SIS-models, depending whether treatment is considered.

In addition, virus transmission is affected by (i) change in sharing partners, and (ii) entry and exit from the community, which happen at shorter timescales than the duration of an untreated infection is. These phenomena can be captured in a network model where each connection describes only one sharing event. Simultaneous rewiring of the network and transmission are studied theoretically and numerically in a model. Assumptions on the network, HCV-incidence rate and HCV-prevalence are compared to data on drug users from the UK.

SOE 10.8 Tue 12:30 MA 001

Spatio-temporal dynamics of the cholera epidemic of 1831/1832 in Austria — •Michael Leitner[1] and Gero Vogl[2] — [1]Heinz Maier-Leibnitz Zentrum (MLZ), Technische Universität München, Lichtenbergstr. 1, 85748 Garching, Germany — [2]Fakultät für Physik, Universität Wien, Boltzmanngasse 5, 1090 Wien, Austria

Caused by large-scale troop movements in the Russian empire, cholera reached Europe in 1830 and caused the first cholera pandemic to affect the western world. Within the confined region of Weinviertel in Lower Austria (approx. 5000 km^2), first cases were registered in 1831, while major outbreaks followed in the summer months of 1832. We reconstructed the dynamics of the disease from the causes of death in the clerical burial records on the temporal scale of single days and spatial scale of single villages. We analyze the data in terms of connectivity, both concerning geographical distance and bodies of flowing water. In contrast to analyzes of recent epidemics, we hope to obtain finer-resolution information on the dynamics due to the lower human mobility in past times.

SOE 10.9 Tue 12:45 MA 001

Containment of contagious processes on temporal networks via adaptive edge rewiring — •Vitaly Belik[1,2], Florian Fiebig[1], and Philipp Hövel[1] — [1]Institut für Theoretische Physik, TU Berlin — [2]Helmholtz-Zentrum für Infektionsforschung, Braunschweig

We consider a recurrent contagious process spreading on a time-varying network topology. As a containment measure we propose an adaptive rewiring mechanism: after detection of the disease, to temporary isolate infected nodes, rewiring the incoming edges away from those nodes. As a case study we use the network of animal trade in Germany. One of the main results reveals heterogeneous performance of adaptation in respect to different index nodes (where epidemic initially started): some index nodes lead to easily controllable epidemics and some not. Our findings are important for designing response strategies for infectious diseases management.

SOE 10.10 Tue 13:00 MA 001

Spread of Infections on Temporal Networks — •Andreas Koher, Lucian Willareth, Hartmut Lenz, and Igor M. Sokolov — Humboldt University, Berlin

Social interactions can be naturally abstracted to temporal networks, where bonds appear as long as the corresponding contacts exist. In epidemiological studies the temporal dimension is usually projected out however, in order to apply the standard tools from (static) network analyses even though, a systematic error will be introduced thereby. We present an intuitive algebraic formalism by contrast, which is explicitly based on temporal networks and which allows to calculate potential paths of an infection. By applying the idea to a SIR (susceptible-infected-recovered) type of disease, we will present an elegant way to find all possibly affected nodes of an outbreak. The method can be efficiently implemented and will be demonstrated on a recorded data set.

SOE 11: Evolutionary Game Theory II (joint session BP / SOE / DY)

Time: Tuesday 14:00–16:15 Location: MA 001

SOE 11.1 Tue 14:00 MA 001

Frequency-Dependent Selection at Rough Expanding Fronts — •Jan-Timm Kuhr and Holger Stark — Institut für Theoretische Physik, Technische Universität Berlin

Microbial colonies are a formidable model system to study longstanding questions of population dynamics, ecology, and evolutionary dynamics. Growth on surfaces naturally allows to observe range expansions, where microbes colonize new territory. The small number of reproducing individuals introduces strong demoscopic fluctuations, which interact with mutation and selection at the front.

We use generalized Eden models to explore statistical properties of multi-species range expansions, where the front's geometry and evolutionary dynamics couple to each other. In earlier work we found that irreversible mutations entail a new type of non-equilibrium phase transition accompanied by enhanced surface roughening [1].

If reproduction rates depend on local species composition, we distinguish a variety of patterns. Focusing on social dilemmas, we obtain new exponents for both kinetic roughening and the transition between global defection vs. global cooperation. This is also reflected in the dynamics of single species domains which at large times show enhanced fluctuation statistics.

[1] J.-T. Kuhr, M. Leisner, and E. Frey, New J. Phys. **13**, 113013 (2011).

SOE 11.2 Tue 14:15 MA 001

Evolutionary Fitness in Variable Environments — •Anna Melbinger and Massimo Vergassola — University of California San Diego

One essential ingredient of evolutionary theory is the concept of fitness as a measure for a species' success in its living conditions. Here, we quantify the effect of environmental fluctuations onto fitness by analytical calculations on a general evolutionary model and by studying corresponding individual-based microscopic models. We demonstrate that not only larger growth rates and viabilities, but also reduced sensitivity to environmental variability substantially increases the fitness. Even for neutral evolution, variability in the growth rates plays the crucial role of strongly reducing the expected fixation times. Thereby, environmental fluctuations constitute a mechanism to account for the effective population sizes inferred from genetic data that often are much smaller than expected.

SOE 11.3 Tue 14:30 MA 001

Non-selective evolution of growing populations — •Karl Wienand[1], Matthias Lechner[1], Felix Becker[2], Heinrich Jung[2], and Erwin Frey[1] — [1]Arnold Sommerfeld Center for Theoretical Physics, Ludwig-Maximilians Universität, Munich, Germany — [2]Biozentrum, Ludwig-Maximilians Universität, Munich, Germany

Evolution results from the interplay between directed selection and non-selective effects. Most theoretical analyses of non-selective evolution rely on constant population sizes and result in some trait taking over the entire population. However, bacterial populations both in nature and in the laboratory are often observed during their exponential growth. In this work we show that, during growth, populations "freeze" to a random steady state composition. To show this, we employed theoretical models based on Pólya urns and performed experiments on two *Pseudomonas putida* strains in non-selective conditions. We found excellent agreement between experiments and theory. We were also able to elucidate the importance of initial conditions on the steady state distribution on population compositions. In particular, the initial size of the populations can tune the relative importance of initial assortment and growth as noise sources for the final distribution.

SOE 11.4 Tue 14:45 MA 001

Counterintuitive findings for evolution on networks — •Laura Hindersin and Arne Traulsen — Max Planck Institute for Evolutionary Biology, Plön, Germany

How does spatial population structure affect the fixation time of a novel mutation?

In the framework of evolutionary graph theory, individuals inhabit the nodes of a network. We study the Moran birth-death process, where reproduction happens with probability proportional to fitness. The links of a node determine which other individuals can be replaced by the offspring of that individual.

Intuitively, one might assume that adding a link to a given network would always decrease fixation time. However, a simple counterexample disproves this intuition. We show analytically for small networks, that adding a link can increase the fixation time. Simulating the stochastic process on larger lattices, we find a similar result. By adding links to a 2D-lattice without boundary conditions, the fixation time can increase as well. This shows the validity of our counterintuitive result even for larger populations.

[1] Hindersin L, Traulsen A. 2014 Counterintuitive properties of the fixation time in network-structured populations. J. R. Soc. Interface 11: 20140606. http://dx.doi.org/10.1098/rsif.2014.0606

SOE 11.5 Tue 15:00 MA 001

The Cost and Dynamics of Competence in *Bacillus subtilis* — •Jeffrey Power, Melih Yüksel, and Berenike Maier — Universität zu Köln, Cologne, Germany

When bacterial cells deplete all of the nutrients in their environment, they can enter a stationary growth phase. In *Bacillus subtilis*, the stationary phase is of particular interest as a fraction of a culture in the stationary phase will stochastically switch into a competent state, where cells can take up extracellular DNA. Competence presents the opportunity for the acquisition and implementation of new genes, but at the cost of a reduced growth rate.

To better understand the advantage of stochastic switching, stationary phase competition assays were carried out competing strains with various fractions of competent cells against the wild type. Flow cytometry was used to monitor changes in the mixed populations over time, and fitness advantages were quantified by means of selection coefficients. We found selection coefficients of s = 0.04(1) for the non-competent *comK* strain and s = -0.07(1) for the hypercompetent *rok* strain, indicating that competence development has a large cost.

This work is a fundamental start to better understanding the dynamics of the stationary phase and the evolutionary advantage of stochastically switching a population subset into a competent state.

SOE 11.6 Tue 15:15 MA 001

A Two-Player Game with Linear State-Dependent Payoff Function — •Tim Herrmann[1], Mark Kirstein[2], and Katharina Fischer[3] — [1]TU Dresden — [2]TU Dresden, Chair of Managerial Economics — [3]TU Dresden, Institut für mathematische Stochastik

In classic game theory all elements of a game (set of players, set of strategies, payoff function) are static. In contrary, real-world strategic interactions are often characterized by changes of at least one of the three elements of a game over time. In our model a game with state-dependent payoff functions is analysed. The payoff function of the $(n+1)$-st round depends linearly on the payoff of the n-th round. Thereby the structure of the game can change, e.g. from prisoner's dilemma structure to a structure, where individual rationality coincides with collective rationality. Therefore, the concepts of short-term and long-term rationality are defined. It is shown for our game with a state-dependent payoff function, that the following criteria of long-term rationality are equivalent (besides a few special cases): Pareto optimality, collective rationality and the Nash equilibrium in recursive dominant strategies. For symmetric payoff functions these three criteria of (individual and collective) long-term rationality are additionally equivalent to the collective short-term rationality. The concept of ESS is refined to absolute ESS (ESSA) and relative ESS (ESSR). It is shown that ESSA-tuples are equivalent to the above mentioned criteria for symmetric payoff functions and long-term rationality.

SOE 11.7 Tue 15:30 MA 001

Evolutionary Coalitional Games — •Tadeusz Płatkowski — Faculty of Mathematics, Informatics, and Mechanics \\ University of Warsaw, Warsaw, Poland

We introduce the concept of evolutionary coalitional games played in a large population. The members of the population play a strategy chosen from a finite set, and interact in randomly formed coalitions. The interactions are described by a multiplayer strategic game. Each coalition generates a total utility, identified with the value of the coalition, and equal to the sum of the payoffs of its all members from the multiplayer game. The total utility is distributed among the coalition

members, proportionally to their Shapley values. Evolution of the whole population is governed by the replicator equations. Polymorphic stationary states of the population are studied for various types of the multiplayer social dilemma games. It is argued that application of coalitional game theory solution concepts to social dilemma models of evolutionary game theory can foster cooperation in the long run.

SOE 11.8 Tue 15:45 MA 001

Evolutionary games of condensates in coupled birth-death processes — •Johannes Knebel, Markus F. Weber, Torben Krüger, and Erwin Frey — Ludwig-Maximilians-Universität, München, Deutschland

Condensation phenomena occur in many systems, both in classical and quantum mechanical contexts. Typically, the entities that constitute a system collectively concentrate in one or multiple states during condensation. For example, particular strategies are selected in zero-sum games, which are generalizations of the children's game Rock-Paper-Scissors. These winning strategies can be identified with condensates.

In our work, we apply the theory of evolutionary zero-sum games to explain condensation in bosonic systems when quantum coherence is negligible. Only recently has it been shown that a driven-dissipative gas of bosons may condense not only into a single, but also into multiple non-degenerate states. This phenomenon may occur when a system of non-interacting bosons is weakly coupled to a reservoir and is driven by an external time-periodic force (Floquet system). On a mathematical level, this condensation is described by the same coupled birth-death processes that govern the dynamics of evolutionary zero-sum games. We illuminate the physical principles underlying the condensation and find that the vanishing of relative entropy production determines the condensates. Condensation proceeds exponentially fast, but the system of condensates never comes to rest: The occupation numbers of condensates oscillate, which we demonstrate for a Rock-Paper-Scissors game of condensates.

SOE 11.9 Tue 16:00 MA 001

Length selection and replication in a thermal flow chamber — •Simon A. Lanzmich[1], Lorenz M. R. Keil[1], Moritz Kreysing[2], and Dieter Braun[1] — [1]Systems Biophysics, LMU Munich, Germany — [2]MPI of Molecular Cell Biology and Genetics, Dresden, Germany

The replication of long nucleic acids is central to life. On the early Earth, suitable non-equilibrium boundary conditions were required to surmount the effects of thermodynamic equilibrium such as dilution and degradation of oligonucleotides. One particularly intractable experimental finding is that short genetic polymers replicate faster and outcompete longer ones, leading to ever shorter sequences and the loss of genetic information. We show in theory and experiment that heat flux across an open chamber in submerged rock concentrates replicating oligonucleotides from a constant feeding flow and selects for longer strands. The thermal gradient triggers a complex interplay of molecular thermophoresis, external flow and laminar convection, where the latter drives strand separation and exponential replication. The measurements are understood quantitatively based on the calculation of stochastic trajectories inside the chamber using a two-dimensional random walk model. This allowed to derive lifetimes and thermal oscillation frequencies of the nucleic acids. In an intermediate range of external velocities, the superposition of flow fields retains strands of 75 bases, while strands half as long die out, inverting above dilemma of the survival of the shortest. The combined feeding, thermal cycling and positive length selection opens the door for stable molecular evolution in the long-term micro-habitat of asymmetrically heated porous rock.

SOE 12: Physics of Sustainability and Human-Nature Interactions (Symposium SYPS)

Time: Wednesday 9:30–12:15 Location: H 0105

Invited Talk SOE 12.1 Wed 9:30 H 0105

Anticipating and avoiding tipping points — •Timothy M. Lenton — University of Exeter, Exeter, UK

A 'tipping point' occurs when a small change in forcing triggers a strongly non-linear response in the internal dynamics of a system, qualitatively changing its future state. Large-scale 'tipping elements' have been identified in the Earth's climate system that may pass a tipping point under human-induced global change this century. At the smaller scale of ecosystems, some tipping points have already been observed, and more are anticipated in future. Our capacity to forecast such abrupt, non-linear changes has historically been poor. However, much excitement has recently been generated by the theory that some approaching tipping points carry generic early warning signals. I will critically examine the prospects for gaining early warning of approaching tipping points. Promising methods are based on detecting 'critical slowing down' in the rate a system recovers from small perturbations, and on accompanying changes in the statistical distribution of its behaviour. I will show examples of early warning signals in paleo-data approaching past abrupt climate changes, and in models being gradually forced past tipping points. I will also consider the conditions under which the methods fail. Finally, I will discuss how we might respond to early warning to try and avoid tipping points, especially in the climate system.

Invited Talk SOE 12.2 Wed 10:00 H 0105

Climate investment under uncertainty: the two degree target and the desire for dynamic consistency — •Hermann Held and Delf Neubersch — Center of Earth System Research and Sustainability, University of Hamburg, Grindelberg 5, 20144 Hamburg

During the climate Conferences of the Parties 2009-2011 the global community developed a formal consensus to limit the anthropogenically induced increase of global mean temperature to 2K ("two-degree targe" or "2°-target"). While the latest IPCC (Intergovernmental Panel on Climate Change) report (2014) summarizes cost estimates that can be interpreted as rather low, suggesting some potential political feasibility of the 2°-target, some authors start to question the conceptual validity of the 2°-target: it might be too late to still comply with it, given the slow pace of mitigation policy. Moreover, it is pointed out that a strictly interpreted temperature target does not have a straightforward generalization when uncertainty is internalized in decision-making under anticipated future learning.

Here we present a generalization of the 2°-target that addresses both of these problematic aspects and that respects dynamic consistency under anticipated future learning. Consequences for climate policy are highlighted. We find that previous climate economic analyses of the 2K-target in terms of low cost for transforming the energy system are still valid, when being re-interpreted. Moreover, mitigation costs could be reduced by up to 1/3 if the climate response to greenhouse gas forcing were known with certainty, pointing to the expected economic value of geo-scientific information.

Invited Talk SOE 12.3 Wed 10:30 H 0105

What are the resources required to fulfil human needs? — •Julia Steinberger — Sustainability Research Institute, University of Leeds, UK

All human societies require environmental resources, in the form of energy and materials, to survive and flourish. However, the exact level of resource requirements may be difficult to estimate, since it can depend on many factors. These factors include: local biophysical conditions, such as climate or available crops for food; technological options and efficiencies for delivering key services; but also socio-economic parameters, including consumption levels and inequality in distribution. This talk will present recent advances in the international study of energy requirements for human needs. These results demonstrate that high levels of human wellbeing are attainable at moderate as well as very high energy use, and that the average level of energy use required to achieve high human wellbeing is declining over time. Moreover, it can be shown that energy itself does not play a dominant role in explaining the considerable advances in human wellbeing over the past half century. An agenda for analysing the resource requirements to fulfil universal basic human needs will then be presented. This agenda must take into account socio-economic as well as technological choices, since fulfilling human needs at low levels of resource use most likely requires a re-organisation and re-orientation of many socio-economic activities.

15 min. break

Invited Talk SOE 12.4 Wed 11:15 H 0105

Design of Sustainable Supply Chains for Sustainable Cities — •Anna Nagurney — Isenberg School of Management, University of Massachusetts Amherst

Supply chains provide the critical infrastructure for the production and distribution of goods and services in our Network Economy and serve as the conduits for the manufacturing, transportation, and consumption of products ranging from food, clothing, automobiles, and high technology products, to even healthcare products. Cities as major population centers serve not only as the principal demand points but also as the locations of many of the distribution and storage facilities, transportation providers, and even manufacturers. The sustainability of supply chains is, hence, a precursor to the sustainability of our cities.

In this presentation, we discuss a plethora of relevant supply chain networks for cities from food to energy ones. We provide the foundations of the methodologies in terms of variational inequality theory and projected dynamical systems theory and describe both an optimization model for sustainable supply chain network design as well as a game theory one with multiple decision-makers and frequencies of the network economic activities.

Invited Talk SOE 12.5 Wed 11:45 H 0105

Ecological econophysics for degrowth — •Salvador Pueyo — Dept. d'Ecologia, Universitat de Barcelona, Barcelona, Catalonia, Spain — Research & Degrowth, Barcelona, Catalonia, Spain

Climate change, resource scarcity and ecosystem degradation suggest that we have already overshot the sustainable level of economic throughput. One of the greatest challenges of our time is to move from a growth-based economy to a socially benign degrowth. The obstacles ahead are not only political and cultural but also technical: How to transform the economic system in depth without undesired emergent properties or loss of its basic functionality? How to shrink the economy without triggering uncontrolled recessions? How to effectively increase equality to compensate for a decreasing average consumption? Several of the involved features are best expressed as frequency distributions (of recession sizes, of individual income or resource consumption), thus demanding the kind of approach used in statistical physics, which links distributions to mechanisms. This econophysical approach should be combined with that of ecological economics, which treats the economy as a subsystem of the biosphere instead of an autonomous system. Researchers in econophysics or complexity economics are in a unique position to move beyond more mundane goals and apply their knowledge to help changing the system in favor of sustainability, equality and democracy while we still have the opportunity.

SOE 13: Opinion Formation, Segregation, and Language Dynamics

Time: Wednesday 15:00–16:30 Location: MA 001

SOE 13.1 Wed 15:00 MA 001

Data-driven modeling in continuous opinion dynamics — •Jan Lorenz[1] and Thomas Metz[2] — [1]Jacobs University Bremen, Germany — [2]Albert-Ludwigs-Universität Freiburg, Germany

Models of continuous opinion dynamics as the bounded confidence model or related models with continuous opinions show interesting transitions and bifurcation patterns regarding their stable opinion distributions. The consensus transition which divides stable consensus from stable bipolarization at a critical bound of confidence is of course an interesting phenomena with analogies to real-world phenomena, but full consensus (polarization) on one (two) single point(s) in a continuum is probably not a state reached very often in groups and societies. A major model improvement overcoming this unrealistic convergence was the introduction of noise in the sense that agents sometimes start from scratch with a new random opinion. Nevertheless, all these models of continuous opinion dynamics models have rarely been compared with opinion landscapes from real-world processes of opinion dynamics. We present results from data-driven modeling of continuous opinion dynamics which start with the identification of stylized facts of opinion landscapes from large scale representative surveys and panels. Opinion landscapes indeed often show some clustering which bounded confidence models are able to produce, but the models typically do not reproduce the structure of real-world clustering patterns. We present simple modeling ideas which could bring models and data closer together.

SOE 13.2 Wed 15:15 MA 001

Flow-networks methods: applications to opinion dynamics — •Liubov Tupikina and Jürgen Kurths — Potsdam Institute for Climate Impact Research, P.O. Box 601203, 14412 Potsdam, Germany

Networks were successfully applied to describe complex systems, such as, brain, climate, processes in society. Recently a socio-physical problem of opinion-dynamics was studied using network techniques. We present the toy-model of opinion-formation based on the physical model of advection-diffusion. We assume that the opinion of each person (state of the node in network) in society is binary, i.e. can be only 0 or 1. Opinion can be spread from one person to another if they know each other, or in the network-terminology, if they are connected. The assumptions for the model can be formulated as the following: -the node-states are influenced by the network structure in such a way, that opinion can be spread only between adjacent nodes (the advective term of the opinion-dynamics), -the network structure can have two scenarios: network topology is not changing with time; additional links can appear or disappear with fixed probability (elements of the adaptive networks theory). Considering these assumptions for our opinion spreading model and applying them to the advection-diffusion system we obtain the description of our model as the system. We investigate the behaviour of the suggested model. We study the "waiting time" of the system to get to the stable state and the stability of the model regimes for different extreme values of the model parameters.

SOE 13.3 Wed 15:30 MA 001

Random allocation policies in segregative dynamics — •Julien Randon-Furling[1] and Aurélien Hazan[2] — [1]SAMM - Université Paris-1 Panthéon-Sorbonne, Paris, France — [2]LISSI - Université Paris-Est Créteil, Lieusaint, France

Schelling-type multi-agent systems in which a fraction f of spatially-fixed agents are able to switch groups were recently introduced (see eg EPJB 86:421). We present some of their properties together with new results derived from their application, focusing on:

(i) their ability to exhibit more complex patterns of group segregation and mixing than standard Schelling-type systems;

(ii) the benefits of random, non-preferential allocation policies (eg by housing associations) — a type of policies for the investigation of which the new model was designed;

(iii) comparisons with data from social housing and mixity within the twenty "Arrondissements" of central Paris.

SOE 13.4 Wed 15:45 MA 001

Zoonivers; Crowd-sourced science — •Taha Yasseri — University of Oxford, Oxford, UK

In this work we will investigate uses of the Zooniverse, by far the most successful citizen science project with nearly 900,000 users contributing to 20+ projects, which have led to more than 60 scientific papers across the sciences and humanities during its 4 year history. However, its community of volunteers, the features and characteristics of their contribution patterns, their motivations and objectives, the ways that they satisfy them through different types of contributions, and many other social aspects of it are still unknown. We study the transactional records of the users' activities in order to create an accurate picture of the community of contributors. By performing numerical analyses on the activity logs we produce a typology of users based on temporal features of their activity. We perform time series analysis to extract the modes of contribution and its dynamic characteristics. This will help us understand the incentives for and participation patterns on the Zooniverse and could help directly design a more efficient contribution platform and enhance engagement on the Zooniverse, as well as in other Citizen Science projects.

SOE 13.5 Wed 16:00 MA 001

Universality and Variation in Language — •Martin Gerlach and Eduardo G. Altmann — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

Natural language is a remarkable example of complex dynamical sys-

tems which combines variation and universal structure. This combination can be studied in detail looking at the statistical analysis of word frequencies in written texts. On the one hand, there are universal laws (e.g., Zipf's and Heaps' laws) which are extremely robust with respect to language, topic, and time. On the other hand, all languages are constantly changing and word frequencies show a strong variation across time and topics. Starting from large records of written texts we investigate the statistical and dynamical processes underlying the co-existence of variation and universality in word statistics. Our findings find applications in problems of information retrieval and language change (e.g., the adoption of new words).

[1] M. Gerlach and E. G. Altmann, "Scaling laws and fluctuations in the statistics of word frequencies", New J. Physics 15, 113010 (2014)
[2] F. Ghanbarnejad, M. Gerlach, J. M. Miotto, and E. G. Altmann, "Extracting information from S-curves of language change", J. R. Soc. Interface 11, 20141044 (2014)
[3] M. Gerlach and E. G. Altmann, "Stochastic model for the vocabulary growth in natural languages", Phys. Rev. X 3, 021006 (2013)

SOE 13.6 Wed 16:15 MA 001

On the failure of nations — •Hermann Rampacher — Seehaldenstraße 10 88662 Überlingen

To avoid a nation's failure the collective cooperation must be optimized. To measure the actual Level of cooperation first a set ofnorms {n(k)} must be investigated, where every n(k) prohibits an interaction i(k)tied to one of the largest risksfor the planet' survival. The ideal cooperation worldwide woulb be achieved if and wheb all the n(k) are obeyed. In the real world subsets of {n(k)} are violated. Secondly those probabilities p(k' will be investigatedbelonging to those n(k')which are violated. The more People suffering from violence - including killing and imprisonment of the state - the larger is the social temperature t. The more rapidly the t will increase, the larger the risk of a nation' failure. Violation of n(k') causes a damage s(k').The expectation value of s(k') equals perdefinition the rank r(k') of r(k') and n(k'). Now the expectation value ofa nation's actual cooperation is inlinear Approximation the sum of all p(k#)x n(k'). Every violation of n(k') activates until now latent correlation among both the i(k') and the n(k'). This leads to the violation of additional n(k"), a process like an epidemic or or pandemic.

SOE 14: Fluctuating Electricity Supply: Modelling of Generation, Backup and Storage (joint session AKE / DY / SOE)

Time: Wednesday 15:00–16:30 Location: A 151

Invited Talk SOE 14.1 Wed 15:00 A 151

Fluctuations from photovoltaic and wind power systems — •Detlev Heinemann[1], Gerald Lohmann[1], Mohammed Reza Rahimi Tabar[2], and Mehrnaz Anvari[2] — [1]Universität Oldenburg, Institut für Physik, AG Energiemeteorologie & ForWind — [2]Universität Oldenburg, Institut für Physik, AG TWiSt & ForWind

Solar and wind resources vary considerably in time and space, and changes in their magnitude are almost immediately translated into output power variations of wind and solar power plants. Analyzing the stochastic properties of wind and solar resources in different temporal and spatial scales is therefore a necessary step towards a proper representation of these contributions to large scale power systems.

This presentation describes known stochastic properties of wind and solar resources as well as reports on current studies of (i) their conditional probability distribution functions in different time lags and (ii) increment statistics of large-scale wind and solar production.

Conditional distribution functions show severe deviations from Gaussian statistics and possess positive skewness, while the risk of flickering events in both wind and solar generally increases with parameters as wind speed and solar elevation, respectively. Spatial averaging significantly influences this behavior. The comparison of wind and solar power fluctuations is strongly affected by the presence of a deterministic contribution in the solar part. Applying a detrending approach for the solar data results in an significant improvement of the solar increment statistics.

SOE 14.2 Wed 15:30 A 151

Facing Europe: Revised wind power upscaling algorithms — •Bruno Schyska, Lüder von Bremen, and Alexander Kies — University Oldenburg - ForWind, Oldenburg, Germany

In the wind energy sector, upscaling models are used to estimate the total wind energy production within a certain region from a small number of reference sites. Each reference site is considered to be representative for a certain sub-region. Upscaling models therefore include selection schemes for the reference sites as well as statistical, partly non-linear, models to estimate the energy production in the sub-regions. Until now, upscaling models are mainly used on country level. For larger areas such as Europe no operational model and no research model exist.

In this study, revised upscaling models for the estimation of near real-time wind energy production in Europe are presented. These models include different approaches for the estimation of the energy production in the sub-regions as well as different selection schemes for the reference sites using cluster analyses. Cluster analyses are based on wind speed data from the MERRA reanalysis data set as well as on the geographical distribution of installed wind energy capacities in Europe. From the comparison, the selection scheme, which requires the minimal number of reference sites, is selected for long-term investigations of the wind energy production in Europe.

SOE 14.3 Wed 15:45 A 151

Backup flexibility classes in complex renewable energy networks — •David Schlachtberger[1], Sarah Becker[1], Stefan Schramm[1], and Martin Greiner[2] — [1]Frankfurt Institute for Advanced Studies, Uni Frankfurt, Frankfurt am Main, Germany — [2]Department of Engineering, Aarhus University, Aarhus, Denmark

How large will be the demand for more flexible backup plants in an European power system with an increasing share of fluctuating renewable energies? We use eight years of high resolution weather-based wind and solar power generation data to split the backup systems required to cover the residual load into three flexibility classes for daily, weekly, and seasonal time-scales. They are distinguished by the maximum rates of change of their power output. We find that a large fraction of seasonally and weekly flexible backup systems can no longer be reasonably integrated above a penetration of renewables of around 50% and 90% of the mean load, respectively. We also find that the total required backup capacity can only be reduced if countries share their excess generation and backup power.

SOE 14.4 Wed 16:00 A 151

Dimensioning the Minimal Storage Needs in Renewable Power Systems — •Stefan Weitemeyer, David Kleinhans, and Carsten Agert — NEXT ENERGY · EWE Research Centre for Energy Technology at the University of Oldenburg, Germany

Integrating a high share of electricity from non-dispatchable Renewable Energy Sources (RES) in a power supply system is a challenging task; it will likely require large-scale installations of costly storage capacities.

We present a modelling approach to investigate which storage characteristics are most adequate for scenarios with high shares of RES. Adapted from an optimization approach, the model allows to systematically study the influence of important storage parameters (size, efficiency, power) on the integration of RES. In particular, the implications of simultaneously using multiple storage classes in combination with fossil back-up power plants can be investigated.

Applying our model to data for Germany, our simulations show how an extensive integration of RES requires different storage characteristics during different phases of the pathway towards a 100% RES scenario. The results also imply that a balance between installing storage capacities and additional generation capacities is required.

SOE 14.5 Wed 16:15 A 151

The temporal development of storage needs in the European energy transition — •Alexander Kies, Lüder von Bremen, and Bruno Schyska — ForWind, Universität Oldenburg, Oldenburg

Europe is on the way towards a highly renewable energy system. In

2012 23.5% of the gross electricity consumption in the EU-28 was produced from renewable sources. This share is expected to increase further up to very high penetration levels close to 100% in the next decades. To ensure reliability and stability of the power system several solutions to the generation-load-mismatch problem have been proposed like over-installation of renewables, transmission capacity extensions and the use of storages. In this work we investigate the development of storage needs in 34 European countries for different transmission grid scenarios until 2050. A large weather data set with a spatial resolution of 7 x 7 km and a hourly temporal resolution covering Europe is used to model the fluctuating feed-in from the renewables, i.e. wind, photovoltaics, hydro, concentrated solar power and wave. Additionally the controllable renewable generation types biomass and geothermal were considered. Starting from the renewable shares in the year 2012 we model the increase in renewable capacities in a linear and a logistic way until levels of 100% in 2050 for different transmission grid scenarios and calculate the storage needs for every year. The remaining generation shares to cover the load are assumed to come from conventional generation. We show that storage needs are unlikely to grow rapidly until 2030, but thereafter are of high importance. However, this process can be slowed down considerably by transmission grid extensions.

SOE 15: Physics of Sustainability and Human-Nature Interactions I (joint with DY, jDPG, BP, AKE) - session accompanying the sympoisum SYPS

Time: Wednesday 16:45–18:30 Location: MA 001

Topical Talk SOE 15.1 Wed 16:45 MA 001

The Industrial Society's natural Sustainability — •Hans G. Danielmeyer and Thomas Martinetz — Institut für Neuro- und Bioinformatik, Uni Lübeck

Human nature and industrial engineering form a predictable macrosystem with six S-functional variables and biologically stabilized parameters [1]. S-functions display storing lifetimes with time shifts like Sinus functions with phase shifts. Since 18th century UK the real GDP per capita increased 100-fold; only a factor of 2.7 yields for the G7 the biologic limit of 118 years for the life expectancy.

This is orders of magnitude below all earlier predictions. The industrial society will be materially sustainable. But the present financial system is unsustainable because saturating growth and interest rates dry out saving, life insurances, and pension funds. This caused the Great Depression and the crash of 2008, not neoclassical excuses [2]. The only cure is bringing finance in line with human biology: return to the sustainable income distribution between Word War II and 1980; increase retirement age; continue innovation; and defend the G7 position globally. Believing in the Neoclassical Paradigm of exponential growth is already Chinas problem because it wastes resources with unsustainable investments.

[1] H. G. Danielmeyer and T. Martinetz, An exact theory of the industrial evolution and national recovery, www.inb.uni-luebeck.de, 2009 pdf. [2] C. Teuling and R.Baldwin, Secular Stagnation: Facts, Causes and Cures, CEPR London 2014, www.voxeu.org/sites/default/files/Vox_secular_stagnation.pdf

SOE 15.2 Wed 17:15 MA 001

The decoupling of CO2 emissions and human development — Kai Kornhuber[1], Dominik Reusser[1], •Luis Costa[1], Jürgen Kropp[1,2], Rybski Diego[1], and Schellnhuber Joachim[1,3] — [1]Potsdam Institute for Climate Impact Research, Potsdam, Germany — [2]University of Potsdam, Potsdam, Germany — [3]Santa Fé Institute

Evidence of a decoupling between greenhouse gas emission and socioeconomic development would benefit international climate negotiations in two ways. First, it would communicate to emerging countries that socioeconomic progress is not strictly connected with ever-growing emissions. Secondly, it informs developed economies on reduction targets that do not jeopardize progress. Using the Environmental Kuznets Curve as background and country-panel data between 1990 and 2013, a model was established to test postulated relationships between socioeconomic progress (measured using the Human Development Index (HDI)) and CO2 emissions from fossil fuels. An inverted U-curve with a time-dependent maximum moving towards higher HDI and lower per capita CO2 mission was established as the relationship delivering the lower fitting error. Extrapolating the global decoupling trend until 2050 returns global cumulative emissions of CO2 that are incompatible with meaningful with long-term climate protection targets. Individual countries presented remarkable differences in their decoupling dynamics. Further insights and implications of the analysis will be discussed, as well as future research needs.

SOE 15.3 Wed 17:30 MA 001

The size distribution, scaling properties and spatial organization of urban clusters: a global and regional perspective — •Till Fluschnik, Steffen Kriewald, Anselmo García Cantú Ros, Bin Zhou, Dominik Reusser, Jürgen Peter Kropp, and Diego Rybski — Potsdam Institute for Climate Impact Research (PIK)

Human development has far-reaching impacts on the surface of the globe. The transformation of natural land cover occurs in different forms and urban growth is one of the most eminent transformative processes. We analyze global land cover data and extract cities as defined by maximally connected urban clusters. The analysis of the city size distribution for all cities on the globe confirms Zipf's law. Moreover, by investigating the percolation properties of the clustering of urban areas we assess the closeness to criticality. We study the Zipf-exponents as a function of the closeness to percolation and find a systematic decrease with increasing scale, which could be the reason for deviating exponents reported in literature.

SOE 15.4 Wed 17:45 MA 001

Limits and opportunities of a regionalized food production for cities: A global analysis — •Steffen Kriewald, Anselmo García Cantú Ros, Till Sterzel, Prajal Pradhan, and Jürgen P. Kropp — Potsdam Institute for Climate Impact Research, Potsdam, Germany

The massive ongoing urbanisation in the 21st century is a major challenge for societies and therefore crucial developments towards a sustainable future will take place in cities. Together with many other issues a proper food supply is essential. Today, the necessary transport of food, especially the increasing transport by plane due to the global food supply chain, leads to a significant amount of greenhouse gas emissions. A reorganisation of cities in terms of their food allocation could save a considerable amount of emissions. We provide a global overview of the potential of peri-urban agriculture based on land-use, population, yield and dietary datasets. Our analysis indicates that up to 2 billion city dwellers can be fed by local grown products. However, Climate Change will drastically decrease the possibility of a local food supply for many regions.

SOE 15.5 Wed 18:00 MA 001

Food demand and supply under global change: need for sustainable agricultural intensification — •Prajal Pradhan[1], Dominik Reusser[1], Matthias Lüdeke[1], and Juergen Kropp[1,2] — [1]Potsdam Institute for Climate Impact Research, Potsdam — [2]University of Potsdam, Dept. of Geo- and Environmental Sciences, Potsdam

Global food demand is expected to increase by 60–110% between 2005 and 2050. Meeting growing food demand along with reducing agricultural environmental impacts is a global sustainability challenge. We investigated diet shifts, emissions, livestock feed, local food, and yield gaps to address this challenge. Globally, we identified sixteen dietary patterns. Diets common in developed world, exhibit higher emissions. Currently, 40% of global crops is fed to livestock. Two billions people are self-sufficient within 5′ grid, while 1 billion Asians and Africans require inter-continental trade. However, they can become self-sufficient by closing yield gaps. By 2050, the global agricultural emissions will approach 7–20 Gt $CO_{2eq.}$/yr and feed demand may increase up to 1.3 times. The number of trade dependent people will range 1.5–6 billion which may be further increased by 4–16% due to climate change. In future, diet shifts will significantly increase crop demand, emissions, and trade. These can be reduced by technological change, consuming local food, and closing yield gaps. Sustainability of inputs and

management required to close yield gaps depends on how options are chosen and implemented. Hence, a combination of sustainable intensification, expansion, trade and diet shifts is required to feed growing population.

SOE 15.6 Wed 18:15 MA 001

Sustainabilty for a Warming Planet — •Humberto Llavador[1,2], John Roemer[3], and Joaquim Silvestre[4] — [1]Universitat Pompeu Fabra (Barcelona) — [2]Barcelona GSE — [3]Yale University — [4]University of California, Davis

A clean biosphere is a resource in jeopardy due to man-made GHG emissions. What is the fair way to share this scarce global resource across present and future generations, and across regions of the world? This study proposes that the guiding ethics should be sustainability and egalitarianism. Sustainability is interpreted as a pattern of economic activity over time that sustains a given rate of growth of human welfare indefinitely; in doing so, the atmospheric concentration of carbon must be capped at some level not much higher than exists today.

Human welfare depends not only upon consumption, but also upon education, knowledge, and a clean biosphere. The analysis shows that we should be investing more in education and substantially more in knowledge creation than is currently the case.

International cooperation is vital in capping global greenhouse gas emissions at a sufficiently low level. We propose that solving the bargaining problem between developing and developed nations requires recognizing the relationship between economic growth and the climate problem. We propose that the dates at which developing countries converge in living standards to those of developed countries should not be altered by the agreement. This principle, along with sustainability, suffices to determine how emissions should be allocated across regions and time.

SOE 16: Annual Member's Assembly

Time: Wednesday 18:35–19:30 Location: MA 001

The assembly will be held subsequently to the last session. All members and guests of SOE sessions are welcome to provide feedback and suggestions. Announcements on related events can be made as well as suggestions for symposia and focus sessions on the next DPG conferences. After the assembly, there will be the possibility to join for dinner (details to be announced in the assembly).

SOE 17: Social Systems, Opinion and Group Dynamics

Time: Thursday 9:30–11:15 Location: MA 001

SOE 17.1 Thu 9:30 MA 001

Bag-of-calls analysis reveals group-specific vocal repertoire in long-finned pilot whales — •Sarah Hallerberg[1], Heike Vester[2], Kurt Hammerschmidt[3], and Marc Timme[1] — [1]Network Dynamics, Max Planck Institute for Dynamics and Self-Organization, 37077 Göttingen — [2]Ocean Sounds, Sauoya 01, 8312 Henningsvaer, Norway — [3]Cognitive Ethology Lab, German Primate Center, Kellnerweg 4, 37077 Göttingen

Besides humans, a large number of marine mammal species exhibit fundamental prerequisites to evolve language: cognitive abilities, flexibility in vocal production and advanced social interactions. Group specific communication is key to understanding potential vocal learning and thus vocal cultures. Here, we analyse the vocal repertoires and their group-specificity for long-finned pilot whales (Globicephalus melas) recorded in Northern Norway, by observer-based single-call sorting and a bag-of-calls approach we newly develop. The observer based analysis shows a complex vocal repertoire with 140 different call types, call sequences, call repetitions and group specific differences in the usage of call types. The bag-of-calls approach reveals that groups of pilot whales can be distinguished by properties of the ensembles of the vocalisations they produce. Comparing inter- and intra-group differences quantifies group specificity in a statistical significant way, indicates that pilot-whales have group-specific vocal cultures.

SOE 17.2 Thu 9:45 MA 001

Sequences of pilot whale calls — •Florencia Noriega[1], Heike Vester[1], Kurt Hammerschmidt[2], Sarah Hallerberg[1], and Marc Timme[1] — [1]Network Dynamics, Max Planck Institute for Dynamics and Self-Organization (MPIDS), 37077 Göttingen — [2]Deutsches Primatenzentrum, 37077 Göttingen

Vocal communication is highly evolved in social marine mammals such as killer whales, pilot whales or other dolphins. Their vocal repertoires consist of a variety of sounds ranging from noisy (like clicks and buzzes) to tonal signals (like calls and whistles). There is evidence that at least two or three sounds are sometimes used by killer whales in systematic combination and that they communicate by exchanging vocal signals. However, the way these vocal signals are combined and used by the animals is largely unknown. In this study we investigate the bigram structure observed in sequences of pilot whale calls recorded from six different groups of animals. We are specially interested in whether combinations of calls such as bigrams occur more often than expected when the calls are assumed to be independent. Apart from group specific results, we encounter common properties in the usage of calls across groups. Particularly, we find a tendency to produce sequences of repeated calls and similar distributions of time intervals between consecutive calls.

SOE 17.3 Thu 10:00 MA 001

Cluster formation in king penguin chicks — •Richard Gerum[1], Ben Fabry[1], Claus Metzner[1], Céline Le Bohec[2,3], Francesco Bonadonna[4], Anna Nesterova[4], and Daniel Zitterbart[1,5] — [1]University of Erlangen-Nürnberg, Germany — [2]CNRS/UdS, Strasbourg, France — [3]CSM LIA-647 BioSensib, Monaco — [4]CEFE-CNRS, Montpellier, France — [5]AWI, Bremerhaven, Germany

Several penguin species display complex and not well understood group dynamics such as cluster formation. We hypothesize that cluster formation can be driven by predators (short-term) or environmental factors (long-term). A preliminary analysis of video recordings of king penguin (*Aptenodytes patagonicus*) colonies on the sub-Antarctic Possession and Kerguelen Islands, obtained during 2011-2014, reveals that chicks can dynamically form irregular-shaped clusters of several hundreds or thousands of individuals. In this study, we focus on short-term arrangements induced by predation events. Isolated or loosely grouped king penguin chicks are an easy target for giant petrels (*Macronectes* spp.). When chicks are attacked by petrels, they flee away and try to maintain a safety distance from the predator. Using a computer simulation of the attack and flight behavior, we demonstrate that randomly attacking predators can lead to the formation of chick clusters that closely resemble those observed in our video recordings. The shape and size of the clusters strongly depend on the safety radius around the predator that triggers a flight response. Our results suggest that the escape behavior of king penguin chicks in response to predator attacks can lead to the emergence of large and dense clusters for protection.

SOE 17.4 Thu 10:15 MA 001

How relevant is the grading of soccer matches by experts and algorithms? An objective view — •Andreas Heuer[1] and Jens Smiatek[2] — [1]Institute for Physical Chemistry, University of Münster, Germany — [2]Institute for Computational Physics, University of Stuttgart, Germany

The grading of soccer players, e.g., by sports magazines is common usage to evaluate their performance. Often these grades are important parameters for player transfers and internet manager games.

In this talk we answer the question about the quality of the grades on a team level. We analyze grades, formulated by experts, and grades, determined on an algorithmic basis using match-data.

Via a specifically designed statistical analysis we can identify on an objective basis to which degree the grades indeed reflect the strengths of the individual teams or whether they are just a mirror-image of the random effects, inherently present in soccer matches or follow from the prejudices of experts. Interestingly, it turns out that the quality of both types of grading systems is relatively poor.

SOE 17.5 Thu 10:30 MA 001

A conceptual statistical framework to compare different sports and its application in basketball, handball and soccer — •Jens Smiatek[1], Dennis Riedl[2,3], and Andreas Heuer[2] — [1]Institut für Computerphysik, Universität Stuttgart, Allmandring 3, 70569 Stuttgart, Germany — [2]Institut für Physikalische Chemie, Universität Münster, Corrensstrasse 28/30, 48149 Münster, Germany — [3]Institut für Sportwissenschaft, Universität Münster, Horstmarer Landweg 62 b, 48149 Münster, Germany

We present a statistical framework to analyze the main properties of soccer, handball and basketball. Our approach is based on time series analysis and statistical mathematics without model parameters. The framework allows us to elucidate stochastic contributions as well as team strengths and their persistence in time. We compare the importance of offense and defense ability in team sports and investigate the underlying differences. Our findings indicate significant deviations as well as similarities between the considered leagues and sports. The outcomes of our analysis can be of interest for a deeper understanding of the characteristics of popular sports games and the prediction of match results in relation to stochastic contributions.

SOE 17.6 Thu 10:45 MA 001

Analysis of correlations in the temporal distribution of public loudspeaker announcements — •Hubert Ceeh — Technische Universität München, Physik Department, Lehrstuhl E21, James-Franck-Straße, D-85748 Garching, Germany

Announcements over public loudspeakers serve the purpose of delivering urgent messages, warning signals and alarms. They are usually preluded by a distinct major triad so that loud activities and thinking processes can be interrupted and full attention is paid to the content of the announcement. This work aims to investigate the time structure of announcements and especially addresses the question if one announcement triggers another one within a short time frame. For this purpose announcements were detected by a real-time Fourier analysis of the ambient noise in a common open space office. In the analysis, correlations between the time tags of the announcements are sought and the temporal distribution is modelled by multi-exponential distributions based on Poisson statistics.

- 15 min break -

SOE 18: Social Networks

Time: Thursday 11:15–12:00 Location: MA 001

SOE 18.1 Thu 11:15 MA 001

Emergent human behaviour on Twitter modelled by a stochastic differential equation — •Anders Mollgaard and Joachim Mathiesen — Niels Bohr Institute, Copenhagen, Denmark

In the online era, humans are connected in real time on global scales. Local or seemingly local information is instantaneously shared across geographical boundaries. In particular, social media have become an important platform for the sharing of information and have allowed for detailed studies of the coherent behaviour of humans on a global scale. We have analysed data from the social-media site, Twitter, and used it to study fluctuations in tweet rates of brand names. These have been found to reveal strongly correlated human behaviour that leads to 1/f noise and bursty collective dynamics. Here we use a basic definition of aggregated "user interest" to model collective human dynamics by a stochastic differential equation with multiplicative noise. The model is supported by an analysis of tweet rate fluctuations and it reproduces both the bursty dynamics found in the data and the 1/f noise.

[1] Mathiesen, Joachim, et al. "Excitable human dynamics driven by extrinsic events in massive communities." Proceedings of the National Academy of Sciences 110 (2013): 17259-17262.
[2] Mollgaard, Anders, et al. "Emergent human behaviour on Twitter modelled by a stochastic differential equation." In print.

SOE 18.2 Thu 11:30 MA 001

Proposal of segmentation method of time series in the blogosphere — •Kazuya Satou[1], Hideki Takayasu[2,3], and Misako Takayasu[1] — [1]Tokyo Institute of Technology 4259,Nagatsuta-cho, Midori-ku, Yokohama-shi, Kanagawa, 226-8502 Japan — [2]Sony Computer Science Laboratories, 3-14-13, Higashigotanda, Shinagawa-ku, Tokyo, 141-0022 Japan — [3]Meiji University, 4-21-1, Nakano, Nakano-ku, Tokyo, 164-8525, Japan

Time series of the words written in the blogosphere have various types of changes, and it is difficult to extract trends by conventional parametric methods.

In this presentation, we introduce a sequential segmentation method of time series based on Fisher's exact test. In this method, various types of trends are automatically detected by comparing the p-value with that of randomized time series. Since Fisher's exact test is non-parametric, and can be tested with small number of samples, the proposed method can be potentially applied for the general time series.

In addition, we combine the method with the random diffusion model which detects large discontinuous changes in blog time series.

We discuss the results of detection accuracy of the proposed method by using artificial time series and compare with that of conventional methods. Finally, we show the segmentation results applied for real blog time series.

SOE 18.3 Thu 11:45 MA 001

Prediction of topics' survival using large-scale social data: case of comedian popularity — •Kenta Yamada[1,2], Ryo Tamaoka[1], and Kiyoshi Izumi[1,3] — [1]Graduate School of Engineering, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656 Japan — [2]PRESTO, Japan Science and Technology Agency, 4-1-8 Honcho, Kawaguchi, Saitama, 332-0012, Japan — [3]CREST, Japan Science and Technology Agency, 4-1-8 Honcho, Kawaguchi, Saitama, 332-0012, Japan

We proposed a new indicator analyzing large-scale textual data in blogs, which predicts future popularity of a topic after a related event. The indicator was tested about the prediction of comedians' popularity after famous comedican contests on television. There are some popular comedian contests in Japan such as the M-1 grand prix. We can universally observe clear peak and power law decaying in the number of blog entries including a champion and vice-champion name (34 samples) after contests as well as the cases in which the number of entries including the event's name follows power function after the events such as Christmas in the previous study [1]. We fitted the number of entries including the comedian's name using five days data after the contest by a power function and cumulated differences between fitted line and actual data from 6 to 12 days after the contest. We found that this index of cumulative differences has a good predictive capability for the number of future (11months later) entries about the comedian.

[1] Y. Sano, K. Yamada, H. Watanabe, H. Takayasu, and M. Takayasu, PRE 87, 012805 (2013).

SOE 19: Networks: From Topology to Dynamics II (joint session SOE / DY / BP)

Time: Thursday 12:00–13:15 Location: MA 001

SOE 19.1 Thu 12:00 MA 001

Sensitivity against author name disambiguation of a motif-based success score in coauthorship networks — •David F. Klosik[1], Stefan Bornholdt[1], and Marc-Thorsten Hütt[2] — [1]Institut für Theoretische Physik, Universität Bremen — [2]School of Engineering and Science, Jacobs University Bremen

Motivated by the question whether large-scale citation datasets allow for a quantitative assessment of social influences in form of coauthorship of publications we investigate a success score [L. Krumov, C. Fretter, M. Müller-Hannemann, K. Weihe, and M.-T. Hütt, EPJ B (84), 535 (2011)] for small collaboration patterns in coauthorship networks. We find that when applied to a network compiled from aggregated citation data provided by the American Physical Society this score which is based on the scale of small induced subgraphs (as known from motif-analysis) is highly sensitive to details of the network construction from the data; especially to the inevitable disambiguation of author names (i.e., the scheme applied to group instances of author names into a vertex). We argue that these findings might not be exclusive to coauthorship networks since similar ambiguities are present in the network representations of other data [D.F. Klosik, S. Bornholdt, M.-T. Hütt, Phys. Rev. E 90, 032811 (2014)].

SOE 19.2 Thu 12:15 MA 001

Random Walks on Citation Networks — •Vimal Kishore and Eduardo G. Altmann — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

Scientific papers are the main source of communication of scientific ideas and are connected to each other through citations. The digitalization of articles allows scientists to easily trace not only the citations contained in a paper but also the citations a paper received. This motivates us to consider random walks on citation networks as models of the search of scientific information scientists perform. The spreading of the random walkers in the network provides information on the flow of scientific ideas across different publications and fields. We discuss different mechanisms leading to a sub-linear growth of the number of discovered papers as a function of random-walk steps.

SOE 19.3 Thu 12:30 MA 001

Restricting the h-index to a citation time window: A case study of a timed Hirsch index — •Michael Schreiber — Institut für Physik, TU Chemnitz

The h-index has been shown to increase in many cases mostly because of citations to rather old publications. This inertia can be circumvented by restricting the evaluation to a citation time window. Here I report results of an empirical study analyzing the evolution of the thus defined timed h-index in dependence on the length of the citation time window.

SOE 19.4 Thu 12:45 MA 001

An Interacting Network Perspective on Global Trade — •Julian Maluck and Reik V. Donner — Potsdam Institute for Climate Impact Research, Germany

In the last years the International Trade Network (ITN) has caught rising attention among the scientific community. By decomposing countries into national industry sectors, data provided by multi-regional input-output tables allow for a more detailed investigation into the substructure of the ITN. We introduce an interacting network approach to quantify trends and extreme events in global trade patterns between 1990 and 2011. Different definitions of subgraphs exhibit different characteristic topological features of the ITN. This study compares and evaluates partitions that are defined by industry sector and by country, respectively. We assess how meaningful the notion of national economies in present-day globalized economy still is and show that the approach of interacting networks provides suitable methods to perceive important patterns in global trade.

SOE 19.5 Thu 13:00 MA 001

From diffusion to evolutionary game theory on the multilayer — •Rubén J. Requejo, Nikos E. Kouvaris, and Albert Díaz-Guilera — Foundamental Physics Department, Universitat de Barcelona

I will present some results obtained within the LASAGNE project (multi-LAyer SpAtio-temporal Generalized NEtworks), starting with the effect of the multiplex structure on the diffusion of particles, following with the extension of agent-based dynamics to the multiplex by means of an evolutionary game theoretical model of interacting metapopulations, which shows the effect of the multilayer structure on the replicator dynamics, and finishing with the observation of chimera states in the multiplex for a public goods game with cooperators, defectors and jokers.

SOE 20: Energy Systems (joint session DY/ AK Energy / SOE)

Time: Thursday 9:30–12:45 Location: BH-N 243

SOE 20.1 Thu 9:30 BH-N 243

Decentral Smart Grid Control — •Benjamin Schäfer[1], Moritz Matthiae[1], Dirk Witthaut[1,3,4], and Marc Timme[1,2] — [1]Network Dynamics, Max Planck Institute for Dynamics and Self-Organization (MPIDS), 37077 Göttingen — [2]Institute for Nonlinear Dynamics, Faculty of Physics, University of Göttingen, 37077 Göttingen — [3]Forschungszentrum Jülich, Institute for Energy and Climate Research (IEK-STE), 52428 Jülich — [4]Institute for Theoretical Physics, University of Cologne, 50937 Köln

Stable operation of complex flow and transportation networks requires balanced supply and demand. For the operation of electric power grids - due to their increasing fraction of renewable energy sources - a pressing challenge is to fit the fluctuations in decentralized supply to the distributed and temporally varying demands. Common smart grid concepts suggest to collect consumer demand data, centrally evaluate them and send price information back to customers. Besides restrictions regarding cyber security, privacy protection and large required investments, it remains unclear how such central smart grid options guarantee overall stability.

Here we propose a Decentral Smart Grid Control, where the price is directly linked to the local grid frequency at each customer. The grid frequency provides all necessary information about the current power balance such that it is sufficient to match supply and demand without the need for a centralized IT infrastructure. We analyze the performance and the dynamical stability of the power grid with such a control system and determine its stability conditions.

SOE 20.2 Thu 9:45 BH-N 243

Dynamical Models of Power Grids: Identifying and Curing Weak Links — •Martin Rohden and Hildegard Meyer-Ortmanns — Jacobs University Bremen, Canpus Ring 8, 28759 Bremen

The inclusion of more and more renewable energy sources into modern power grids leads inevitably to drastic changes of the topology of power grids [1]. Nevertheless it is not known to date what an optimal network topology for power transport and robustness could be. Adding simply new transmission lines can induce long-ranged alterations on the power flow [2]. Here we use the recently introduced novel criteria of redundant capacities to identify weak links in power grids. We propose new strategies to cure these critical links and show their advantages over possible alternatives. Our results may serve as a step towards optimal network topologies in real-world power grids.

[1]: M. Rohden, A. Sorge, D. Witthaut and M. Timme, Chaos **24**, 013123 (2014)

[2]: D. Labavic, R. Suciu, H. Meyer-Ortmanns and S. Kettemann, Eur. Phys. J. Special Topics (EPJ ST), **223**, pp 2517-2525 (2014)

SOE 20.3 Thu 10:00 BH-N 243

The induced feedback of Demand-Side Management in the German power market and grid — •Sabine Auer[1,2], Jobst

Heitzig[1], and Jürgen Kurths[1,2,3,4] — [1]Potsdam Institute for Climate Impact Research, D-14412 Potsdam, Germany — [2]Department of Physics, Humboldt University Berlin, D-12489 Berlin, Germany — [3]Institute for Complex Systems and Mathematical Biology, University of Aberdeen, AB24 3UE Aberdeen, UK — [4]Department of Control Theory, Nizhny Novgorod State University, Gagarin Avenue 23, 606950 Nizhny Novgorod, Russia

The integration of Variable Renewable Energy (VRE) into the German power system becomes increasingly challenging with growing wind and solar power capacities. To prevent negative energy prices and to secure future energy supply, a debate about redesigning the German power market has aroused. Two competing solutions, a capacity market and an optimized spot market, are under consideration, so far [1]. Either using demand as negative capacities or real-time market pricing will increase the price elasticity of demand and therefore, create a feedback loop between physical loads and power pricing [2].

In our research, we study these feedbacks in regard to power market and grid, especially in terms of stability [3]. Will these new concepts increase system stability by smoothing price evolution or rather provoke highly non-linear dynamics?

[1] BMWi. Ein Strommarkt für die Energiewende (2014). [2] M. Roozbehani et. al. (2012), IEEE, 27(4), 1926-1940. [3] P. Menck, J. Heitzig, N. Marwan J. & Kurths (2013). Nature Physics, 9(2), 89-92.

SOE 20.4 Thu 10:15 BH-N 243

Flow tracing in renewable electricity networks — Mirko Schäfer[1], •Bo Tranberg[2], and Martin Greiner[2] — [1]Frankfurt Institute for Advanced Studies — [2]Aarhus University

Renewable electricity networks are defined as power grids with a large penetration of fluctuating renewable power generation. Flow tracing algorithms track the renewable power as it flows from the generation nodes through the network to the consumption nodes. This allows for fair pricing schemes of future transmission investments. A new analytical expression is presented and applied to the pan-European transmission grid.

SOE 20.5 Thu 10:30 BH-N 243

Large-deviation study of the maximum-disturbance stability of power grids — •Alexander K. Hartmann[1], Timo Dewenter[1], Wiebke Heins[2], and Benjamin Werther[2] — [1]Institut of Physics, University of Oldenburg — [2]Institut for Electrical Energy Technology, Technical University of Clausthal

We study numerically the distribution of "maximum-disturbance" stability of power grids. The model is based on networks of oscillators. Here, we consider different ensembles of random networks, like standard Erdös-Renyi and two dimensional spacial networks. To access the distribution down to very small probabilities, we use specific large deviation techniques [1]. The stability is given by a conservative estimation of an asymptotic stability boundary, which is well known in stability theory [2,3]. The starting point is the matrix $\mathbf{A}$ defined by $\mathbf{J^T A} + \mathbf{AJ} = \mathbf{E}$, $\mathbf{J}$ being the Jacobean Matrix. By calculating the maximum disturbance of $\mathbf{x}$, which results in the quadratic form $V = \mathbf{x^T A x} = \epsilon(\mathbf{x})$ not being a Lyapunov-function of the system any longer, the boundaries for the stability can be found.

For comparsion, for the given networks also simple stability measures beased on shortest paths [4], on the eigenvalues of the Jacobi matrix and on a linearized power-flow model [5] are obtained.

[1] A.K. Hartmann, Eur. Phys. J. B **84**, 627-634 (2011)
[2] R. Unbehauen, Systemtheorie (Vol. 2), Oldenbourg, Munich (1998)
[3] E.J. Davison and E.M. Kurak, Automatica **7**, 627-636 (1971)
[4] A.K. Hartmann, Eur. Phys. J. B **87**, 114 (2014)
[5] T. Dewenter and A.K. Hartmann, preprint arXiv:1411.5233 (2014)

SOE 20.6 Thu 10:45 BH-N 243

Impact of network topology on decentral frequency-based smart grid control — •Carsten Grabow[1] and Jürgen Kurths[2] — [1]Potsdam Institute for Climate Impact Research, Potsdam, Germany — [2]Potsdam Institute for Climate Impact Research, Potsdam, Germany

Replacing conventional power sources by renewables in power grids poses a big challenge nowadays. In particular, a stable operation of the power grid requires new methods and ideas in aligning the arising fluctuations in decentralised supply to the temporally varying demands. In this context, a decentral Smart Grid Control has been proposed recently in order to directly link the price information to the local grid frequency. Principally, it has been shown that this approach leads to an efficient decentralized strategy for matching supply and demand in a dynamically stable way. However, first results are restricted to simple small and regular networks. In our talk, we will extend the local and global stability analysis of the decentral Smart Grid Control to the collective dynamics of small network motifs, in particular, star-like networks and regular grid motifs. For larger networks, we numerically investigate decentralization scenarios finding additional phenomena that have to be considered to support power grids in exhibiting a stable state.

15 min. break

SOE 20.7 Thu 11:15 BH-N 243

Detours around basin stability in power networks — •Paul Schultz[1,2], Jobst Heitzig[1], and Jürgen Kurths[1,2,3,4] — [1]Potsdam Institute for Climate Impact Research, D-14412 Potsdam, Germany — [2]Department of Physics, Humboldt University Berlin, D-12489 Berlin, Germany — [3]Institute for Complex Systems and Mathematical Biology, University of Aberdeen, AB24 3UE Aberdeen, UK — [4]Department of Control Theory, Nizhny Novgorod State University, Gagarin Avenue 23, 606950 Nizhny Novgorod, Russia

To analyse the relationship between stability against (large) perturbations and topological properties of a power transmission grid, we employ a statistical analysis of a large ensemble of synthetic power grids, looking for significant statistical relationships between the single-node basin stability measure and classical as well as tailor-made weighted network characteristics. Especially, we propose a strategy to directly estimate a power grid's stability - even on short time scales - to omit the need of costly simulations. The focus lies on the identification of grid nodes that appear critical for stability, using for example a version of Newman's current flow betweenness. This method enables us to predict poor values of single-node basin stability for a large extent of the nodes, offering a node-wise stability estimation at low computational cost.

Further, we analyse the particular function of certain network motifs to promote or degrade the stability of the system. Here we uncover the impact of so-called detour motifs on the appearance of nodes with a poor stability score and discuss implications for power grid design.

SOE 20.8 Thu 11:30 BH-N 243

Network Measures for Power Grid Stability in Practice — •Frank Hellmann — Potsdam-Institut für Klimafolgenforschung, Potsdam, Deutschland

A key challenge for the emerging future grid infrastructure is the dynamical stability of the power grid in the presence of fluctuating power sources and changing topologies.

I show how tools based on novel as well as existing network topology measures can help with identifying vulnerable points in the power grid and can guide the design of the future grid in practice.

SOE 20.9 Thu 11:45 BH-N 243

Predicting critical links in complex supply networks — •Xiaozhu Zhang[1], Dirk Witthaut[1,2,3], Martin Rohden[1,4,5], Sarah Hallerberg[1], and Marc Timme[1,6] — [1]Network Dynamics, Max Planck Institute for Dynamics and Self-Organization (MPIDS), 37077 Göttingen, Germany — [2]Forschungszentrum Jülich, Institute for Energy and Climate Research - Systems Analysis and Technology Evaluation (IEK-STE), 52428 Jülich, Germany — [3]Institute for Theoretical Physics, University of Cologne, 50937 Köln, Germany — [4]IIIrd Institute of Physics, Faculty of Physics, Georg August University, 37077 Göttingen, Germany — [5]School of Engineering and Science, Jacobs University, 28759 Bremen, Germany — [6]Institute for Nonlinear Dynamics, Faculty of Physics, Georg August University, 37077 Göttingen, Germany

It has been observed that most large-scale outages in power grids can be traced back to single transmission line failures [1]. Yet, identifying which infrastructures in power grids and other supply networks are critical remains an open challenge, with severe consequences for network planning and stability. In this work we propose that the critical links can be reliably predicted from the network structure and the normal operation state prior to edge failure. Numerical simulations of a variety of flow network models confirm that the topological edge redundancy as well as renormalized linear response theory provide general key indicators for network robustness.

[1] Pourbeik et al., Power and Energy Magazine, IEEE 4.5 (2006): 22-29.

SOE 20.10 Thu 12:00 BH-N 243

Modelling the Dynamical Formation of Coalitions of Power Grid Operators to Reduce Needs for Backup Capacity — •Jobst Heitzig[1] and Sarah Becker[2] — [1]Potsdam Institute for Climate Impact Research, Potsdam, Germany — [2]Frankfurt Institute for Advanced Studies, Frankfurt, Germany

Power grid operators face an increasing need for backup capacity due to a raising amount of volatile renewable energy production. This need may be decreased by extending transmission capacities between several neighbouring grids and then pooling their backup capacities. Due to the physical properties of electricity transmission grids, extending a line between two grids may however also reduce the backup capacity needs of a third connected grid, and may do so even more than when the third grid's connection were extended as well. These physical effects generate complex and interesting strategic incentives for individual grid operators to join a backup capacity sharing coalition or not. In this talk, we'll use a model of dynamic coalition formation to show which grids may form coalitions in which order, using real-world example data.

SOE 20.11 Thu 12:15 BH-N 243

Short-Time Stochastic Characterization of the Offshore Wind Profile — •Christian Behnken, Pedro Lind, Matthias Wächter, and Joachim Peinke — ForWind, Institute of Physics, Carl-von-Ossietzky University, 26111 Oldenburg, Germany

Currently descriptions of vertical wind profiles are mostly performed by using standard logarithmic or power law approaches. Especially for short time scales ($1\,s \leq t \leq 10\,min$) the dynamics of the profile strongly influence the load situations and the energy conversion of wind turbines. Since these short-time dynamics are not considered when using the standard techniques, a more detailed approach is presentend in this work. Firstly, PDFs of spatial and temporal velocity increments, estimated from offshore wind speed data, are fitted by using a superposition of Gaussian distributions with a varying standard deviation. It is shown that the empirical PDFs follow a heavy-tailed distribution which matches the proposed theoretical distribution. Furthermore, drift and diffusion coefficients for two-dimensional systems of Langevin equations are estimated directly from wind speed data to investigate dynamic coupling along the profile. This approach gives a first insight into the dynamics of wind profiles on short time scales.

SOE 20.12 Thu 12:30 BH-N 243

Intermittency and Synchronization in Wind Farm — •Mehrnaz Anvari and Joachim Peinke — Institute of Physics and Forwind, Carl von Ossietzky University, 26111 Oldenburg, Germany

The renewable wind and solar sources and their share in electricity production have been increased constantly in recent years. These sources have new stochastic characteristics such as intermittency and non-Gaussian behavior, which may cause instability in power grids in very short-term time scales.

In this work, we focus on wind power that influenced by atmospheric turbulence. Hence frequent extreme fluctuations in power output of wind turbines are detectable. This intermittent behavior also, is present in cumulative power of the total wind field, even for a country-wide installation. To understand the origin of such extreme events, we consider the interactions between wind turbines and for this purpose, we evaluate the phase synchronization in wind farm. We conclude that, the existence of partial phase synchronization between turbines in specific time intervals can explain the origin of extreme events in this complex system. We found that higher synchronized wind turbines will produce higher intermittent power output.

SOE 21: Plenary Talk Simon Levin

Time: Thursday 14:00–14:45 Location: H 0104

Plenary Talk SOE 21.1 Thu 14:00 H 0104

Collective Motion, Collective Decision-making, and Collective Action: From Microbes to Societies — •Simon Levin — Princeton University, Princeton, NJ 08544, USA

Ecological and economic systems are alike in that individual agents compete for limited resources, evolve their behaviors in response to interactions with others, and form exploitative as well as cooperative interactions as a result. In these complex adaptive systems, macroscopic properties like the flow patterns of resources such as nutrients and capital emerge from large numbers of microscopic interactions, and feed back to affect individual behaviors. Contagion can lead to critical transitions from one basin of attraction to another, as for example with eutrophication, desertification, pest outbreaks, and market collapses. In both sorts of systems, evolution of one type or another leads to the differentiation of roles and the emergence of system organization, but with no guarantee of robustness. It is crucial to understand how evolutionary forces have shaped individual behaviors in the face of uncertainty. In this talk, I will explore the common features of these systems, especially as they involve the evolution of intragenerational and intergenerational resource allocation and the evolution of cooperation in dealing with public goods, common-pool resources and collective movement. I will describe examples from bacteria and slime molds to vertebrate groups to insurance arrangements and social norms in human societies.

SOE 22: Economic Models

Time: Thursday 15:00–17:00 Location: MA 001

SOE 22.1 Thu 15:00 MA 001

A Stock-Flow Consistent Input-Output Model with Applications to Energy Price Shocks and Interest Rates — •Oliver Richters[1,2], Matthew Berg[3], and Brian Hartley[4] — [1]Theoretical Physics / Complex Systems, Institute for Chemistry and Biology of the Marine Environment, Carl von Ossietzky University Oldenburg — [2]Sustainable Money Research Group — [3]University of Missouri Kansas City — [4]The New School for Social Research

By synthesizing Stock-Flow Consistent (SFC) models, Input-Output (IO) models, and aspects of Ecological macroeconomics, a method is developed to simultaneously model monetary flows through the financial system, flows of produced goods and services through the real economy, and flows of physical materials through the natural environment. We highlight the linkages between the physical environment and the economic system by emphasizing the role of the energy industry. First, the model is applied to analyze the role of energy price shocks in contributing to recessions, incorporating several propagation and amplification mechanisms. Second, it is demonstrated that contrary to some claims, 0% interest rates are not a necessary condition for a stationary economy in stock-flow equilibrium, although this does not necessarily imply that the economy is also ecologically sustainable. Connections to econophysics are emphasized.

SOE 22.2 Thu 15:15 MA 001

Constrained Dynamic Models (CD-Models) in Economics as a Unification of commonly used Economic Models — •Erhard Glötzl — Karl-Kautsky-Weg 26, A-4040 Linz, Austria

Constrained dynamics are well known from classical Mechanics. Identifying *economical forces* with physical forces, *economical power* with the reziproke value of mass and realizing that economical constraints mostly are given by accounting identities one can transform the concept of constraint dynamics to economic models. It can be shown, that commonly used economic models such as Classic, Neoclassic, GE, DSGE, Keynesian, Post-Keynesian, ABM and SFC models can be interpreted as special cases of CD-Models. CD-Models thereby provide the basis for a wide variety of different closures of economic models, which are ultimately the result of different assumptions about the power relations between economic agents.

SOE 22.3 Thu 15:30 MA 001

Modeling the dynamics wealth inequality and its possible control — •Yonatan Berman, Yoash Shapira, and Eshel Ben-Jacob — Tel-Aviv University, Tel-Aviv, Israel

In the past few decades, wealth inequality is rapidly increasing in western economies, thus imposing social and economic instabilities. One of the major challenges in studying the mechanisms that govern wealth inequality is the need to bridge between the individual and the population levels. In this talk we will present a new modeling approach for the dynamics of wealth inequality using stochastic iterated maps. By incorporating various economic parameters and their historical values, we were able to accurately capture the historical dynamics of wealth inequality in the United States during the 20th century.

We show that the capital income to national income ratio and the personal savings fraction are the most critical factors in determining inequality. The sensitivity of wealth inequality to the economic mobility is found as relatively low at the current mobility state.

Most notably, it is found that the most probable and important contributor to the recent surge in inequality is the major decrease in personal savings since the 1980's. Following these results we use the model to predict a further increase in wealth inequality in the near future. However, given a substantial increase in private savings or a major decrease in capital income to national income ratio, this scenario might be prevented.

SOE 22.4 Thu 15:45 MA 001

The Role of Nonergodicity for Economic Theory — •Mark Kirstein — TU Dresden, Chair of Managerial Economics

The direction of the mathematisation of predominant economics is unthinkable without the tacit underlying assumption of ergodicity. Despite its foundational character, the assumption of (non)ergodicity is virtually unrecognised in the economic discipline, closely intertwined with equilibrium concepts, and absent from the curriculum, as contrasted with such popular assumptions like rational expectations formation, representative agent, efficient markets, perfect competition, etc.

Nonergodicity is fulfilled, if the time average of a system is unequal to its ensemble average. Nonergodicity is a necessary property of a mathematical model, if the model is supposed to describe occurences of endogenous novelties and change. The nonergodic case is the more general, whereas the ergodic case is much easier to handle mathematically. Capitalistic economies are downright defined through their potential of evolution and non-routine change and so are its very centerpiece financial markets. Accepting that proper mathematical models of economic or financial processes should posses the property of nonergodicity, puts emphasis on the crucial role of time through which a certain amount of uncertainty enters into economic reasoning. This contribution seeks to clarify this specific relation between the idea of (non)ergodicity from statistical mechanics and its role in and for economics and finance.

SOE 22.5 Thu 16:00 MA 001

Economic Growth and the Piketty Data — •Juergen Mimkes — Physics Department, Paderborn University

In physical economics the model equations of economic growth lead to exponential functions of income for capital and labor. The growth coefficients depend on the distribution factor (p) of annual profits between capital and labor. A low participation of labor in annual profits leads to an efficient economy, to high growth rates of the DAX (for capital) and low growth rates of the GDP/capita (for labor). This agrees with the data by Piketty. Several ways are diskussed to follow Piketty in equalizing growth rates for capital and labor.

SOE 22.6 Thu 16:15 MA 001

Cycles and phases of prosperity and depression in an agent-based macroeconomic system with financial markets — •Wenzhi Zheng and Yu Chen — Department of Human and Engineered Environmental Studies, the Graduate School of Frontier Science, the University of Tokyo, Kashiwa City, Chiba ken, Japan

The operation of market-based economy today is strongly fueled by the financial system. As in the prosperity, growing demands and enough capacity to produce keep the development of the economy. Meanwhile huge amounts of credit is created and the boom of asset and equity price create even more virtual wealth. This process usually would not last long. After the prosperity, people have to suffer dramatic fluctuations which may hurt the economy for a short period, like several crashes in the U.S.A, or for decades, like which is happening in Japan. However, traditional macroeconomics overlooks the important interactions between the economy and the financial system. In this work, we will introduce an agent-based economy in which the financial system plays a significant role. In the model, while the financial system accelerates the growth of economy, it also induces short-term and long-term cycles. In this perspective, Japan is just in a long-term recession phase in which strong financial stimulus is not the solution to reactivate the economy. At last, we will try to give policy advice for economies falling into different phases for different reasons based on effective control parameter in our model.

SOE 22.7 Thu 16:30 MA 001

Price dynamics: zero-intelligence and strategic traders. — •Wei-Te Yu and Hsuan-Yi Chen — Department of Physics, National Central University, Jhongli 32001, Taiwan

Understanding price dynamics is one of the important things in studying financial markets. We propose an agent-based model with an order book to study how the price changes evolve. In our model, the agents have infinite money to put buying orders. Shares held by the agents are put on the selling order according to specific strategies which depends on price history. First, agent with zero intelligence, i.e., buying and selling orders are put randomly, are used in the simulations. Then the results of zero-intelligence-agent simulations are compared to markets with technical trading strategies. This allows us to distinguish features of price dynamics that could be attributed to the price-history-dependent trading strategies.

- 15 min. break -

SOE 23: Physics of Sustainability and Human-Nature Interactions II (joint with DY, jDPG, BP) - session accompanying the symposium SYPS

Time: Thursday 17:00–18:30 Location: MA 001

Topical Talk SOE 23.1 Thu 17:00 MA 001

Critical Transitions in Socio-econo-ecological Systems—A Global Adaptive Model of the Regional Transitions to Agriculture 8000 BC to AD 500 — •Carsten Lemmen and Kai W. Wirtz — Helmholtz-Zentrum Geesthacht, Geesthacht, Germany

Critical transitions in societies emerge as boundaries between cultural "ages", e.g. the transition from the Industrial to the Information Age, or from the Holocene to the Anthropocene. Societal transitions are believed to emerge from nonlinear feedbacks between environment, economy, and society, but hypotheses have been difficult to test so far.

We propose to employ "numerical experiments in history" and consider one of the major critical transitions in world history—the abandonment of a foraging lifestyle in favor of agriculture and pastoralism. We investigate this transition with a deterministic and dynamic model of society. The global model resolves regional-scale human-environment interactions in space and time, based on only few prognostic adaptive societal traits and their co-evolutionary dynamics with population size.

We successfully reproduced the agropastoral transition as seen in archaeological data; we tested demic and cultural hypotheses about its expansion, finding both equally consistent with the data; we explored the stability of the expansion pattern facing large-scale palaeoenvironmental excursions and found strong resilience of populations and their key traits. Our model enabled us to quantify global and regional emissions of CO_2 and the sustainable population size for the past 10000 years.

SOE 23.2 Thu 17:30 MA 001

Evaluating a Socio-environmental Complex Adaptive System: The Case of Self-Organized Socio-environmental Develop-

ment in State Chiapas. — •Felipe Lara-Rosano[1] and Adriana Quiroga-Carapia[2] — [1]Universidad Nacional Autonoma de Mexico (UNAM), Mexico City, Mexico — [2]Colegio de la Frontera Sur (ECOSUR), San Cristobal las Casas, Mexico

The project "Social and Environmental Innovation for Development in Areas of High Poverty and Biodiversity in the Southern Border of Mexico" was proposed by a research institute: the Colegio de la Frontera Sur (ECOSUR), and financed by the Mexican Research Council. Its central objective: to create opportunities for social and environmental innovation on the southern border of Mexico, seeking to strengthen the local capacity for sustainable management of natural resources and the welfare of its inhabitants. Because of the complex system and environment dynamics the solution of the problem is not a fixed one but it is a process that must be continuously evaluated and adapted based on the standpoint of the complex systems paradigm. The assessment of the socio-environmental development project is performed conceptualizing and organizing the community as a complex adaptive system in interaction with its environment. The system has properties expressed as state variables associated with a value that is changing through the development process. The analysis of the system dynamics is based on the behavior of its state variables. The Colegio de la Frontera Sur (ECOSUR) successfully applied this method in rural development projects in state Chiapas in 2013.

SOE 23.3 Thu 17:45 MA 001

Macroscopic description of complex adaptive networks coevolving with dynamic node states — •Marc Wiedermann[1,2], Jonathan F. Donges[1,3], Jobst Heitzig[1], Wolfgang Lucht[1,2], and Jürgen Kurths[1,2] — [1]Potsdam Insitute for Climate Impact Research, Germany — [2]Humboldt University, Berlin, Germany — [3]Stockholm Resilience Centre, Stockholm University, Sweden

When investigating the causes and consequences of global change, the collective behavior of human beings is believed to have a considerable impact on natural systems. Here, we study opinion formation and imitation of nodes on a complex network depending on the state of individual resource stocks that are harvested by each node. Numerical simulations reveal that high interaction rates between nodes cause a likely depletion of the resource whereas low interaction rates ensure their sustainable existence. However, adaptively rewiring the nodes' neighborhood structure with an appropriate frequency guides the system into an equilibrium state where all nodes behave sustainably and a full depletion of the resource stocks is avoided. In order to explain these observations, we derive a consistent macroscopic description of the system, which provides a general framework to model and quantify the influence of single node dynamics on the macroscopic state of a network and is applicable to many fields of study, such as epidemic spreading or social modeling. Our results suggest that with the current trend to faster imitation and ever increasing global network connectivity, societies are becoming more vulnerable to environmental collapse if they remain myopic at the same time.

SOE 23.4 Thu 18:00 MA 001

Exploring the safe and just operating space in an inhomogeneous world — •Wolfram Barfuss[1,2], Boyan Beronov[1,3], Marc Wiedermann[1,4], and Jonathan Donges[1,5] — [1]Potsdam Institute for Climate Impact Research, Germany — [2]Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany — [3]Ludwig-Maximilians-Universität München, Germany — [4]Humboldt-Universität zu Berlin, Germany — [5]Stockholm Resilience Centre, Stockholm University, Sweden

The Anthropocene has become reality during the 20th century, meaning that our species is pressuring the Earth's ecosystems on a global scale. In the meantime the challenge of eradicating poverty has not yet come to an end. Effectively dealing with these issues requires us to better understand the driving forces, feedback loops and tipping elements in the whole earth system, constituted from natural and social components. To take a step forward in this direction, we refine an existing conceptual coevolutionary model between social and ecological domains by adding inhomogeneities modelled after real-world data. We then propose an analysis framework, 'the safe and just space'-plot, which aligns with the current debate of simultaneously staying within the Planetary Boundaries and ensuring the social foundations and transforms it into a practical tool for studying socio-ecological models as well as real-world observations. First results from comparing the model outcome with real-world data indicate that the current state of the world is neither particularly safe nor particularly just.

SOE 23.5 Thu 18:15 MA 001

Topology of Sustainable Management of Dynamical Systems with Desirable States — •Jobst Heitzig[1] and Tim Kittel[1,2] — [1]Potsdam Institute for Climate Impact Research — [2]Humboldt University Berlin

The sustainable management of systems mainly governed by an internal dynamics for which one desires to stay in a certain region of their state space requires an understanding of the topology of the system's state space in terms of what regions are "safe" to stay in, and to what qualitative degree, and which of these regions can be reached from which others by the internal dynamics or by management.

The paradigm of optimal control on the one hand does not provide sufficient concepts for such a qualitative analysis and on the other hand typically requires quite a lot of structural knowledge about the problem, in particular, some or other form of quantitative evaluation of states.

In this talk, we will derive in a purely topological way a thorough qualitative classification of the possible states and management options of a system with respect to the possibility of avoiding or leaving some given undesired region by means of some given management options. Our results indicate that the sustainable management of a system may require discrete decisions such as choosing between ultimate safety and permanent desirability, or between permanent safety and increasing future options, etc.

SOE 24: Extreme Events (joint session DY / SOE)

Time: Thursday 15:00–17:00 Location: BH-N 243

Invited Talk SOE 24.1 Thu 15:00 BH-N 243

Branched Flows, Extreme Waves and the Random Focusing of Tsunami Waves — •Ragnar Fleischmann — Max Planck Institute for Dynamics and Self-Organization

Wave propagation in random media - this might sound abstract but is in fact very tangible and almost omnipresent in science and everyday life. Examples are surface water waves, but also light, sound, electrons, tsunamis and even earth quakes are waves that in a natural environment typically propagate through a complex medium. Due to its complexity, the medium is often best described as random, with examples including the turbulent atmosphere, complex patterns of ocean currents or a semiconductor crystal sprinkled with impurities. In recent years it has become clear that even very small fluctuations in the random medium, if they are correlated, lead to focussing of the waves in pronounced branch-like spatial structures and to extreme wave intensities. This branching has been reported for electron, micro, sound, and water waves.

I will give an overview over the progress we made in the last few years in the understanding of branched flows and the statistic of extreme waves. As an example, I will discuss the random focusing of tsunamis and its implications for the prediction of tsunami wave heights.

SOE 24.2 Thu 15:30 BH-N 243

Computing the probability of rare trajectories — •Jorge C. Leitão[1], João M. Viana Parente Lopes[2], and Eduardo G. Altmann[1] — [1]Max Planck Institute for the Physics of Complex Systems, 01187 Dresden, Germany — [2]Department of Physics and Center of Physics, University of Minho, P-4710-057, Braga, Portugal

Estimating the probability of extreme events often requires finding rare trajectories in (high-dimensional non-linear) dynamical systems. In this talk we show how such trajectories can be efficiently sampled using importance sampling Monte Carlo methods. We argue that the applicability and efficiency of these methods depend on the sensitivity of the observed quantity (in which the extreme event is measured) to perturbations of the initial conditions (in the phase space). We show analytical results and numerical simulations for different observables in (hyperbolic and non-hyperbolic) chaotic systems.

- J. C. Leitão, J. M. Viana Parente Lopes, E. G. Altmann "Efficiency

of Monte Carlo Sampling in Chaotic Systems", Phys. Rev. E 90, 052916 (2014)

- J. C. Leitão, J. M. Viana Parente Lopes, E. G. Altmann "Monte Carlo Sampling in Fractal Landscapes", Phys. Rev. Lett. 110, 220601 (2013)

SOE 24.3 Thu 15:45 BH-N 243

Record statistics for complex random vector — •Shashi C. L. Srivastava — Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Straße 38, 01187 Dresden Germany

In this talk, we present the analytical results for average record and average number of records in case of delta-correlated variables. These results are then compared with the numerical results for eigenfunctions of quantized standard map and found in good agreement [1]. Specifically, we will discuss the distribution of records which turns out to be a Gumbel distribution and the logarithmic dependence of average number of records on Planck's constant.

References:

[1] Srivastava, S. C. L., Lakshminarayan, A., and Jain, S. R. Record statistics in random vectors and quantum chaos, EPL 101, 10003 (2013).

SOE 24.4 Thu 16:00 BH-N 243

Statistical analysis of extreme weather events in a changing climate — •Philipp Müller and Holger Kantz — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

It is often claimed and from the perspective of atmospheric physics also plausible, that extreme weather conditions might occur more frequently in a warmer climate. We discuss statistical approaches to the characterization of the intensity and the frequency of extreme weather conditions on moving time windows. We present analysis results from the analysis of instrumental weather data from the past 100 years in central Europe. Temperature extremes, precipitation extremes, and wind speed extremes have different properties, whereas some very destructive extremes such as hailstorms have not been sufficiently recorded. Based on these data, we are unable to proof the existence of a systematic trend in extreme weather in Germany, although there are signatures which are consistent with a trend towards warming.

SOE 24.5 Thu 16:15 BH-N 243

A data-adaptive definition of extreme events in time series exhibiting seasonality — Eva K. Hauber[1,2,3] and •Reik V. Donner[1] — [1]Potsdam Intsitute for Climate Impact Research, Potsdam, Germany — [2]University of Copenhagen, Denmark — [3]University of Natural Resources and Life Sciences, Vienna, Austria

Environmental time series are often characterized by strong seasonal variations. In such a case, extreme events are traditionally defined by removing the underlying seasonal component in the mean and applying a threshold-based definition of an extreme to the residuals. However, this approach is only valid if the probability distribution function (PDF) shows a seasonal modulation exclusively of its mean. In turn, real-world climatological records exhibit heteroskedasticity, implying that their variance (but often also the shape of the PDF) changes over the year as well. Here, we present a data-adaptive method that allows defining extreme events under such conditions. Our approach is based on kernel estimates of the conditional PDF of the data taking the phase during the year as a covariate, which allow estimating any given quantile of the PDF as a function of this phase. We demonstrate the capabilities of this new approach for artificial time series as well as real-world observational data. Our results indicate that even for short time series covering only a few periods, the data-adaptive method leads to a systematic reduction of false identifications of extremes in comparison to standard techniques.

SOE 24.6 Thu 16:30 BH-N 243

Forecasting extreme events in high-dimensional excitable systems — •Stephan Bialonski[1], Gerrit Ansmann[2,3,4], and Holger Kantz[1] — [1]Max-Planck-Institute for the Physics of Complex Systems, Dresden, Germany — [2]Department of Epileptology, University of Bonn, Bonn, Germany — [3]Helmholtz Institute for Radiation and Nuclear Physics, University of Bonn, Bonn, Germany — [4]Interdisciplinary Center for Complex Systems, University of Bonn, Bonn, Germany

The dynamics of many high-dimensional systems, ranging from nature to technology and society, can exhibit extreme events, i.e. large deviations from the average behaviour. Since extreme events can pose severe threats and can have implications for economy, politics, or health, a successful and reliable prediction of such events is highly desirable. We investigate extreme events in a high-dimensional deterministic system: a network of FitzHugh-Nagumo units. Mimicking field studies, we assume that the temporal evolution of only some degrees of freedom of the system is observed and that the exact equations of motion are unknown. Addressing these challenges, we present a data-driven approach to predict extreme events which is only based on the time series of some observables and on the coupling topology of the network. By iterative predictions, we are able to forecast the onset of an extreme event as well as the propagation and extinction of excitation, i.e. the full life-cycle of an extreme event.

SOE 24.7 Thu 16:45 BH-N 243

The Role of Perturbation Growth in Critical Transitions and Extreme Events — •Nahal Sharafi[1], Sarah Hallerberg[1], and Marc Timme[1,2] — [1]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany — [2]Göttingen University, Göttingen, Germany

Extreme events and critical transitions happen in a variety of dynamical systems. Marked by their high magnitude as well as their infrequent and irregular occurrence, they can lead to disasters.

Employing quantifiers of chaos, we work towards identifying changes in the dynamical structure of complex systems before an extreme event or a critical transition happens. Next we use these changes as precursors of the events. Apart from possible practical implementations, such as predictions, we use the relation between predictor and event in order to understand the dynamical origins of the events under study.

As candidate precursors, we consider changes in different features of covariant Lyapunov vectors such as growth rate, localization or direction.

SOE 25: Networks: From Topology to Dynamics III (joint session DY / SOE / BP)

Time: Friday 9:30–12:45 Location: BH-N 128

SOE 25.1 Fri 9:30 BH-N 128

Networks: From Dynamics to Topology — •Jose Casadiego[1,3] and Marc Timme[1,2,3] — [1]Network Dynamics, Max Planck Institute for Dynamics and Self-Organization, 37077 Göttingen, Germany — [2]Institute for Nonlinear Dynamics, Faculty of Physics, University of Göttingen, 37077 Göttingen, Germany — [3]IMPRS Physics of Biological and Complex Systems, Göttingen Graduate School for Neurosciences, Biophysics and Molecular Biosciences, 37077 Göttingen, Germany

How single units interact in a complex network fundamentally underlies its collective dynamics. Yet, identifying the physical structure of interactions from recorded time series still poses a great challenge. Up-to-date methods either require (i) a detailed pre-knowledge of the units' dynamical features, (ii) to externally drive the network or (iii) the network dynamics to be at stable states, such as fixed points or limit cycles. Here we develop a theory to reveal physical interactions of networks that relies on recorded time series only. By decomposing the dynamics of single units in terms of network interactions of different orders (pairs, triplets, quadruplets,...), we pose network reconstruction as an error minimization problem. We propose a greedy algorithm to solve such minimization problems. Our approach is principally model independent, ensuring its generality and applicability in different fields and making it particularly suitable when structural connections are desired, dynamical features are unknown and perturbing the network is unfeasible. Thus, our approach may serve as a key stepping stone for the expanding field of model-independent network reconstruction.

SOE 25.2 Fri 9:45 BH-N 128

Revealing the Topology of Circulatory Networks in Nature — •Mirko Lukovic[1] and Erik Martens[2,3] — [1]Max Planck Institute for Dynamics and Self-Organization, Goettingen, Germany —

[2]Department of Biomedical Sciences, University of Copenhagen, Denmark — [3]Department of Mathematical Sciences, University of Copenhagen, Denmark

Complex networks such as those used for communication, resource delivery and transportation are ubiquitous in nature and society. From the internet and urban traffic, to the intimate networks of the circulatory systems in our bodies, understanding how their topology and structure relate to their function and efficiency is an essential first step in their management. Given the wide variety of existing transport networks with structures that range from being tree-like to cases where there is an intricate arrangement of nested loops, our goal is to use circulation times of the flow in order to infer global properties of the underlying network structure. To this end we investigate circulatory transport networks by modeling the flow as a stochastic process whose first passage time properties we determine for a variety of different network topologies. We also set up a framework in which different branching rules of the flow can be tested and its effects on the first passage times analyzed. Our results will help develop an effective and non-invasive method for probing circulatory networks such as the human vascular system.

SOE 25.3 Fri 10:00 BH-N 128

Symbolic Regression and Network Analysis for the prediction of El Nino — •Markus Abel[1], Markus Quade[1], Ruggero Vasile[1], Avi Goz[2], Shlomo Havlin[3], and Armin Bunde[4] — [1]Ambrosys GmbH, Albert-Einstein Str. 1-5 Potsdam, Germany — [2]Department of Solar Energy & Environmental Physics, Ben-Gurion University, Jerusalem, Israel — [3]Department of Physics Bar-Ilan University Ramat-Gan 52900 Israel — [4]Institute For Theoretical Physics, University of Giessen, Germany

In the context of the modeling of dynamical systems, statistical analysis and data-based modeling is a hihgly promising method. We use symbolic regression, in particular genetic programming and nonparamtric regression to find effective models for the prediction of el Nino events. The data used consist of a novel method to form a network from the correlations of grid points in the El Nino basin. We compare our results with existing methods. Depending on the method used a predictive power of up to 100% is achieved, i.e. all events are correctly predicted.

SOE 25.4 Fri 10:15 BH-N 128

Model selection and hypothesis testing for large-scale network models with overlapping groups — •Tiago P. Peixoto — Institut für Theoretische Physik, Universität Bremen

The effort to understand network systems in increasing detail has resulted in a diversity of methods designed to extract their large-scale structure. Unfortunately, many of these methods yield diverging descriptions of the same network, making both the comparison and understanding of their results a difficult challenge. A possible solution to this outstanding issue is to shift the focus away from arbitrary methods, and move towards principled approaches based on statistical inference of generative models. In this talk we consider the comparison between a variety of generative models including features such as degree correction, where nodes with arbitrary degrees can belong to the same group, and community overlap, where nodes are allowed to belong to more than one group. Because such model variants possess an increased number of parameters, they become prone to overfitting. We present a method of model selection based on the minimum description length criterion and posterior odds ratios that is capable of fully accounting for the increased degrees of freedom of the larger models, and selects the best one according to the statistical evidence available in the data. In applying this method to many empirical datasets from different fields, we observe that community overlap is very often not supported by statistical evidence, and is selected as a better model only for a minority of them. On the other hand, we find that degree-correction tends to be almost universally favored by the available data.

SOE 25.5 Fri 10:30 BH-N 128

Breakdown of quantum transport in scale-free networks — •Nikolaj Kulvelis and Oliver Mülken — Uni-Freiburg, Deutschland

We apply the model of continuous time quantum walks (CTQW) to a subset of scale-free networks (SFN) containing solely trees. A quantity characterising the global transport for large time scales is introduced and, by means of estimating the dominant spectral degeneracy, calculated for given system size and branching strength. Taking the limit of infinite system size a phase transition resembling breakdown of transport is observed beyond a critical branching strength. All our analytic calculations are supported by Monte Carlo simulations and discussed.

SOE 25.6 Fri 10:45 BH-N 128

Two-dimensional unimodular Lattice Triangulations as small-world and scale-free networks — •Benedikt Krüger, Ella Schmidt, and Klaus Mecke — Institut für Theoretische Physik, Staudtstr. 7, 91058 Erlangen

Triangulations are an important tool in physics for describing curved geometries. Unimodular triangulations on 2d lattices can also be considered as connected, simple, and maximal planar graphs, which allows the appliance of methods from graph theory on triangulations. We calculate the scaling behaviour of the degree distribution, clustering coefficient and the average shortest path length for random triangulations. Introducing a simple measure for the order of a triangulation and interpreting it as the energy of the triangulation we measure canonical averages of these observables using Monte-Carlo-Simulations. We find a crossover behaviour of all considered observables at small negative temperatures and hints for small-world and scale-free behaviour in certain temperature ranges.

15 min. break

SOE 25.7 Fri 11:15 BH-N 128

Nonlinear elasticity of athermal networks: a critical phenoemenon — •Abhinav Sharma[1], Albert Licup[1], Michael Sheinman[1], Karin Jansen[2], Gijse Koenderink[2], and Frederick Mackintosh[1] — [1]VU, Amsterdam, Netherlands — [2]AMOLF, Amsterdam, Netherlands

Biopolymer networks exhibit highly interesting mechanical behavior. An instructive model system is that of a network composed of rope-like filaments–zero resistance to compression but finite resistance to stretching. For networks with connectivity below Maxwell point,there is no elastic modulus for small deformations. However,when networks are subjected to an external strain, stiffness emerges spontaneously beyond a critical strain. We demonstrate that the spontaneous emergence of elasticity is analogous to a continuous phase transition. The critical point is not fixed but depends on the geometry of the underlying network.The elastic behavior near the critical point can be described analogous to that of Magnetization in ferromagnetic material near the curie temperature.Surprisingly, the critical exponents are independent of the dimensionality and depend only on the average connectivity in the network.By including bending interactions in the rope network, we can capture the mechanical behavior of biologically relevant networks. Bending rigidity acts as a coupling constant analogous to the external magnetic field in a ferromagnetic system. We show that nonlinear mechanics of collagen are successfully captured by our framework of regarding nonlinear mechanics as a critical phenomenon.

SOE 25.8 Fri 11:30 BH-N 128

Coarsening dynamics of transient networks in an experiment with dipolar hard spheres — •Armin Koegel and Reinhard Richter — Experimentalphysik 5, Universität Bayreuth, D-95440 Bayreuth, Germany

Permanent magnetic dipoles may self-assemble to linear chains and rings, even without an externally applied magnetic field. This has been investigated for nano-sized particles in ferrofluids; see e.g. [1,2] However, in this system the emerging structures and their dynamics are difficult to observe. Similar aggregates have also been observed in a mixture of glass beads and magnetized steel spheres, which are shaken in a vessel [3]. In the present contribution we focus on the formation of transient networks in this system, when quenching the amplitude of the vibrations [4]. We analyze the evolving networks by the number of spheres in a network cluster, its gyration radius, and its average shortest path length.

[1] P.G. De Gennes and A. Pincus, *Phys. Kondens. Mater.* **1**, 189 (1970).

[2] T. A. Prokopieva, V. A. Danilov, S. S. Kantorovich, Ch. Holm, *Phys. Rev. E* **80**, 031404 (2009).

[3] D. L. Blair, A. Kudrolli, *Phys. Rev. E* **67**, 021302 (2003).

[4] http://www.ep5.uni-bayreuth.de/de/research/Magnetic-Soft-Matter/video/ferronetwork.html

SOE 25.9 Fri 11:45 BH-N 128

Exclusion processes on networks — •Izaak Neri[1,2], Norbert Kern[3], and Andrea Parmeggiani[3] — [1]Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Straße 38 01187 Dresden Germany — [2]Max Planck Institute of Molecular Cell Biology and Genetics, Pfotenhauerstr. 108 01307 Dresden — [3]Laboratoire Charles Coulomb UMR 5221 & CNRS, Universite Montpellier 2, F-34095, Montpellier, France

We present a study of exclusion processes on complex networks, as a paradigmatic model for transport subject to excluded volume interactions. Building on the phenomenology of a single segment and borrowing ideas from random networks we investigate the effect of connectivity on transport. In particular, we argue that the presence of disorder in the network crucially modifies the large scale transport features: disorder induces strong density heterogeneities in the network such that certain regions of the network are almost fully congested while other regions allow for free flow of matter.

SOE 25.10 Fri 12:00 BH-N 128

Synchronization-Desynchronization Transitions in Complex Networks: An Interplay of Distributed Time Delay and Inhibitory Nodes — •Carolin Wille[1,2], Judith Lehnert[1], and Eckehard Schöll[1] — [1]Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany — [2]Institut für Theoretische Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany

We investigate the combined effects of distributed delay and the balance between excitatory and inhibitory nodes on the stability of synchronous oscillations in a network of coupled Stuart–Landau oscillators. To this end a network model is proposed for which the stability can be investigated analytically. It is found that beyond a critical inhibition ratio synchronization tends to be unstable. However, increasing distributional widths can counteract this trend leading to multiple resynchronization transitions at relatively high inhibition ratios. All studies are performed on two distribution types, a uniform distribution and a Gamma distribution.[1]

[1] C. Wille, J. Lehnert, and E. Schöll, Phys. Rev. E 90, 032908 (2014)

SOE 25.11 Fri 12:15 BH-N 128

Efficient sampling of networks with high clustering — •Rico Fischer[1], Jorge Leitao[1], Tiago Peixoto[2], and Eduardo Altmann[1] — [1]Max-Planck-Institut für Physik komplexer Systeme — [2]University of Bremen

The problem in network generation is to obtain networks which satisfy specified properties but that are otherwise random. Traditional Markov Chain Monte Carlo methods (like Metropolis-Hastings) can be used in this problem but often fail in important cases, e.g., they do not correctly sample random networks with high clustering coefficients due to a rough >> landscape, which typically leads to abrupt phase transitions, metastable states and hysteresis. In this talk we show how an efficient sampling of high-clustering networks is obtained using multicanonical Monte-Carlo methods. We characterize the efficiency of this method, we use it to investigate the phase transition methods, and we explore different applications.

SOE 25.12 Fri 12:30 BH-N 128

Shape and scaling of spatially embedded transport networks — •Robin de Regt and Christian von Ferber — Coventry University, UK

Real world transport networks are usually embedded in two- or three-dimensional space. Here, we explore the shape and scaling properties of these spatially embedded complex networks. The work presented we focus on the interplay of spatial embedding and scaling statistics. In particular, complex transport networks of public transport appear to show that spatial and scaling properties within these networks are closely correlated. To support our claim we have analysed a number of public transport networks in a number of large scale conglomerations.