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Overview of Invited Talks and Sessions

(Lecture rooms MA 001, H 0104, BH-N 128, H 2033, EB 107, Urania, and Poster E)

Public Evening talk (in german)

PLV X	Wed	20:00–21:00	Urania	**Kollektive Dynamik in Sozialen Systemen: Netzwerke, Emotionen und Big Data** — •Frank Schweitzer

Invited Tutorial talks

SOE 1.1	Sun	16:00–16:50	H 0104	**Market microstructure: dynamics of the stock markets** — •Thomas Guhr
SOE 1.2	Sun	16:50–17:40	H 0104	**Maximum-entropy models in economics and finance** — •Tiziano Squartini
SOE 1.3	Sun	17:40–18:30	H 0104	**350 years of puzzles in economics – and a solution.** — •Ole Peters

Young Scientist Award for Socio- and Econophysics (YSA) - Award Session and Prize Talk

SOE 6.1	Mon	15:00–15:45	MA 001	**Tipping points and crises in simple macroeconomic models** — •Jean-Philippe Bouchaud
SOE 6.2	Mon	16:00–16:45	MA 001	**Network science beyond networks: Information flow models for social and biological systems** — •Martin Rosvall

Invited and Topical Talks

SOE 8.1	Tue	9:30–10:15	MA 001	**Estimation of Agent-Based Models using Sequential Monte Carlo Methods** — •Thomas Lux
SOE 18.1	Thu	9:30–10:00	MA 001	**Epidemic threshold on temporal networks** — •Vittoria Colizza
SOE 18.2	Thu	10:00–10:30	MA 001	**Critical regimes driven by recurrent mobility patterns of reaction-diffusion processes in networks** — •Jesus Gomez-Gardenes
SOE 18.3	Thu	10:30–11:00	MA 001	**Phase Transitions in Cooperative Coinfections** — •Peter Grassberger, Li Chen, Fakhteh Ghanbarnejad, Weiran Cai
SOE 18.4	Thu	11:15–11:45	MA 001	**Linear and nonlinear scenarios of societal change** — •Andrzej Nowak
SOE 18.5	Thu	11:45–12:15	MA 001	**Collective Sensing and Decision-Making in Animal Groups: From Fish Schools to Primate Societies** — •Iain Couzin
SOE 23.1	Fri	9:30–10:00	MA 001	**Network reconstruction for the prediction of spreading processes** — •Diego Garlaschelli

Sessions

SOE 1.1–1.3	Sun	16:00–18:30	H 0104	**Tutorial: Dynamics and Fluctuations in Economic and Financial Markets (joint session SOE/DY/TUT/AKjDPG)**
SOE 2.1–2.4	Mon	9:30–10:30	MA 001	**Financial Markets and Risk Management I**
SOE 3.1–3.4	Mon	10:30–11:30	MA 001	**Economic Models I**
SOE 4.1–4.7	Mon	11:30–13:15	MA 001	**Social Systems, Opinion and Group Dynamics I**
SOE 5.1–5.4	Mon	12:00–13:00	BH-N 128	**Energy Systems / Power Grids (joint session DY/SOE)**
SOE 6.1–6.2	Mon	15:00–17:00	MA 001	**Award Session: Young Scientist Award for Socio- and Econophysics (YSA)**
SOE 7.1–7.31	Mon	17:00–20:00	Poster E	**Poster**
SOE 8.1–8.1	Tue	9:30–10:15	MA 001	**Monte Carlo Methods in Financial Market Modeling (Invited Talk Thomas Lux)**
SOE 9.1–9.4	Tue	10:15–11:30	MA 001	**Economic Models II**
SOE 10.1–10.4	Tue	11:30–12:30	MA 001	**Financial Markets and Risk Management II**
SOE 11.1–11.3	Tue	12:30–13:15	MA 001	**Evolutionary Game Theory (joint session SOE/DY/BP)**
SOE 12.1–12.7	Tue	14:00–15:45	MA 001	**Focus Session: Opinion Formation and Voter Models**
SOE 13.1–13.11	Wed	9:30–12:15	MA 001	**Networks: From Topology to Dynamics (joint session SOE/CPP/BP/DY)**
SOE 14	Wed	12:15–13:00	MA 001	**Annual Member's Assembly**
SOE 15.1–15.1	Wed	15:00–15:30	MA 001	**Dynamics in Real-World Multiplex Networks (Invited Talk Vito Latora) (joint session DY/SOE)**
SOE 16.1–16.9	Wed	15:30–18:00	MA 001	**Networks: From Topology to Dynamics (joint session DY/SOE)**
SOE 17.1–17.3	Wed	18:15–19:00	MA 001	**Social Systems, Opinion and Group Dynamics II**
SOE 18.1–18.9	Thu	9:30–13:15	MA 001	**Complex Contagion Phenomena I (Focus Session with EPS-SNPD) (joint session SOE/DY/BP)**
SOE 19.1–19.11	Thu	10:00–13:00	BH-N 128	**Chimera states: symmetry-breaking in dynamical networks (joint session DY/SOE)**
SOE 20.1–20.4	Thu	15:00–18:00	H 2033	**Reduction and Emergence in Econophysics (joint session AGPhil/SOE)**
SOE 21.1–21.5	Thu	15:00–16:15	MA 001	**Traffic Dynamics, Urban and Regional Systems (joint session SOE/DY)**
SOE 22.1–22.7	Thu	16:15–18:00	MA 001	**Focus Session: Computational Social Science**
SOE 23.1–23.13	Fri	9:30–13:15	MA 001	**Complex Contagion Phenomena II (Focus Session with EPS-SNPD) (joint session SOE/DY/BP)**
SOE 24.1–24.8	Fri	10:00–12:15	EB 107	**The Physics of Power-Grids – Fluctuations, Synchronization and Network Structures (joint session DY/SOE)**

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

Wednesday 12:15–13:00 MA 001

- Report on activities and general announcements
- Elections
- Miscellaneous

SOE 1: Tutorial: Dynamics and Fluctuations in Economic and Financial Markets (joint session SOE/DY/TUT/AKjDPG)

Financial and economic markets display nontrivial fluctuation statistics that called attention among physicists. Methods from statistical physics have demonstrated to be able to derive stylized facts from microscopic models, to extract networks from data, and to relate multivariate economic time series to the underlying mechanisms.

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

Tutorial SOE 1.1 Sun 16:00 H 0104

Market microstructure: dynamics of the stock markets — •Thomas Guhr — Fakultät für Physik, Universität Duisburg-Essen

At first sight, stock prices look like random walks. Indeed, Brownian motion models and related stochastic processes do a good job in describing some of the features which are empirically found in financial data. This is consistent with Fama's celebrated Efficient Market Hypothesis (EMH) which states that price changes are unpredictable. However, the closer one looks, the less reliable are those schematic models. This is so, because the way how the trading proceeds in time, i.e. the rules imposed and the ensuing dynamics, is largely ignored. Traders submit their buy and sell orders to the order book, whose content is made available to all market participants. The order flow eventually leads in a highly complex fashion to the realized prices.

Market microstructure is a quickly growing field in which economists, physicists, data scientists and mathematicians try to clarify these dynamical processes. An appealing feature, particularly for physicists, is the wealth of data available for analysis and subsequent model building. I am going to present large-scale data analysis to identify non-Markovian features. Fundamental economic reasoning as in the EMH favors Markovian models in which prices develop (apart from a deterministic drift) without memory. Sizeable memory effects could be exploited to make profit. I will present large-scale data analyses which show that there are various non-Markovian effects due to the highly complex market dynamics. Thus, there are limits to market efficiency which, furthermore, can be quantitatively identified.

Tutorial SOE 1.2 Sun 16:50 H 0104

Maximum-entropy models in economics and finance — •Tiziano Squartini — IMT School for Advanced Studies Lucca, P.zza San Francesco 19, 55100 Lucca (IT)

Entropy-maximization represents the unifying concept underlying the definition of a number of methods which are now part of the discipline known as "network theory". Despite the perfect generality of this approach, a particularly fruitful application of it has been observed in disciplines like economics and finance. This tutorial will be devoted to illustrate the methodological aspects of the aforementioned approach, with particular emphasis on the definition of null models. The latter can be employed in a number of applications, ranging from pattern detection to network reconstruction: examples will be provided of both, by taking as case studies real-world systems, as the World Trade Web and the Dutch Interbank Network. The aforementioned framework also allows one to properly model fluctuations: the latter can be interpreted as errors affecting the estimation of the quantities of interest and strongly depend on the kind of constraints defining the maximization procedure. In order to illustrate how different reconstruction algorithms perform, a comparison of proposed approaches on the aforementioned real-world systems will be also carried out.

Tutorial SOE 1.3 Sun 17:40 H 0104

350 years of puzzles in economics – and a solution. — •Ole Peters — London Mathematical Laboratory — Santa Fe Institute

In 1654 Fermat and Pascal puzzled over a gambling problem and invented probability theory. Three years later, Huygens declared that random quantities and their expectation values are "the same thing." Economics was the first adopter of the budding theory and to this day maintains much of the spirit of Huygens's early proclamation. Problems arising from this view of randomness have led to numerous puzzles in economic theory and beyond. An early example is the St. Petersburg paradox of 1713, a recent example is the insurance puzzle in general competitive equilibrium theory.

Economics has responded to these puzzles largely with labels. Humans are labelled irrational or risk averse.

An alternative treatment emerged from physics, where randomness entered in the 1850s with the development of statistical mechanics. Here, the question of ergodicity arose: are expectation values indicative of temporal behavior? The insight that in many cases an expectation value does not reflect the dynamics can be used to resolve the class of economics puzzles I will discuss. It leads to an alternative economic formalism that makes testable predictions. It can answer economic questions by assessing systemic stability where previously only moral assessments were available.

More at https://ergodicityeconomics.com/lecture-notes/

SOE 2: Financial Markets and Risk Management I

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

SOE 2.1 Mon 9:30 MA 001

Reality-check for Econophysics: Likelihood-based fitting of physics-inspired market models to empirical data — •Nils Bertschinger[1,2], Iurii Mozzhorin[2], and Sitabhra Sinha[3] — [1]Frankfurt Institute for Advanced Studies — [2]Goethe University, Frankfurt am Main — [3]Institute of Mathematical Sciences, Chennai

The statistical description and modeling of volatility plays a prominent role in econometric, risk management and finance. GARCH and stochastic volatility models have been intensively studied and are routinely fitted to market data, albeit providing a phenomenological description only.

In contrast, the field of econophysics explains observed market statistics as emerging from the collective dynamics of many actors following heterogeneous, yet simple, rather mechanistic rules. While such models generate volatility dynamics qualitatively matching several stylized facts and thus illustrate the possible role of different mechanisms, such as chartist trading, herding behavior etc., rigorous and quantitative statistical fits are still mostly lacking.

Here, we show how *Stan*, a modern probabilistic programming language for Bayesian modeling, can be used to fit several models from econophysics. In contrast to the method of moment matching, which currently gains popularity, our fits are purely likelihood based with many advantages, including systematic model comparison and principled generation of model predictions. In particular, we investigate the models by Vikram & Sinha and Franke & Westerhoff, and provide quantitative comparisons with standard econometric models.

SOE 2.2 Mon 9:45 MA 001

Information Transmission Channels of the Foreign Exchange Network — •Alexander Becker, Irena Vodenska, and H Eugene Stanley — Boston University, Boston, USA

The foreign exchange market is a network in which the currencies are the nodes and the exchange rate pairs are the edges. While the underlying macroeconomic fundamentals describe the nodes, trading happens on the edges. In an attempt to understand the dynamics of the foreign exchange market, we need to separate the information contained in the nodes from the information in the links.

We use the symbolic performance, describing the appreciation and depreciation of currencies against all other currencies in the market, in other words, the node state, to evaluate the information that is encoded in the edges of the network. We compare the empirical distribution of a pair of nodes with the distribution that arises from a

maximum entropy approach. This allows us to quantify the strength of the co-movement of two currencies with respect to the entire market.

We link our results to trading volume of commodities and goods as well as central bank and other political interventions. Our approach allows us to observe the dramatic impact of the capping of the Swiss franc with respect to the euro as well as an decrease in importance of the US dollar with respect to currencies from emerging markets and South East Asia.

SOE 2.3 Mon 10:00 MA 001

Identifying Market States by Methods of Portfolio Management — •Jan Jurczyk and Alexander Eckrot — Universität Regensburg

The world is still thinking about the financial crisis peaking in September 2008. The triggering event was the bankruptcy of Lehman Brothers. To detect such turmoils, one can investigate the time-dependent behaviour of correlations between assets or indices. These cross-correlations have been connected to the systemic risks within markets by several studies in the aftermath of this crisis. We study the SP 500 and DJIA which cover almost all aspects of the US economy and show that monitoring the investor's behaviour approximated by portfolio management mehtods can be used to quantify times of market transition. A method is shown which identifies financial market states and we present evidence of the sharpe transition of 2008.

SOE 2.4 Mon 10:15 MA 001

Extreme portfolio loss correlations in credit risk — •Andreas Mühlbacher and Thomas Guhr — Universität Duisburg-Essen, Lotharstr. 1, 47048 Duisburg

The stability of the financial system is associated with systemic risk factors such as the concurrent default of numerous small obligors. Hence it is of utmost importance to study the mutual dependence of losses for different creditors in the case of large, overlapping credit portfolios. We analytically calculate the multivariate joint loss distribution of several credit portfolios on a non-stationary market. To take fluctuating asset correlations into account we use an random matrix approach which preserves, as a much appreciated side effect, analytical tractability and drastically reduces the number of parameters. We show that for two disjoint credit portfolios diversification does not work in a correlated market. Additionally we show that significant correlations of the losses emerge not only for large portfolios with thousands of credit contracts but also for small portfolios consisting of a few credit contracts only. Furthermore we include subordination levels, which were established in collateralized debt obligations to protect the more senior tranches from high losses. We analytically corroborate the observation that an extreme loss of the subordinated creditor is likely to also yield a large loss of the senior creditor.

SOE 3: Economic Models I

Time: Monday 10:30–11:30 Location: MA 001

SOE 3.1 Mon 10:30 MA 001

Bilateral trade agreements and the interconnectedness of global trade — Jullian Maluck[1,2], Nicole Glanemann[1,3], and •Reik V. Donner[1] — [1]PIK Potsdam, Germany — [2]HU Berlin, Germany — [3]WHU - Otto Beisheim School of Management, Vallendar, Germany

Over the last decades, bilateral trade agreements (BTAs) have increased considerably in number and economic relevance. Notably, such agreements substantially affect global trade, since the reorganization of flows of goods and services has prominent impacts on the contracting countries' economic sectors, but also on other parties that are (directly or indirectly) engaged in trade with these countries. Here, we empirically study the effect of BTAs on the input-output linkages between the contractual parties' national economic sectors by measuring their Trade Interconnectedness (TI), which describes the relative importance of direct and indirect production linkages between the two countries. By analyzing its time evolution for each pair of trade agreement partners, we demonstrate that while most BTAs are succeeded by an increase in TI between the contractors, there are some notable exceptions. In particular, comparing the trade profiles of China and the United States (US), we find indications that both countries have been pursuing fundamentally different objectives and strategies related to the negotiation of BTAs.

SOE 3.2 Mon 10:45 MA 001

Stability analysis of a time-homogeneous system of money and antimoney in an agent-based random economy — •Julian Stein and Dieter Braun — Systems Biophysics LMU

One source of financial instability might be the creation of money [1] also leading to non-local transfers of wealth (Cantillon effect) and a loss of economic memory [2]. Motivated by an analogy to particle physics, time-homogeneity can be imposed on monetary systems to solve the associated problems. As a result, full reserve banking is implemented by a two-currency system of non-bank (money) and bank assets (antimoney) [3]. Payments are either made by passing on money or receiving antimoney at respective price levels. Liquidity is provided by the simultaneous transfer of money and antimoney from seller to buyer at a negotiated liquidity price. Thus interest rates and credit are implemented by a varying price for liquidity. We aim to study the problem of credit crunches in such systems. An agent-based random economy is set-up, in which households and firms apply stochastic trading strategies to exchange goods via a limit order book mechanism.

The comparison of the prevailing monetary system with the money-antimoney system shows that symmetric price equilibria can be reached by imposing a limit on the agents antimoney holdings. Quantity theory is satisfied. Crash and boom scenarios show a quantitative and qualitative similar behavior for the different monetary systems, indicating the overall functionality of the money-antimoney system.

[1] Am Econ Rev 102 (2012) [2] New J Phys 16, 033024 (2014), [3] Physica A 290, 491 (2001)

SOE 3.3 Mon 11:00 MA 001

Repeated gambles with uncertain parameters — •Mark Kirstein[1], Alexander Adamou[2], and Ole Peters[2,3] — [1]Economics Department, TU Dresden — [2]London Mathematical Laboratory — [3]Santa Fe Institute

Gambles repeated multiplicatively create non-ergodic changes in the gambler's wealth. The growth-optimal bet fraction maximises the time-average growth rate of his wealth or, equivalently, expected changes in his logarithmic utility. Standard treatments use models in which the gambler knows with certainty the parameters (i.e. the payoffs and probabilities) of the gamble. Here we confront the theoretically appealing results of such analyses with reality outside the model world. A realistic environment is one about which the gambler has some ignorance, manifested as uncertainty in his estimate of the gamble parameters. We build a simple model of this uncertainty, in addition to the more familiar uncertainty in the gamble's outcome. We find that a gambler maximising the time-average growth rate of his wealth under such conditions would bet a lower fraction of his wealth than anticipated by an observer making a conventional analysis, which assumes the gamble parameters are known. Indeed, it would look to this observer as if a gambler were weighing probabilities non-linearly, a psychological bias identified by behavioural economists as inconsistent with all models of rationality. Our approach, conversely, explains the gambler's behaviour as consistent with a straightforward optimisation strategy through time that accounts for his ignorance about the environment, for which no psychological assumptions are needed.

SOE 3.4 Mon 11:15 MA 001

The winner takes it all. But who wins and how? — •Chengyuan Han[1,2,3], Malte Schröder[4], and Dirk Witthaut[1,3] — [1]Forschungszentrum Jülich, Institute for Energy and Climate Research - Systems Analysis and Technology Evaluation (IEK-STE), 52428 Jülich, Germany — [2]Department of Physics and Astronomy, Rheinische Friedrich-Wilhelms Universität Bonn, 53115 Bonn, Germany — [3]Institute for Theoretical Physics, University of Cologne, 50937 Köln, Germany — [4]Network Dynamics, Max Planck Institute for Dynamics and Self-Organization (MPIDS), 37077 Göttingen, Germany

In economies of scale, specific production costs decrease as the production increases. This leads to a centralization of production when

transaction costs are negligible: The winner takes it all. But who wins this competition and how? We study a mathematical model of trade, which each node in a network individually tries to minimize the costs, including production and transaction costs, to satisfying a fixed demand. This optimization problem can be simplified to a local percolation model, and admitting an efficient solution. We show that centralization process can be discontinuous and study which node becomes the central producer. Surprisingly, the model reveals that closeness centrality is not always a good indicator to the final supplier of the network. In geographically embedded networks, nodes with the low degree and betweenness centrality are more likely to win. We also introduced the idea of Entropy to maximize the diversity of the purchase.

SOE 4: Social Systems, Opinion and Group Dynamics I

Time: Monday 11:30–13:15 Location: MA 001

SOE 4.1 Mon 11:30 MA 001

Predicting hidden user properties using online egocentric networks — •Gábor Tamás and János Török — Department of Theoretical Physics, Budapest University of Technology and Economics, H-1111 Budapest, Hungary

Social physics applies the methods of statistical physics to study the effects of human relations. Social networks are considered to be composed of humans as nodes and social relations as links between them. Using data from online social networks it is possible to study the properties and behavior of humans and even pin out and correct errors and missing information. Here we aim to predict the age of egos with a very simple method. This is an important issue in a world when privacy is a key issue.

We had access to a Hungarian social network site, where the connections and the birth date of the registered users were given. The basis of our method is to use the egocentric network of people to determine its communities and the average age within them. We found that most of our acquaintances have similar age as we have or they are 25 year younger or older (different generation) which could be separated by histogram technique.

Our algorithm does not use machine learning methods and is based only on a few assumptions. It was very efficient, in some cases the code predicted the age of the ego with more than 90 % probability with 2 years accuracy. Our success suggests that we need the privacy of our friends to hide our properties.

SOE 4.2 Mon 11:45 MA 001

Quantifying and suppressing ranking bias — •Giacomo Vaccario[1], Matus Medo[2], Nicolas Wider[1], and Manuel S. Marian[2] — [1]ETH, Zurich, Switzerland — [2]University of Friburg, Friburg, Switzerland

With the increasing size of information repositories as the World Wide Web or scholarly publication databases, we rely more and more on rankings algorithms to filter and rank information. Ranking algorithms that have proven to be particularly successful are those based on a network perspective, such as Google's PageRank, or on normalization procedure, such as relative citation count. Even though these algorithms seem to be objective and hence, are often considered "fair" they have strong biases. For example, the popular Google PageRank is known to fail in individuating young valuables nodes in time evolving networks. For this reason we propose a new method to define and quantify biases of rankings. In this method, we define a null model based on a multivariate hyper-geometric distribution to generate random, but unbiased rankings. Then we quantify the bias of a given ranking by computing its average deviation from the unbiased rankings using the Mahalanobis distance. As example, we apply the proposed method on established indicators of papers importance (citation count, relative citation count and PageRank) and show that their rankings are biased with respect to both the age and topic of the papers. Finally, we give a general normalization procedure to partially cure the observed biases.

SOE 4.3 Mon 12:00 MA 001

Are modern democracies dynamical unstable? — •Claudius Gros — Institute for Theoretical Physics, Goethe University Frankfurt

Modern societies face the challenge that the time scale of opinion formation is continuously accelerating in contrast to the time scale of political decision making. With the latter remaining of the order of the election cycle we examine here the case that the political state of a society is determined by the continuously evolving values of the electorate. Given this assumption we show that the time lags inherent in the election cycle will inevitable lead to political instabilities for advanced democracies characterized both by an accelerating pace of opinion dynamics and by high sensibilities (political correctness) to deviations from mainstream values. Our result is based on the observation that dynamical systems become generically unstable whenever time delays become comparable to the time it takes to adapt to the steady state. The time needed to recover from external shocks grows in addition dramatically close to the transition. Our estimates for the order of magnitude of the involved time scales indicate that sociopolitical instabilities may develop once the aggregate time scale for the evolution of the political values of the electorate falls below 7-15 months.

European Physical Journal B 90, 223 (2017).

SOE 4.4 Mon 12:15 MA 001

How to effectively use LinkedIn to enhance your employability? Insights from a social experiment in India — •Yash Chawla, Rafal Weron, Grzegorz Chodak, and Katarzyna Sznajd-Weron — Wroclaw University of Science & Technology, Wroclaw, Poland

LinkedIn is one of the leading social networks for building professional profiles, with over 39 million students/graduates on the platform. However, students treat LinkedIn as a job application portal rather than a professional networking platform. Through observations and monitoring activities, we have developed a simple protocol for the students to increase their employability. The protocol defines the content strategy as well as the type of users, groups, company pages to follow and engage with. We have carried out an empirical study among a group of 100 students in India, half of which applied the protocol, and have been able to determine that the protocol gave students an advantage in terms of job availability information, skill set requirements identification, mentoring, making applications and recruitment. We believe that our study not only provides practical advice for LinkedIn users, but also valuable insights for researchers modeling opinion formation and information spreading in social networks.

SOE 4.5 Mon 12:30 MA 001

A Qualitative Introduction to Normative Sociodynamics — •Hermann Rampacher — Rampacher&Partner GbR VDE Überlingen

In normative sociodynamics peace is an observable P depending on n arguments p[a(i)], where a(i) are actions performed with probability p[a(i)].If for increasing p a(i) contributes with the value b(i) to increase the risk of global self-destruction, a(i) is prohibited by a social norm. n p[a(i)] with the largest values b(i) represent states of a certain social system. If n norms are obeyed, P reaches its ideal value. We postulate: if a social system's solidarity - everybody does one's duty - reaches its ideal value, as well as peace reaches its ideal value. Action d(i) if done, is a duty, as far as d(i) contributes to reduce the risk of global self-destruction. Solidarity as a long-term project always differs from its ideal value, consequently P differs from its ideal value, because needy men without immediate help are forced to violate some norms to get what they need to survive. Government interventions - the government has the monopoly on the use of force - to approximate real and ideal value of P has to put through norms with larger b(i) at the expense of those of smaller b(j). The smaller the intervention force - including death penalties and imprisonment -, the higher is the value of the nation's justice. Another observable, more simple to measure, the social temperature T, observes the actual probabilities of force between citizens and between citizens and their government. The larger T, the worse the actual prognosis of a nation's stability, peace and future.

SOE 4.6 Mon 12:45 MA 001

The role of educational trainings in the diffusion of smart

metering platforms: An agent-based modeling approach — •Tomasz Weron[1], Anna Kowalska-Pyzalska[2], and Rafał Weron[2] — [1]Faculty of Pure and Applied Mathematics, Wrocław University of Science and Technology, 50-370 Wrocław, Poland — [2]Department of Operations Research, Wrocław University of Science and Technology, 50-370 Wrocław, Poland

Using an agent-based modeling approach we examine the impact of educational programs and trainings on the diffusion of smart metering platforms (SMPs). We also investigate how social responses, like conformity or independence, mass-media advertising as well as opinion stability impact the transition from predecisional and preactional behavioral stages (opinion formation) to actional and postactional stages (decision-making) of individual electricity consumers. We find that mass-media advertising (i.e., a global external field) and educational trainings (i.e., a local external field) lead to similar, though not identical adoption rates. Secondly, that spatially concentrated 'group' trainings are never worse than randomly scattered ones, and for a certain range of parameters are significantly better. Finally, that by manipulating the time required by an agent to make a decision, e.g., through promotions, we can speed up or slow down the diffusion of SMPs.

SOE 4.7 Mon 13:00 MA 001

The Packing Rate: a new gold standard in estimating the strength of soccer teams? — •Andreas Heuer — Inst. f. Phys. Chemie, WWU Münster, Germany

A few years ago a new objective metric, the packing rate, has entered the field of soccer statistics. It expresses the total number of players of the opponent which are taken out by passes or by dribbles of a team and has been used by different media to express the strength of soccer teams.

In this presentation, we analyze the information content of this observable. An informative quantity has to fulfill two requirements. (1) In the long-time limit, i.e. without random effects, it has to display a high correlation with the team strength as reflected by the actual results of the team. (2) The random contributions have to be small.

These and other properties of this new metric are analysed on an objective level and compared with other observables, which currently are used to express the strength of soccer teams [1]. It turns out that the packing rate is highly informative.

[1] A. Heuer, O. Rubner, PLoS ONE 9, e104647 (2014)

SOE 5: Energy Systems / Power Grids (joint session DY/SOE)

Time: Monday 12:00–13:00 Location: BH-N 128

SOE 5.1 Mon 12:00 BH-N 128

Energy recuperation system for skip trucks — •Robin Masser, Karsten Schwalbe, and Karl Heinz Hoffmann — Chemnitz University of Technology, Chemnitz, Germany

When braking with conventional brake discs, kinetic energy is converted into heat that is released to the environment. The reduction of the energy made unusable in this process has been in the focus of research during the last decades. Following this goal, our work aims to reduce the fuel consumption of commercial vehicles, in particular of skip trucks. Therefore, a module consisting of a hydraulic pump driven by the cardan shaft and a bladder accumulator is installed to store and reuse energy. The stored energy may then be used to operate auxiliary units, to support the thermal management and as additional propulsion. This system consisting of the hydraulic components, the cooling circuit as well as pressure and heat losses is modeled applying endoreversible thermodynamics. Based on this model, system parameters and control strategies can be optimized in terms of power and efficiency. The resulting fuel and operational cost savings are estimated evaluating recorded urban driving data.

SOE 5.2 Mon 12:15 BH-N 128

Scaling of transmission capacities in coarse-grained renewable electricity networks — •Mirko Schäfer[1], Simon Bugge Siggaard[2], Kun Zhu[1], Chris Risager Poulsen[2], and Martin Greiner[1] — [1]Department of Engineering, Aarhus University, Denmark — [2]Department of Physics and Astronomy, Aarhus University, Denmark

Network models of large-scale electricity systems feature only a limited spatial resolution, either due to lack of data or in order to reduce the complexity of the problem with respect to numerical calculations. In such cases, both the network topology, the load and the generation patterns below a given spatial scale are aggregated into representative nodes. This coarse-graining affects power flows and thus the resulting transmission needs of the system. We derive analytical scaling laws for measures of network transmission capacity and cost in coarse-grained renewable electricity networks. For the cost measure only a very weak scaling with the spatial resolution of the system is found. The analytical results are shown to describe the scaling of the transmission infrastructure measures for a simplified, but data-driven and spatially detailed model of the European electricity system with a high share of fluctuating renewable generation.

SOE 5.3 Mon 12:30 BH-N 128

Frequency fluctuations and dynamically induced cascading failures in power grids — •Benjamin Schäfer[1,2], Dirk Witthaut[3,4], Christian Beck[5], Kazuyuki Aihara[6], Marc Timme[1,2], and Vito Latora[5,7] — [1]Chair for Network Dynamics, Center for Advancing Electronics Dresden (cfaed) and Institute for Theoretical Physics, Technical University of Dresden, 01062 Dresden, Germany — [2]Network Dynamics, Max Planck Institute for Dynamics and Self-Organization (MPIDS), 37077 Göttingen, Germany — [3]Forschungszentrum Jülich, Institute for Energy and Climate Research - Systems Analysis and Technology Evaluation (IEK-STE), 52428 Jülich, Germany — [4]Institute for Theoretical Physics, University of Cologne, 50937 Köln, Germany — [5]School of Mathematical Sciences, Queen Mary University of London, London E1 4NS, United Kingdom — [6]Institute of Industrial Science, The University of Tokyo, Meguro-ku, Tokyo, Japan — [7]Dipartimento di Fisica ed Astronomia, Università di Catania and INFN, I-95123 Catania, Italy

Reliable functioning of infrastructure networks is essential for our modern society. Cascading failures are the cause of most large-scale network outages while small fluctuations dominate the grid on a daily basis. In this talk, we demonstrate the importance of transient dynamics when investigating cascades in power grids. Furthermore, we analyze power grid frequency fluctuations based on measurements from several continents, explaining heavy tails and revealing the impact of trading.

SOE 5.4 Mon 12:45 BH-N 128

Flow-tracing and nodal cost allocation in a heterogeneous highly renewable European electricity network — Bo Tranberg[1], Leon Schwenk-Nebbe[2], Mirko Schäfer[1], Jonas Hörsch[3], and •Martin Greiner[1] — [1]Department of Engineering, Aarhus University — [2]DONG Energy — [3]Frankfurt Institute for Advanced Studies

For a cost efficient design of a future renewable European electricity system, the placement of renewable generation capacity will seek to exploit locations with good resource quality, that is for instance onshore wind in countries bordering the North Sea and solar PV in South European countries. Regions with less favorable renewable generation conditions benefit from this remote capacity by importing the respective electricity as power flows through the transmission grid. The resulting intricate pattern of imports and exports represents a challenge for the analysis of system costs on the level of individual countries. Using a flow-tracing technique, we introduce flow-based nodal levelized costs of electricity (LCOE) which allow to incorporate capital and operational costs associated with the usage of generation capacity located outside the respective country under consideration. This concept and a complementary allocation of transmission infrastructure costs is applied to a simplified model of an interconnected highly renewable European electricity system. We observe that cooperation between the European countries in a heterogeneous system layout does not only reduce the system-wide LCOE, but also the flow-based nodal LCOEs for every country individually.

SOE 6: Award Session: Young Scientist Award for Socio- and Econophysics (YSA)

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

Invited Talk SOE 6.1 Mon 15:00 MA 001

Tipping points and crises in simple macroeconomic models — •Jean-Philippe Bouchaud — CFM, 23 rue de l'Université, Paris, France

We explore the possible types of phenomena that simple macroeconomic models with interactions, frictions and heterogeneities can reproduce. We propose a methodology, inspired by statistical physics, that characterizes a model through its "phase diagram" in the space of parameters. Through this looking glass, we investigate stylized models and find generic phase transitions (or tipping points) between a "good economy" state where unemployment/volatility are low and confidence is high, and a "bad economy" state where unemployment/volatility are high and confidence is low. If the parameters are such that the system is close to such transitions, any small fluctuation may be amplified, leading to a large level of endogenous volatility. This can cause the monetary policy itself to trigger instabilities and be counterproductive. We identify several theoretical scenarios for synchronization and instabilities in large economies that can generate aggregate volatility and acute crises without any identifiable idiosyncratic shocks. This suggests an interesting resolution of the *small shocks, large business cycles* puzzle.

Presentation of the YSA to the Awardee

Prize Talk SOE 6.2 Mon 16:00 MA 001

Network science beyond networks: Information flow models for social and biological systems — •Martin Rosvall — Umeå University, Sweden

To counteract pandemics or comprehend the flows of ideas through social systems, researchers use network flow models. In practice, network flow models have implied memoryless first-order Markov chains on standard networks. However, this conventional approach ignores that the flow direction often depends on more than a single step, that is, where the flows come from or the state of the system. Recent evidence suggests that such higher-order information about real flow pathways is critical for capturing all-important phenomena in the dynamics and function of the system. This evidence exposes a shortcoming of conventional approaches and raises a major scientific question: How can we comprehend the higher-order effects of flow pathways in a barrage of data to understand the continuously changing organization of social and biological systems? In my talk, I will present our work on multilayer and memory networks, which balances under- and overfitting of temporal interaction data with model selection techniques. These techniques allow us to take advantage of today's data explosion for revealing important organizational structures in complex systems and make it possible to address applied research questions in new ways.

After the YSA award session, there is an informal get-together with posters, beer, and pretzels.

SOE 7: Poster

Time: Monday 17:00–20:00 Location: Poster E

SOE 7.1 Mon 17:00 Poster E

The 'Babylonian' Accounts of Society — •Stephen I. Ternyik — POB.201, D-82043 Munich

Since Sumerian and Babylonian times, the socio-physics of our accounting system is based on land as private property. All cyclical economic crises are caused by the exhausting increase of rent over growth (r>g). Nobel laureate R.Stone (1984) already pointed to the scientific problem, that the future accounts of society must statistically balance the economy, ecology and demographics. When rent outperforms growth, banking excesses in credit money do reinforce this depressive instability, thus curbing the incentive for productivity (liquidity flows into assets). The coming acceleration of exponential finance will add to this tendency. Future automation and clean energy can be of human benefit, if we can adjust the accounting systems of our society to the emerging economic reality. Otherwise, we will face a total collapse of the whole body economic. It is like the analogy of a traffic accident that paralyzes all traffic. Spaceship earth can be kept relatively stable, if we will adapt our accounting techniques to dynamic efficiency.

SOE 7.2 Mon 17:00 Poster E

The Geometry of Moore-Penrose Generalized Matrix Inverses — •Martin Erik Horn — Berlin School of Economics and Law/HWR Berlin, FB 1 – Department of Business and Economics, FE Quantitative Methods

More and more introductory business mathematics textbooks present Moore-Penrose generalized matrix inverses as elementary part of the foundations of mathematical economics. This is a didactical problem as most textbooks introduce these inverses by purely algebraic reasoning based on the four Moore-Penrose conditions.

To give a complete picture of these mathematical structures it is helpful to introduce and to describe Moore-Penrose generalized matrix inverses also by using geometric representations based on the ideas of Grassmann's theory of extensions. This didactical path will enable learners to understand that a Moore-Penrose inverse only is the scalar part of a more natural geometric matrix inverse which usually possesses higher-dimensional terms, too

SOE 7.3 Mon 17:00 Poster E

Large-deviation properties of oscillator models of energy grids — •Yannick Feld and Alexander K. Hartmann — Institute of Physics, University of Oldenburg, Germany

The exit from nuclear and fossil-fuel energy is resulting in the need for extensive installation of renewable energy generators. Therefore maintaining a stable energy grid becomes more challenging. To find very stable and very unstable grid topologies we apply Markov Chain Monte Carlo simulations of random networks. With large-deviation techniques, specifically by using an artifical finite-temperature (Boltzmann) ensemble, one can access a broad range of the network probability distribution up to very small probability densities (e.g. 10^{-50})[1]. In the past large-deviation properties of static power grids were investigated [2]. Here we apply the same approach to a dynamic model of power grids, specifically a Kuramoto-like model [3].

[1] A.K. Hartmann, Eur. Phys. J. B **84**, 627-634 (2011)
[2] T. Dewenter and A.K. Hartmann, New J. Phys. **17** 015005 (2015)
[3] G. Filatrella, A.H. Nielsen, and N.F. Pedersen, Eur. Phys. J. B **61** 485-491 (2008)

SOE 7.4 Mon 17:00 Poster E

Lane Change Prediction in an Urban Area — •Karoline Griesbach and Karl Heinz Hoffmann — Institute of Physics Technische Universität Chemnitz, D-09107 Chemnitz, +49 371 531 35456

The prediction of the lane change and its integration in advanced driving assistance systems can reduce traffic accidents. A machine learning algorithm for lane change prediction will be discussed. The algorithm was implemented with different input variables which belong to driver attributes and vehicle attributes. The input data was provided by a naturalistic driving study and divided into a training set and a validation set. The results show that the distinction between lane change and no lane change patterns is possible.

SOE 7.5 Mon 17:00 Poster E

Glassy States of Aging Social Networks — •Forough hassanibesheli[1,3], Leila Hedayatifar[1], Hadiseh Safdari[1], Gholamreza Jafari[1], and Marcel Ausloos[2] — [1]Shahid Beheshti University,Tehran, Iran — [2]Group of Researchers for Applications of Physics in Economy and Sociology (GRAPES), Belgium — [3]Potsdam Institute for Climate Impact Research, Germany

Tension reduction is a predominant principle that contributes to the formation of human interactions. This principle acts as a self-organizing process; it indicates that social communications are estab-

lished based on the tendency towards balanced states. Interesting questions that follow concern what parameters have a pivotal role in the social network dynamics. An appropriate answer seems to lie in the history of relationships. In order to investigate some history (memory) effect on social networks, we introduce a temporal kernel function into the Heider conventional balance theory, allowing for the quality of past relations to contribute to the evolution of the system. We have found out that memory sometimes withstands the quick evolution of the network and eventually preserves the system in unstable but long-lived states namely, glassy states. Under such circumstances, for various time intervals, the system has no tendency to evolve towards global or local minima. In contrast to jammed states (local minimum states), in which systems only experience negative energies, glassy states can occur in positive energy states, thereby imposing instability to and keeping stress in the system.

SOE 7.6 Mon 17:00 Poster E

Are democracies stable? A case study on rise and fall of extremists in Europe — •Kai Seegers, Fakhteh Ghanbarnejad, and Philipp Hövel — Institut für Theoretische Physik, TU Berlin

A German proverb says *competition stimulates business*. This seems to hold true for many examples from politics to economics. Recent outcomes of elections in France, Germany and Austria have shown an increase of power of formerly small right wing parties after the established parties seemed to stop provoking each other and thus lost many votes. Similar examples can be found in marketing of companies, artists creating a fan base and more. In this work we investigate the dynamic of opinions in a population in connection with control measures of different parties with focus on addressing, challenging and attacking the other parties by applying techniques from data mining and analysis of collected digital data. Then we develop a novel approach to model this phenomenon. Finally we compare the real outcome with simulated data and discuss the successful stable strategies for future scenarios.

SOE 7.7 Mon 17:00 Poster E

Statistical patterns of Lithuanian parliamentary elections — •Aleksejus Kononovicius — Vilnius University, Institute of Theoretical Physics and Astronomy, Vilnius, Lithuania

In this contribution we analyze statistical patterns of Lithuanian parliamentary elections. Namely, we consider parties' vote share at polling stations level. Using Bayesian approach we show that the empirical distributions are rather well fitted by the Weibull and Beta distributions, while normal distribution, often used in the literature, works less well. We provide some arguments on why this happens and why normal distribution seems to provide appropriate fit for data considered in the other works. We propose a simple agent-based model, which serves as an argument on why the Beta distribution seems to be the best candidate to fit empirical vote share distributions. The contribution will cover material from [1,2].

[1] A. Kononovicius, Complexity 2017, 7354642 (2017), doi: 10.1155/2017/7354642.

[2] A. Kononovicius, arXiv:1709.07655 [physics.soc-ph].

SOE 7.8 Mon 17:00 Poster E

Multi-Objective Goal Programming Formulation of the Markowitz Portfolio including Diversification with respect to Tail Risks — •Daniel Christopher Merten — Jacobs University, Bremen, Deutschland

The paper aims at adding a tail risk diversification approach to the Markowitz problem, where the tail dependencies are computed using a mixture copula that contains Gaussian and Gumbel contributions whose parameters are estimated based on a maximum likelihood method. In addition, the empirical statistical distributions of the respective assets are reproduced by deploying an extensive set of marginal distributions such as generalized hyperbolic and generalized lambda distributions, while the latter turns out to be the more appropriate option in terms of computational efficiency. Finally, the performance of such an extended Markowitz portfolio is compared to a naive diversification benchmark portfolio.

SOE 7.9 Mon 17:00 Poster E

Fire-walling banks and assets: A network based approach — Sasidevan Vijayakumar[1] and •Nils Bertschinger[2] — [1]Cochin University of Science and Technology, Cochin, India. — [2]Frankfurt Institute for Advanced Studies, Frankfurt am Main

Foreseeing and preventing cascading failures in a financial network is a primary concern in the present era of ever increasing complexity and connectivity in finance. Apart from direct contagion spreading via counter-parties defaulting, another important mechanism by which defaults can propagate in a network of banks is via 'fire-sales' of assets. The initial reasons for such a fire sale could be portfolio constraints, either set by a regulatory authority or due to acute financing needs. Asset liquidation by a bank then depreciate asset prizes and thereby put pressure on the balance sheet of other banks holding the same assets. The latter may then be forced to liquidate its assets thereby triggering further rounds of fire sales.

In this work, we use a quantitative framework to model such 'asset-price-contagion' on a bipartite network consisting of banks and assets. We propose a general centrality measure for this dynamic process which captures the systemic importance of banks as well as assets in the network. Using data from European Banking Authority (EBA), we show that bailing out banks and/or active buying of assets by an agency based on our centrality measure could significantly reduce the probability and extent of contagion. Yet, even such targeted interventions either cannot fully prevent contagion as it exhibits an all-or-nothing phenomenon or incur substantial implementation costs.

SOE 7.10 Mon 17:00 Poster E

Interactive dynamics vs. bursty networks — Ebrahim Sajjadi[1], •Fakhteh Ghanbarnejad[3], Mohammad Reza Ejtehadi[1,2], and Fariba Karimi[4,5] — [1]Department of Physics, Sharif University of Technology, P.O. Box 11155-9161, Tehran 1458889694, Iran. — [2]Center of Excellence in Complex Systems and Condensed Matter (CSCM), Sharif University of Technology, Tehran 1458889694, Iran. — [3]Institut für Theoretische Physik, Technische Universität Berlin, Berlin, Germany — [4]University of Koblenz, Landau, Germany — [5]GESIS, Leibniz Institute for the Social Sciences, Germany

SIS and SIR are common models for describing and predicting the epidemics of the contagious diseases. But these models fail to predict well patterns of spreading dynamics in the case of co-infective diseases, i.e. getting infected by one disease, alters the chance of getting infected by the other one. Co-infection has been studied in the mean field approximation and on complex networks with different topologies [EPL 104 50001 (2013), Nature Physics 11, 936_940 (2015)]. Another study shows temporal correlations of the underlying transmission network, e.g. hospital network, play role on co-infection dynamics [Frontiers in Physics, V 5, P 46 (2017)]. Here we go one step further and study the interplay between burstiness of the temporal networks and different time scales of co-infective dynamics. We show that whithin which range of burstiness, co-infection can effectively spread.

SOE 7.11 Mon 17:00 Poster E

Clustering behaviour and long-range memory in a network-based financial market model with fitness-dependent preferential attachment — Florian Mix[1,2], Julian Maluck[1,2], and •Reik V. Donner[1] — [1]PIK Potsdam, Germany — [2]HU Berlin, Germany

The Cont-Bouchaud model (CBM) is a classical network model of financial markets explaining heavy-tailed stock price fluctuations by the emergence of herding phenomena among traders. Here, we study a thorough extension of the CBM that replaces the uncorrelated random rewiring of links among traders by a simple dynamical process that accounts for the fitness of each trader (measured in terms of its respective economic performance in the past). Specifically, the network of traders exhibits a preferential attachment rule with the linking probability following a Fermi function in dependence on the difference between any two nodes' fitness values. We perform an extensive numerical analysis of the resulting model dynamics in terms of stock price, long-range memory of returns, and probability distributions of emerging cluster sizes, fitness and wealth. Unlike the fixed exponent of the cluster-size distribution of the classical CBM, our model allows for tuning the exponent in terms of the scale parameter of the Fermi function. However, we find that the (finite-time) power-law exponent and the maximum cluster size saturate (if at all) only for very long simulation times, indicating the presence of extraordinary long transients in the model.

SOE 7.12 Mon 17:00 Poster E

From Relational Data to Graphs: Inferring Significant Links using Generalized Hypergeometric Ensembles — •Giona Casiraghi, Vahan Nanumyan, Ingo Scholtes, and Frank Schweitzer — Chair of Systems Design, ETH Zürich, Zürich,

Switzerland

The inference of network topologies from relational data is an important problem in data analysis. Exemplary applications include the reconstruction of social ties from data on human interactions, the inference of gene co-expression networks from DNA microarray data, or the learning of semantic relationships based on co-occurrences of words in documents. Solving these problems requires techniques to infer significant links in noisy relational data.

In this poster, we present a new statistical modeling framework to address this challenge. The framework builds on generalized hypergeometric ensembles, a class of generative stochastic models that give rise to analytically tractable statistical ensembles of directed, multi-edge graphs. We show how this framework can be used to assess the significance of links in noisy relational data. We illustrate our method in two data sets capturing spatio-temporal proximity relations between actors in a social system. The results show that our analytical framework provides a new approach to infer significant links from relational data, with interesting perspectives for the mining of Big noisy data on social systems.

SOE 7.13 Mon 17:00 Poster E

The Expertgame - Measuring Social Capital in the Lab — •Gorm Gruner Jensen[1], Martin Benedikt Busch[2], Marco Piovesan[3], and Jan Olaf Mirko Härter[3] — [1]Institute for Theoretical Physics, University of Bremen, Otto-Hahn-Allee D-28359 Bremen Germany — [2]Biocomplexity, University of Copenhagen, Blegdamsvej 17 2100 København Ø — [3]Økonomisk Institut, University of Copenhagen, Øster Farimagsgade 5, Bygning 26, 1353 København

There is a great interest in studying the dynamics of the formation of social networks. A great number of dynamics have been proposed which lead to networks reproducing observed statistics, such as power law distributions of connectivities or clustering. Here we flip the table and propose an experimental setup, the so called Expert Game, which allow us to directly observe the formation of a self-organized communication network between the participants in the lab. The game consist of a sequence of rounds. At the beginning of each round each player is assigned a question and an expertise. The objective is to find out which players has the expertise matching your question. When a players achieve find their expert they are rewarded with monetary prize. Information is passed between players by sending messages, which are costly to the sender, but free to receive. We find a very high correlation between how many messages a player send, and how many that same player receive. This indicate a reciprocal type of behavior, which effectively punishes the inactive players for not investing in the common good, and helps protecting the active players against exploitation.

SOE 7.14 Mon 17:00 Poster E

Symbolic dynamics techniques for complex systems: Application to share price dynamics — •Dan Xu and Christian Beck — School of Mathematical Sciences, Queen Mary, University of London, London E1 4NS, UK

The symbolic dynamics technique is well-known for low-dimensional dynamical systems and chaotic maps, and lies at the roots of the thermodynamic formalism of dynamical systems. Here we show that this technique can also be successfully applied to time series generated by complex systems of much higher dimensionality. Our main example is the investigation of share price returns in a coarse-grained way [1]. A nontrivial spectrum of Renyi entropies is found. We study how the spectrum depends on the time scale of returns, the sector of stocks considered, as well as the number of symbols used for the symbolic description. Overall our analysis confirms that in the symbol space transition probabilities of observed share price returns depend on the entire history of previous symbols, thus emphasizing the need for a modelling based on non-Markovian stochastic processes. Our method allows for quantitative comparisons of entirely different complex systems, for example the statistics of symbol sequences generated by share price returns using 4 symbols can be compared with that of genomic sequences.

[1] D. Xu and C. Beck, EPL 118, 30001 (2017)

SOE 7.15 Mon 17:00 Poster E

Investigating the effect of deliberate misreporting on opinion formation — •Vincent Kuhlen and Stefan Bornholdt — Institute for Theoretical Physics, University of Bremen, Germany

After elections one may observe the fact that opinion polls underestimated the votes for certain parties. If we assume no errors in the methodologies we are left with only a few possible explanations. One theory is that participants are deliberatly misreporting their preferences in personal interviews due to an element of social stigma. This phenomenon is also known as "shy Tory factor", "shy Trump-ers theory" or "Bradley effect". To examine the effects of this behaviour on opinion formation we studied the voter model on a 2d grid where agents were either neutral, moderate or extremist. Further we assumed that extremists may act like moderates or neutrals while interacting with agents of different opinion and compared the results with the undisturbed case.

SOE 7.16 Mon 17:00 Poster E

Creating the origin of the first Darwinian species — •Charlotte V Vogelbusch[1], Steven H Strogatz[2], Hinrich Arnoldt[1], and Marc Timme[1] — [1]Chair for Networc Dynamics, Institute for Theoretical Physics and Center for Advancing Electronics Dresden (cfaed), TU Dresden, Dresden, Germany — [2]Department of Mathematics, Cornell University, Ithaca, NY 14853, USA

Today's Darwinian evolution based on vertical descent was preceded by collective evolution dominated by horizontal gene transfer (HGT). Currently, no mechanistic dynamical model consistently explains the transition to start Darwinian evolution. Here we introduce a simple model of collectively evolving progenotes, describing genotype changes influenced by individual fitness, mutation, selection and HGT. It is based on a recent proposal characterizing how individual progenotes are dynamically distributed in the space of all possible genotypes by the population entropy [1]. The 'competence', describing the inclination to perform HGT events, was so far considered a non-dynamical bifurcation parameter. In our new model, HGT competence itself evolves dynamically and interacts with the population dynamics. Combining stochastic and nonlinear mean field dynamics illustrates a path towards the first species and the start of Darwinian evolution.

Ref.: [1] Phys. Rev. E 92, 052909 (2015)

SOE 7.17 Mon 17:00 Poster E

On the power-law tail of financial returns: The role of coordinated trading behaviour of heterogeneous speculators — •Ivonne Blaurock, Noemi Schmitt, and Frank Westerhoff — University of Bamberg, Department of Economics, Germany

We propose a novel agent-based financial market model in which the trading behaviour of heterogeneous interacting speculators causes bubbles and crashes, excess volatility, serially uncorrelated returns, fat-tailed return distributions, and volatility clustering. The first three statistical properties are basically due to the speculators' heterogeneity since they all follow their own individual trading signals derived from fundamental and technical analysis. Our main attention here is on the model's ability to produce fat-tailed return distributions and volatility clustering. Schmitt and Westerhoff (JEE, 2017) found that sunspot events may lead to temporary coordination of speculators' trading behaviour. If speculators collectively react to similar trading signals, heterogeneity spontaneously vanishes and extreme returns emerge. Instead of sunspots, our model endogenously generates short-lived periods in which speculators' behaviour is coordinated causing market turmoil. Periods of high volatility are long-lasting since speculators persistently receive strong trading signals due to past price movements.

SOE 7.18 Mon 17:00 Poster E

Opinion Dynamics: Modeling Social Influence as a Coordination Game. — •Michael Schnabel and Daniel Diermeier — University of Chicago, Chicago, USA

We explore the dynamics of binary opinions in a large population of agents that are interacting in an all-to-all fashion and can be described by a mean field model. Individual agents update their opinions by interacting with each other assuming a tendency to align their opinion with that of their partners. The likelihood of an agent to keep or switch its opinion depends on the current state of the system and is described by a rate function that can vary in shape but has to satisfy certain symmetry constraints. Insights about the properties of the system, such as the emergence of collective order (e.g. group-think) are obtained from the diffusion approximation and by calculating the equilibrium distribution of opinions for a representative set of rate functions. From a game theory perspective this type of dynamics is equivalent to a coordination game involving two or more players. We show how to map a given rate function into the corresponding game form and vice versa.

SOE 7.19 Mon 17:00 Poster E

Compulsory Persistent Cooperation in Continuous Public Goods Games — •Yan Li[1,2], Xinsheng Liu[1], and Jens Christian Claussen[2] — [1]Nanjing University of Aeronautics and Astronautics, China — [2]Computational Systems Biology, Jacobs University Bremen

The public goods game (PGG), where players either contribute an amount to the common pool or do nothing, is a paradigm for exploring cooperative behaviors in biological systems, economic communities and other social systems. Since in many situations, including climate game and charity donations, any contribution, however large or small, should be welcome. Consequently, the conventional PGG is extended to a PGG with continuous strategy space, which still cannot escape the tragedy of commons without any enforcing mechanisms. Here we propose persistent cooperation investment mechanisms based on continuous PGG, including single-group games, multi-group games with even investment, non-even investment and non-even investment with preference. We aim to reveal how these investment styles promote the average cooperation level in the absence of any other enforcing mechanisms. Simulations indicate that the multi-group game outperforms the single-group game. Among the multi-group game, non-even investment is superior to even investment, but inferior to non-even investment with preference. Our results may provide an explaination to the emergence of cooperative actions in continuous phenotypic traits based on inner competition and self-management without extrinsic enforcing mechanisms.

SOE 7.20 Mon 17:00 Poster E

Behavioral spruce budworm predation models — •Bhagyashree Hote[1] and Jens Christian Claussen[2] — [1]Computational Life Science Program, Jacobs University Bremen, Germany — [2]Computational Systems Biology, Jacobs University Bremen, Germany

The classical spruce budworm model of predation by birds [Murray, Mathematical Biology, 2002] describes a sublinear onset of predation, motivated by a metaphor that birds predate the spruce budworms only if this food source reaches awareness among the predators. Here we base on our previous extension [Hote et al., 2017], where we explicitely introduce the fraction of birds that are aware of the additional food source as an additional dynamical variable and formulate a plausible dynamics for its increase and decay. For suitable parameters, this model shows an attracting spiral node, which results in damped oscillations of the prey density towards the fixed points. Here we discuss the spatial extension of the model, as well as the transition towards the original model.

SOE 7.21 Mon 17:00 Poster E

Conformity, anticonformity and polarization of opinions: how independence influences the system? — •Katarzyna Hubicka and Tomasz Weron — Faculty of Pure and Applied Mathematics, Wrocław University of Science and Technology, 50-370 Wrocław, Poland

Could independent choices alter a regime? Or are they merely a noise, that may be neglected? Although some research about conformity, anticonformity and their impact on social polarization have been done recently, it is still uncertain how these three can be influenced by the independence. How does it collaborate with them? Does it support the polarization of opinions or perhaps prevents the process? We would like to dispel all the doubts with an expansion of the model, proposed in the paper 'The interplay between conformity and anticonformity and its polarizing effect on society' and revised in the next, entitled 'Conformity, anticonformity and polarization of opinions: insights from a mathematical model of opinion dynamics'.

SOE 7.22 Mon 17:00 Poster E

Stable features in fluctuating supply chains — •Robert Polwin[1,2], Hans Ehm[2], Alexander Seitz[2], and Sebastian M. Krause[1] — [1]Faculty of Physics, University of Duisburg-Essen, 47058 Duisburg, Germany — [2]Infineon Technologies AG, Neubiberg, Germany

Supply chains are complex networks processing the flow of information, currencies and material required for satisfying the customer needs. They are the backbone of todays globally producing industries and enable production and service innovations. Also the semiconductor industry with its long and complex production process and volatile market conditions relies on a stable supply chain network. Here we analyze the supply-demands match of Infineon, a large German semiconductor manufacturer. The customers of Infineon place orders which are daily matched to changing (improved) supply. The daily supply demand match with hundreds of heuristics are performed on hundred thousands of order elements and thousands of supply elements. Despite the fact that real world changes of the confirmed delivery dates towards customers are rare, the detailed analyzes of the confirmation processes (below the customer level) show both statistical features of the order flow, which are stable in time and chaotic patterns. Although the latter once are rare when they occur they exhibit surprising features with causes are not yet understood. These are signs of emergent behavior that goes beyond the dynamics of the systems constituents and are on the one hand of high interest for research on complex system behaviors and give hints to hidden improvement potentials.

SOE 7.23 Mon 17:00 Poster E

Extracting the wide variety of trading in stock markets — Martin Theissen, •Sebastian M. Krause, and Thomas Guhr — Faculty of Physics, University of Duisburg-Essen, Lotharstr. 1, 47048 Duisburg, Germany

Stock markets are complex systems involving large numbers of traders and many correlated stocks. So far, the microscopic analysis and modeling of stock trading was heavily concentrated on single stocks. Here we analyze and compare the trading activity of a large number of stocks [1]. We find that the market microstructure of stocks shows a surprisingly wide variety. Further we identify groups of stocks with a similar behavior. This is helpful for a systemic understanding of stock markets, and for building agent based models of many interacting stocks.

[1] M. Theissen, S.M. Krause and T. Guhr, Regularities and irregularities in order flow data, Eur. Phys. J. B 90, 218 (2017).

SOE 7.24 Mon 17:00 Poster E

Phase transitions in demand driven public transport systems — •Nils Beyer[1], Debsankha Manik[1], Andreas Sorge[1], and Marc Timme[1,2,3] — [1]Network Dynamics, Max Planck Institute for Dynamics and Self-Organization, 37077 Goettingen — [2]Chair for Network Dynamics, Center for Advancing Electronics (cfaed) and Institute for Theoretical Physics, 01062 Dresden — [3]Max Planck Institute for the Physics of Complex Systems, Dresden, 01062

Private cars are a significant source of pollution, energy consumption, congestion, the need for parking space and rising CO2 emissions [1]. Consequently a major challenge of our society in the upcoming decades will be to organize more economic and ecofriendly mobility options. A demand driven public door to door transportation service could be the answer to these problems.

Alonso-Mora et al. developed an algorithm that allows for efficient ride-sharing using only a quarter of the cars currently needed to service New York's taxi customers in their simulations [2]. The influences on the fraction of rides that can be shared in an urban environment has been analyzed by R.Tachet et al. [3]

To offer this service, one not only needs an efficient algorithm to organize taxis or buses, but also basic knowledge of the scaling in the system, as it should function over a range of temporal demand and different topologies. This work uses a discrete event based simulation framework (d3t) [4] to analyze how detours and customer waiting times scale with the amount of buses and customer requests. We start with simple taxi systems and move on to more sophisticated dispatching policies, including the possibility of ride sharing. The main finding is a second order phase transition in the amount of people who cannot be efficiently served by the system.

[1] OECD/ITF (2017), ITF Transport Outlook 2017, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789282108000-en
[2] Alonso-Mora, Javier, et al. "On-demand high-capacity ride-sharing via dynamic trip-vehicle assignment." Proceedings of the National Academy of Sciences (2017): 201611675.
[3] R.Tachet et al. "Scaling law of urban ride sharing." Scientific reports 7 (2017).
[4] A. Sorge et al. "Towards a unifying framework for demand-driven directed transport (D3T)." (WSC '15). IEEE Press, Piscataway, NJ, USA, 2800-2811.

SOE 7.25 Mon 17:00 Poster E

Opinions and consensus in the paradigms-model on different networks — •Yannik Schädler and Stefan Bornholdt — Institute for Theoretical Physics, University of Bremen, Germany

Opinion- and consensus formation in society is an interesting dynamical process, with fashion and paradigm bubbles as an intrinsic feature. Sociophysics models that concentrate on that particular feature have been proposed in recent years [1], [2]. We here study a variant of the

paradigms model and study its dynamics on several network topologies. It contains agents with memory that can interact with neighbours, as well as an innovation and a group-pressure mechanism that generates herding-effects. So far this model has been studied mainly on grid-topologies. The motivation here is to include more realistic social network architectures, and to study the influence of topology in this particular model. We study innovation waiting times or innovation rates in different settings. We find that the network topology indeed changes the dynamics: Simulations show that the network structure strongly affects the likelihood of a consensus.

[1] Katarzyna Sznajd-Weron: Sznajd model and its applications , Acta Physica Polonica B, vol.36, no. 8 (2005)

[2] Bornholdt, S. and Jensen, M. H. and Sneppen, K.: Emergence and Decline of Scientific Paradigms, Phys. Rev. Lett. 106, 058701 (2011)

SOE 7.26 Mon 17:00 Poster E

Studying the Impact of the Filter Bubble effect on Opinion Formations — •Martin Gestefeld and Stefan Bornholdt — Institut for Theoretical Physics, University of Bremen, Germany

In recent years, opinion formation in society appears to be more polarized than in the years before. One hypothesis is that this might be a consequence of online social media and, in particular, the so-called filter bubble effect. The term filter bubble [1] was introduced by Eli Pariser in 2010 and denotes the effect that online social networks and news portals display personalized content via filter algorithms. Therefore it is more likely that a user is confronted with the own opinion resulting in an effective isolation from opposing viewpoints. Here we use the sociophysics model of Deffuant et al.[2] to study this behaviour. Traditionally this continuous model is used to investigate the mixing of beliefs. In order to investigate a filter bubble effect, we modify the Deffuant model by adding a preferential pairing to more similar neighbours. We then study the modified model's dynamics and if this additional dynamics leads to opinion polarization.

[1] Pariser, Eli. The filter bubble: What the Internet is hiding from you. Penguin UK, 2011.

[2] Deffuant, Guillaume, et al.: Mixing beliefs among interacting agents, Advances in Complex Systems 3.01n04 (2000): 87-98.

SOE 7.27 Mon 17:00 Poster E

Opinion dynamics form the perspective of the evolutionary game theory — •Piotr Nyczka — Jacobs University, Bremen, Germany

There are many models in the broad field of opinion dynamics. One of the very intensively studied is the voter model. Actually there are several generalizations of this model known as q-voter, q-r-voter etc. They create the whole class of binary opinion dynamics models. In most of the investigations parameters of these models are fixed, however it seems that nobody knows what could be these parameters in the real world. Moreover, nobody seems to know why their values are like they are.

In this work very important question is addressed: what could be the values of these parameters in the real world and why. A new approach was employed in order to deal with this task. A new model being a beautiful combination of opinion dynamics and the evolutionary game theory is proposed. This model seems to open the brand new perspective for the whole field of opinion dynamics and bring many new questions although.

SOE 7.28 Mon 17:00 Poster E

Bi-modal door-to-door public transportation: a mean-field approach — •Stephan Herminghaus — MPI für Dynamik und Selbstorganisation, Am Fassberg 17, 37077 Göttingen

One of the greatest problems in developing novel public transportation systems is the enormous dynamic range of possible demands. It therefore appears imperative to come up with schemes efficiently coupling different 'modes' of service which feature different benefits. We study a bi-modal coupled system of ride-sharing minibuses and standard line services (like tram) in a mean-field setting. Criteria are developed for jointly optimizing the bi-modal operation, and pertinent scaling relations are derived.

SOE 7.29 Mon 17:00 Poster E

The Voter model with recurrent mobility and Stockholm voting behaviour — •Attila Szilva[1] and Jérôme Michaud[2] — [1]Department of Physics and Astronomy, Uppsala University, Sweden — [2]Department of Physics and Astronomy & Department of Sociology, Uppsala University, Sweden

In order to model the opinion dynamics of voting behaviour in the region of Stockholm, we would like to adapt the Social Influence with Recurrent Mobility (SIRM) variation of the Voter Model to the voting behaviour in the Stockholm region. The initial formulation of the SIRM model has some issues that should be adressed before applying this model to the multiparty situation of Stockholm county. We will present the problem and the data we have as well as preliminary results from simulations. For instance, we will introduce a generalized version of the SIRM model that does no suffer from the issues mentioned above.

SOE 7.30 Mon 17:00 Poster E

Earth system modeling with complex dynamic human societies: the copan:CORE World-Earth modeling framework — •Jonathan F. Donges[1,2], Jobst Heitzig[1], and COPAN team[1] — [1]Potsdam Institute for Climate Impact Research, Potsdam, Germany — [2]Stockholm Resilience Centre, Stockholm University, Stockholm, Sweden

Possible future trajectories of the Earth system in the Anthropocene are determined by the increasing entanglement of processes operating in the physical, chemical and biological systems of the planet and those occurring in its human societies, their cultures and economies. Here, we introduce the copan:CORE open source library that provides a framework for developing, composing and running World-Earth models, i.e., models of socio-ecological co-evolutionary dynamics up to planetary scales. copan:CORE is an object-oriented software package written in Python that is designed for users of different roles. Model end users are enabled to easily run parallel simulations combining already available and tested model components. Component developers can contribute their own building blocks, while framework developers work on the model infrastructure. copan:CORE's modular design is tailored for community integration across disciplines, supporting rapid protyping, ensemble simulations and sensitivity, robustness and structural stability analyses.

SOE 7.31 Mon 17:00 Poster E

Risk assessment of introduction of African Swine Fever (ASF) to disease free regions of Poland. Effective distance and Monte Carlo approaches — •Andrzej Jarynowski[1,2] and Vitaly Belik[2] — [1]Interdisciplinary Research Institute, Wroclaw, Poland — [2]Institute for Veterinary Epidemiology and Biostatistics, Free University of Berlin

African Swine Fever (ASF) is viral infection which causes acute disease in domestic pigs and wild boar. Although the virus does not cause disease in humans, the impact it has on the economy, especially through trade and farming, is substantial. Recent rapid propagation of the (ASF) from East to West of Europe encouraged us to prepare risk assessment and predict future geographical transmission paths.

We analyze 380 Polish counties (poviats), where 23 (located in Northeast Poland) have been affected (until 10.12.2017) for spatial propagation (risk assessment for future). We choose pseudo gravity propagation model by taking into account: swine amount significance, disease vectors (wild boards) significance, pork production chain significance, human failure to restrictions. We use effective distances methodology (Phys Rev E 95, 012313, 2017) as well as standard Monte Carlo simulation and fitted parameters for both approaches.

We have reconstructed the most probable infection paths for affected Polish counties with both methods. With Monte Carlo model, we project few likely scenarios for future spread with risk assessment based on social network analysis.

SOE 8: Monte Carlo Methods in Financial Market Modeling (Invited Talk Thomas Lux)

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

Invited Talk SOE 8.1 Tue 9:30 MA 001

Estimation of Agent-Based Models using Sequential Monte Carlo Methods — •Thomas Lux — University of Kiel

Estimation of agent-based models is currently an intense area of research. Recent contributions have to a large extent resorted to simulation-based methods mostly using some form of simulated method of moments estimation (SMM). There is, however, an entire branch of statistical methods that should appear promising, but has to our knowledge never been applied so far to estimate agent-based models in economics and finance: Markov chain Monte Carlo methods designed for state space models or models with latent variables. This later class of models seems particularly relevant as agent-based models typically consist of some latent and some observable variables since not all the characteristics of agents would mostly be observable. Indeed, one might often not only be interested in estimating the parameters of a model, but also to infer the time development of some latent variable. However, agent-based models when interpreted as latent variable models would be typically characterized by non-linear dynamics and non-Gaussian fluctuations and, thus, would require a computational approach to statistical inference. Here we resort to Sequential Monte Carlo (SMC) estimation based on a particle filter. This approach is used here to numerically approximate the conditional densities that enter into the likelihood function of the problem. With this approximation we simultaneously obtain parameter estimates and filtered state probabilities for the unobservable variable(s) that drive(s) the dynamics of the observable time series.

SOE 9: Economic Models II

Time: Tuesday 10:15–11:30 Location: MA 001

SOE 9.1 Tue 10:15 MA 001

Market Dynamics: Evidence from Lab Experiments — •Heinrich H. Nax — ETHZ; Clausiusstr 37 C3; 8092 Zurich

We discuss old and new evidence from controlled lab and online experiments concerning market dynamics. We discuss common features of human decision-making, and the resulting convergence properties of such behaviorally founded models. Particular attention is paid to equilibrium and out-of-equilibrium dynamics.

SOE 9.2 Tue 10:45 MA 001

Pauli Algebras in Economics: Economathematics from Geometry to Didactics and back — •Martin Erik Horn — Berlin School of Economics and Law/HWR Berlin, FB 1 – Department of Business and Economics, FE Quantitative Methods

According to Hestenes, geometry links the algebra to the physical world. Therefore we start our journey with a closer analysis of the geometry of our world by questioning the Dirac belt trick: Obviously 4π periodicities are an elementary part of our world, and to describe this world, the mathematics of 4π periodicities – and thus Pauli algebras – are required.

Geometry also links the algebra to the physics of socio-economical systems. Consequently the mathematics of 4π periodicities – and thus Pauli algebras – can be applied to describe economic systems (for example in product engineering). A didactical approach to model such simple systems with Pauli algebras will be presented.

At the turning point of our journey we look back on an interesting economathematical picture: problems which might be solved by using linear algebra can equally effective and sometimes even in a much simpler way be solved with Pauli algebra or generalized Pauli algebras.

SOE 9.3 Tue 11:00 MA 001

Implementing the analytic Unification of Economics with the Natural Sciences — •Hans Danielmeyer and Thomas Martinetz — Institute for Neuro- and Bioinformatics, Uni Lübeck

Sir Charles Bean (UK Office for Budget Responsibility) is the first Central Banker to confirm our natural theory's G7 level zero interest prediction and tough conclusions: "back to income tax (for pensions and social security) or outlaw cash and helicopter money"). UK implementation starts with reviewing the economic measurement system. Its global deficit is having no variables for demand that are compatible with supply. We resolved it with the only family of six analytic functions that can assimilate biologically generated demand (far above biologic needs) with technically generated supply. They reproduce all G7 level data taken during peaceful growth without any fitting parameter.

Therefore, implementation of the natural theory's solutions will and must go far beyond the horizon of political parties. This explains easily the electorate's observed G7 level disappointment and its preference for much younger statesmen. The G7 level lifestyle was and will be dominated not by money or socioeconomic utopias but by ingeniuity, longevity, and the capacity for defending both.

SOE 9.4 Tue 11:15 MA 001

Evolutionary ecological-economic modelling: Ecological instability and economic growth — Frank Beckenbach[1], •Sylvie Geisendorf[2], and Christian Klippert[2] — [1]University of Kassel — [2]ESCP Europe Campus Berlin, Heubnerweg 8-10, 14059 Berlin, Germany

The purpose of our contribution is twofold. It proposes a combined ecological-economic model that captures the link between the economy and the ecosystem in a more inclusive way than standard economic optimization models do. This is done in order to demonstrate the non-triviality of finding a policy mix that leads to a sustainable path of the coupled system.

To enable this analysis, the model has three characteristics distinguishing it from traditional environmental and resource economic models: (1) it implements a multi-dimensional link between the economic and the ecological system, considering side effects of production, and thus combines the analyses of environmental and resource economics; (2) following authors from biology it uses a difference equation approach for the biological resource instead of the typical differential equation, allowing for the whole range of stability regimes by means of a single equation, and (3) it links this resource system to an evolving, agent-based industry (on the basis of a Nelson-Winter model) instead of the standard optimization model.

Main results are that (1) in face of multiple influences of the industry on nature, the selection and calibration of policy instruments is highly important to avoid or minimize trade-offs between sustainability dimensions and (2) the most obvious political instrument in case of overexploitation, and the only working as a single instrument, should, surprisingly, be left out of a policy mix for sustainable development.

SOE 10: Financial Markets and Risk Management II

Time: Tuesday 11:30–12:30 Location: MA 001

SOE 10.1 Tue 11:30 MA 001

Ising model of financial markets with many assets — •Alexander Eckrot, Jan Jurczyk, and Ingo Morgenstern — Universität Regensburg, Regensburg, Deutschland

Many models of financial markets exist, but most of them simulate single asset markets. We study a multi asset Ising model of a financial market. This model is able to reproduce the most important stylized facts. Furthermore we find that a separation of news into different channels leads to complex cross-correlations, similar to those found in real markets. We also investigate the impact of different decision functions used by the agents to determine the level of imitation.

SOE 10.2 Tue 11:45 MA 001

Intrinsic and spurious long-range memory in financial markets and ABMs through the lense of first passage times — •Aleksejus Kononovicius and Vygintas Gontis — Vilnius University, Institute of Theoretical Physics and Astronomy, Vilnius, Lithuania

We aim to explain the phenomenon of long-range memory in socio-economic systems by proposing a simple agent-based model (ABM). From the simple ABM we derive non-linear stochastic differential equations (NSDEs), which are related to a general class of NSDEs reproducing power-law statistics [1]. We have shown that the model is able to reproduce empirical PDF and PSD of high-frequency absolut return [2]. This model also well captures another set of statistical properties (collectively known as bursting statistics) [3,4], which may put an end to discussion whether long-range memory in financial market is intrinsic or spurious.

[1] A. Kononovicius, V. Gontis, PhysA 391, 1309-1314 (2012). doi: 10.1016/j.physa.2011.08.061.

[2] V. Gontis, A. Kononovicius, PLoS ONE 9, e102201 (2014). doi: 10.1371/journal.pone.0102201.

[3] V. Gontis, A. Kononovicius, S. Reimann, ACS 15, 1250071 (2012). doi: 10.1142/S0219525912500713.

[4] V. Gontis, S. Havlin, A. Kononovicius, B. Podobnik, H. E. Stanley, PhysA 462, 1091-1102 (2016). doi: 10.1016/j.physa.2016.06.143.

SOE 10.3 Tue 12:00 MA 001

Riskmanagement for electric power supply in times of variable, renewable source of energy — •Magda Schiegl — University of Applied Sciences Landshut, Am Lurzenhof 1, D- 84036 Landshut, Germany

It is well known that a production increase in fluctuating sources of energy, as for instance photovoltaic (pv) and wind energy, leads to a need of growing surplus power installed in order to meet the demand side. We apply methods of riskmanagement to evaluate the reliability of the German energy supply depending on the relation between the fluctuating, renewable energy and the total energy production. To reach this aim we begin with empirical data analysis: The energy time series of pv and wind production on the one hand and the load time series on the other. We separate the time series into a deterministic and a stochastic part by the help of Fourier analysis. On this basis we develop stochastic models for the three time series and calibrate them on the empirical, German power data. Finally, we calculate quantities known from riskmanagement as for instance the default probability or the expected shortfall for these calibrated models. This enables us to discuss the reliability of the future power supply on the basis of a stochastic model and not only as a scenario analysis of past, empirical data as is known from the literature.

SOE 10.4 Tue 12:15 MA 001

Estimation of Covariance Matrices using Gaussian Processes — •Rajbir-Singh Nirwan[1] and Nils Bertschinger[1,2] — [1]Frankfurt Institute for Advanced Studies — [2]Goethe University, Frankfurt am Main

Estimating covariances between financial assets plays an important role in risk management and optimal portfolio allocation. Especially if the number of assets is large compared to the number of observations, the sample estimators of covariance and correlation are very unstable or can even become singular. To cope with this problem, a wide range of estimators, e.g. factor models such as the CAPM or shrinkage estimators, have been developed and employed in portfolio optimization.

Here, we propose a novel covariance estimator based on the Gaussian Process Latent Variable Model (GP-LVM). Our estimator can be considered as a non-linear extension of standard factor models with readily interpretable parameters reminiscent of market betas. Furthermore, our fully Bayesian treatment naturally shrinks the sample covariance matrix (which maximizes the likelihood function) towards a more structured matrix given by the prior and thereby systematically reduces estimation errors.

We evaluated our model on the stocks of S&P500 from 1990 to 2017 and found significant improvements in terms of model fit as well as portfolio performance compared to the current state-of-the-art covariance estimators.

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

Time: Tuesday 12:30–13:15 Location: MA 001

SOE 11.1 Tue 12:30 MA 001

Equality-efficiency tradeoff in a dynamical Voluntary Contribution Game with Assortative Matching and heterogeneous agents. — •Stefano Duca — ETH Zurich, Zurich, Switzerland

Many scholars in the socio-economical literature have noted that any system that allows and incentivizes the transfer of wealth between agents exhibits a trade-off between efficiency and equality. Using an agent based model we study the welfare properties over time of Assortative Matching in Voluntary Contribution Games (VCM).

Every round, individuals choose how much to contribute into a group account and are ranked according to it. Based on this ranking, participants are then matched in equal-size groups; members of each group share their group output equally according to a VCM payoff function. Wealth accumulates over time and agents differ in talent and starting wealth.

In this paper, we study several ranking mechanisms based on different dimensions and ask what are the properties of these mechanisms in terms of total production of wealth and its distribution.

We find that, while in general it is impossible to determine a single best ranking system, some perform objectively better than others.

Using a computational approach we determine the mechanism that maximizes the social welfare, chosen from the Pareto frontier, depending on the preferences of a social planner.

SOE 11.2 Tue 12:45 MA 001

Exiting the Primordial Soup – Transition from Pre-Darwinian to Darwinian Evolution — Charlotte V. Vogelbusch[1], Steven H Strogatz[2], •Hinrich Arnoldt[1], and Marc Timme[1] — [1]Chair for Network Dynamics, Institute for Theoretical Physics and Center for Advancing Electronics Dresden (cfaed), TU Dresden, Dresden, Germany — [2]Department of Mathematics, Cornell University, Ithaca, NY 14853, USA

Darwin proposed the now-accepted existence of a last universal common ancestor (LUCA) from which all species emerged in an evolutionary process. Life on earth just before LUCA was fundamentally collective - a primordial soup - as ancient life forms shared their genetic material freely through massive horizontal gene transfer (HGT). How to exit this collective state and start Darwinian evolution is far from understood and heavily debated. Here we present a minimal model for this hypothesized "Darwinian transition." The model suggests that HGT-dominated dynamics may have been intermittently interrupted by selection-driven processes during which genotypes became fitter and decreased their inclination toward HGT. Stochastic switching in the population dynamics may have destabilized the HGT-dominated collective state and led to the emergence of vertical descent, the first well-defined species, and thus started Darwinian evolution [1]. Moreover, advanced models with dynamic inclination to HGT competence

suggest a viable route from collective pre-Darwinian to vertical Darwinian evolution and hint to a constrained exit window in parameter space. Ref.: [1] Phys. Rev. E 92, 052909 (2015)

SOE 11.3 Tue 13:00 MA 001

Analytical approximation of temporal difference multi-agent reinforcement learning — •Wolfram Barfuss[1,2], Jonathan F. Donges[1,3], and Jürgen Kurths[1,2,4] — [1]Potsdam Institute for Climate Impact Research, GER — [2]Humboldt University, Berlin, GER — [3]Stockholm Resilience Centre, Stockholm University, SWE — [4]University of Aberdeen, UK

Reinforcement learning in multi-agent systems has been studied by the fields of economic game theory, artificial intelligence and physics. Especially an economic and physics perspective has lead to analytical approaches of learning dynamics in multi-agent systems. However, these studies put their focus on simple iterated normal form games, such as the iterated Prisoners Dilemma. Environmental dynamics, i.e. changes in the state of the agent's environment affecting the payoffs received by the agents are mostly lacking. In this work we combine the analytical approach from physics with temporal difference learning from the field of artificial intelligence. This form of learning explicitly uses the discounted value of future environmental states to adapt the agent's behavior. We develop a uniform notation for multi-agent environment systems, generalizable to any environment and an arbitrary number of agents. We find four reinforcement learning variants emerging and compare their dynamics. This work is important to advance the understanding of interlinked social and environmental dilemmas, such as climate change, pollution and biosphere degradation.

SOE 12: Focus Session: Opinion Formation and Voter Models

Time: Tuesday 14:00–15:45 Location: MA 001

SOE 12.1 Tue 14:00 MA 001

Person-situation debate revisited: Phase transitions with quenched and annealed disorders — •Katarzyna Sznajd-Weron and Arkadiusz Jedrzejewski — Department of Theoretical Physics, Faculty of Fundamental Problems of Technology, Wrocław University of Science and Technology, Wrocław, Poland

We study the q-voter model of opinion dynamics driven by stochastic noise arising from one out of two types of nonconformity: anticonformity or independence. We compare two approaches that were inspired by the famous psychological controversy known as the person-situation debate. We relate the person approach with the quenched disorder and the situation approach with the annealed disorder, and investigate how these two approaches influence order-disorder phase transitions observed in the q-voter model with noise. We show that under a quenched disorder, differences between models with independence and anticonformity are weaker and only quantitative. In contrast, annealing has a much more profound impact on the system and leads to qualitative differences between models on a macroscopic level. Furthermore, only under an annealed disorder may the discontinuous phase transitions appear.

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SOE 12.2 Tue 14:15 MA 001

Pair approximation for the q-voter model with independence on complex networks — •Arkadiusz Jedrzejewski — Department of Theoretical Physics, Faculty of Fundamental Problems of Technology, Wroclaw University of Science and Technology, Wroclaw, Poland

We investigate the q-voter model with stochastic noise arising from independence on complex networks. Using the pair approximation, we provide a mathematical description of its behavior. The analytical results are validated by carrying out Monte Carlo experiments. The pair approximation prediction exhibits substantial agreement with simulations, especially for networks with weak clustering and large average degree. Nonetheless, for the average degree close to q, some discrepancies originate.

In the work, we are mainly interested in the time evolution and stationary values of the up-spin concentration. It turns out that the qualitative behavior of a system on studied weakly clustered complex networks is similar as on a complete graph. However, the quantitative behavior depends on the average node degree of an underlying network. What is interesting is that networks which have very different arrangements of edges and node degree distributions lead to the same results when they have the same value of the average node degree. Moreover, we show that in the limiting case the prediction of pair approximation coincides with the mean-field theory.

SOE 12.3 Tue 14:30 MA 001

The biased-voter model — •Raul Toral[1], Maxi San Miguel[1], and Agnieszka Czaplicka[2] — [1]IFISC (CSIC-UIB), Palma de Mallorca, Spain — [2]BIFI, U. de Zaragoza, Spain

Most of the voter-model literature assumes that each one of the possible options are equivalent. In this work we focus in the situation where there is a bias. This situation has been considered previously as, for example, indicating the lack of asymmetry in the social preference for one or another language in a bilingual community. We introduce bias by letting a fraction of the agents to copy with a higher probability one of the two options. We address the question of how the ratio of the density of connections between biased nodes and unbiased nodes influences the behavior. It seems that a crucial role for reaching consensus are the degrees of biased and unbiased nodes, rather than the number of links between pairs of biased or unbiased nodes. Even if the majority of the nodes is biased but weakly connected, the probability to reach consensus cannot be larger than in a random network. On the other extreme case, when biased nodes form a well-organized minority, one obtains in some cases a higher probability to order for the preferred state. In the thermodynamic limit any non-zero value of the bias leads to preferred consensus, but when the network is finite, there is always a chance to order in the not preferred state. For a random network case we find that behavior of the system depends of the effective bias, which is the value of bias parameter multiplied by the number of biased nodes. When the topology is not random that scaling disappears. Our analytical results are supported by numerical simulations.

SOE 12.4 Tue 14:45 MA 001

Zealotry Effects on Opinion Dynamics in the Adaptive Voter Model — •Pascal Klamser[1,2,3], Marc Wiedermann[3,4], Jonathan F. Donges[3,5], and Reik V. Donner[3] — [1]Institute for Theoretical Biology, Department of Biology, Humboldt-Universität zu Berlin — [2]Bernstein Center for Computational Neuroscience, Humboldt-Universität zu Berlin — [3]Potsdam Institute for Climate Impact Research — [4]Department of Physics, Humboldt-Universität zu Berlin — [5]Stockholm Resilience Centre, Stockholm University

The adaptive voter model has been widely studied as a conceptual model for opinion formation processes on time-evolving social networks. Past studies on the effect of zealots, i.e., nodes whose opinon is fixed, only considered the voter model on a static network. Here, we extend the study of zealotry to the case of an adaptive network topology co-evolving with the state of the nodes. Numerical simulations reveal that below the fragmentation threshold a low density of zealots is sufficient to spread their opinion to the whole network. Beyond the transition point, zealots must exhibit an increased degree as compared to ordinary nodes for an efficient spreading of their opinion. The numerical findings are verified using a mean-field approximation. Our results imply that the spreading of the zealots' opinion in the adaptive voter model is strongly dependent on the link rewiring probability and the average degree of normal nodes in comparison with that of the zealots. In order to avoid a complete dominance of the zealots' opinion the remaining nodes can adjust the probability of rewiring and/or the number of connections with other nodes.

SOE 12.5 Tue 15:00 MA 001

Opinion dynamics on social networks in an age of digital transformation — •Kilian B. Zimmerer[1,2], Wolfram Barfuss[1,3], and Jonathan F. Donges[1,4] — [1]Potsdam Institute for Climate Impact Research, Telegrafenberg A31, D-14473 Potsdam, Germany — [2]Department of Physics and Astronomy, University of

Heidelberg, Im Neuenheimer Feld 226, D-69120 Heidelberg, Germany — [3]Department of Physics, Humboldt University, Newtonstr. 15, D-12489 Berlin, Germany — [4]Stockholm Resilience Centre, Stockholm University, Kräftriket 2B, 114 19 Stockholm, Sweden

Increased connectivity due to digitization has led to interaction patterns which enable individuals to broadcast information in ways similar to traditional mass media. Thus, the role of mass media to act as a gatekeeper by disseminating only information that is both relevant and sufficiently proven is weakened. A frequently discussed consequence is the apparent emergence of echo chambers in which misinformation is believed to be true. The dynamics causing their emergence, as well as adaptive policies avoiding social networks dominated by misinformation must be better understood. Therefore, the impact of increasing connectivity on a multiplex network model of continuous opinions is studied in this work.

SOE 12.6 Tue 15:15 MA 001

Opinion dynamics in a model with multiple issues — •Sven Banisch and Eckehard Olbrich — Max Planck Institute for Mathematics in the Sciences, Inselstrasse 22, D-04103 Leipzig, Germany

Arguments in a discussion often address different aspects of the issue at stake. But, some of these aspects are also relevant for other issues, which induces correlations between opinions on different issues. Those correlations could originate from factual interdependencies between the considered processes in the world, but they give also rise to ideologies and group identities which can induce further dependencies on their part. Many of the classical models of opinion dynamics studied in sociophysics are not able to address these issues. Drawing upon expectancy-value models in attitude research and the theory of conceptual spaces we developed a multi-level representation of opinions which allows to study of opinion dynamics on multiple interrelated issues. The model is based on three different ingredients: (1) interacting agents align their views regarding the significance of different argumentative domains; (2) different (partially overlapping) sets of these domains are associated with different political issues and an agent's attitude is a function of the importance assigned to the argument domains and their evaluative relevance for the issues; and (3) agents preferentially interact with other agents that hold similar attitudes. We show under which conditions these combined processes give rise to polarization and discuss the role of correlations of attitudes towards multiple political issues in this context.

SOE 12.7 Tue 15:30 MA 001

Cooperation dynamics reflecting social dilemmas and social conformity in multiplex structured networks — •Yui Murayama[1], Ohashi Hirotada[1], and Kaj-Kolja Kleineberg[2] — [1]Dept. Systems Innovation, The University of Tokyo, 7-3-1 Hongo,Bunkyo-ku, Tokyo, Japan — [2]Computational Social Science, ETH Zurich, Clausiusstrasse 50, CH-8092,Zurich, Switzerland

Solving many important economical or environmental challenges require large-scale cooperation. Cooperation is surprisingly common even in situations where defection seems the logical choice. Individual behavior, however, is not only determined by the strategic interactions, but also by social influence. Our interest is in how cooperation evolves among networked agents who make decision in dilemmatic situations and what are conditions attaining full cooperation.

We employ two-layer networks; one layer corresponds to strategic interactions and the other layer represents social conformity. In strategic interactions layer, agents play prisoner's dilemma or public goods games. In the social conformity layer, agents change their behavior playing voter games or majority votes with their neighbors. Each layer comprises the same set of nodes but has different link structure.

We identify under which conditions cooperation thrives and when the system becomes stuck in a state with distinct groups of cooperators and defectors. Finally, we propose measures that promote full cooperation and hence successfully overcome the persistence of defectors.

SOE 13: Networks: From Topology to Dynamics (joint session SOE/CPP/BP/DY)

Time: Wednesday 9:30–12:15 Location: MA 001

SOE 13.1 Wed 9:30 MA 001

Dynamics of interacting tipping elements on complex networks — •Jonathan F. Donges[1,2], Ann-Kristin Klose[1], and Ricarda Winkelmann[1] — [1]Earth System Analysis, Potsdam Institute for Climate Impact Research, Potsdam, Germany — [2]Stockholm Resilience Centre, Stockholm University, Stockholm, Sweden

In recent years, an increasing number of potential tipping elements have been identified in ecological, climatic and social systems. Tipping elements are defined by their ability to undergo large qualitative change that is caused by a small perturbation in a parameter or state variable. We investigate the emergent nonlinear dynamics of pairs, chains and networks of generalized tipping elements. Understanding the dynamics of systems of interacting tipping elements on complex networks is relevant for assessing the resilience and transformative capacity of complex systems such as the Earth's climate system and the World's energy system in the context of decarbonization transformation for meeting the Paris climate agreement.

SOE 13.2 Wed 9:45 MA 001

The interdependent network of gene regulation and metabolism is robust where it needs to be — •Marc Hütt[1], David Klosik[2], Anne Grimbs[1], and Stefan Bornholdt[2] — [1]Jacobs University, Bremen, Germany — [2]Institute for Theoretical Physics, University of Bremen, Bremen, Germany

Despite being highly interdependent, the major biochemical networks of the living cell – the networks of interacting genes and of metabolic reactions, respectively – have been approached mostly as separate systems so far. Recently, a framework for interdependent networks has emerged in the context of statistical physics. In a first quantitative application of this framework to systems biology, here we study the interdependent network of gene regulation and metabolism for the model organism *Escherichia coli* in terms of a biologically motivated percolation model [1]. Particularly, we approach the system's conflicting tasks of reacting rapidly to (internal and external) perturbations, while being robust to minor environmental fluctuations. Considering its response to perturbations that are localized with respect to functional criteria, we find the interdependent system to be sensitive to gene regulatory and protein-level perturbations, yet robust against metabolic changes. We expect this approach to be applicable to a range of other interdependent networks.

[1] Klosik, D. F., Grimbs, A., Bornholdt, S., and Hütt, M.-T. (2017). Nature Communications, 8(1):534.

SOE 13.3 Wed 10:00 MA 001

Robust connectivity in networks with groups of vulnerable nodes — •Sebastian M. Krause[1,2], Michael M. Danziger[3], and Vinko Zlatić[2] — [1]Faculty of Physics, University of Duisburg-Essen, Lotharstr. 1, 47048 Duisburg, Germany — [2]Theoretical Physics Division, Rudjer Bošković Institute, Bijenicka c. 54, 10000 Zagreb, Croatia — [3]Department of Physics, Bar-Ilan University, Ramat Gan 5290002, Israel

In many networked systems there are large groups of similar nodes which are vulnerable to the same failure or adversary. For example, servers in a communication network running the same software will fail together, if this software has a bug. Therefore, we are often faced with networks where all nodes of a group can fail together. Further, many different vulnerabilities can cover the whole network. This structural weakness has so far been overlooked in studies of network robustness. Here we discuss, how multiple redundant paths enable a high level of robustness, even if no node is trusted [1,2]. With each vulnerability described as a color, we discuss "color-avoiding percolation". We present a fast numerical algorithm for real world networks and analytical results for random network ensembles.

[1] Sebastian M. Krause, Michael M. Danziger, and Vinko Zlatić, Hidden Connectivity in Networks with Vulnerable Classes of Nodes, Phys. Rev. X 6, 041022 (2016).

[2] S. M. Krause, M. M. Danziger, and V. Zlatić, Color-avoiding percolation, Phys. Rev. E 96 022313 (2017).

SOE 13.4 Wed 10:15 MA 001

When is a network a network? Multi-order graphical model

selection in time series data on networks — •Ingo Scholtes — Chair of Systems Design, ETH Zürich, Zürich, Switzerland

We introduce a novel framework for the modeling of time series data on networks. Such data are important, e.g., when studying click streams of users in the Web, travel patterns of passengers in transportation systems, information cascades in social networks, biological pathways, or time-stamped social interactions. While it is common to apply graph analytics and network analysis to such data, recent works have shown that temporal correlations can invalidate the results of such methods. This raises a fundamental question: When is a network abstraction of time series data justified?

Addressing this open question, we propose a framework that combines Markov chains of multiple, higher orders into a multi-layer network model that captures temporal correlations at multiple length scales simultaneously. We develop a model selection technique to infer the optimal number of layers of such a model and show that our method outperforms baseline Markov order detection techniques.

An application to eight real-world data sets capturing causal paths in time series data on networks shows that the inferred models provide an optimal summarization of the causal topologies of real-world complex systems. Our work highlights fallacies of network-based modelling techniques and provides a principled answer to the open question when they are justified. Generalizing networks to optimal multi-order models, it opens perspectives for the study of complex systems.

SOE 13.5 Wed 10:30 MA 001

Exact expected cluster sizes for bond percolation in finite networks — Joan Pont Serra and •Konstantin Klemm — IFISC (CSIC-UIB), Mallorca, Spain

Bond percolation describes the statistical ensemble generated by randomly deleting edges from a given network. Traditionally studied on grids (lattices), bond percolation forms a crucial part of modern network theory with implications for epidemic spreading and network robustness under failures. For quenched systems of size well above 20 nodes, the computation of percolation quantities relies on heuristics (e.g. by the graph spectrum) or Monte Carlo sampling. Here we introduce an exact computational method that is time-efficient when the network has certain separation properties. Specifically, we work with a branch decomposition of low width. Then the network is recursively separable by removing a small number of nodes in each step. For several test networks, we present exact results for the first time. We find that the computational cost of our exact method is lower than that of Monte Carlo runs required to reach an acceptable precision.

SOE 13.6 Wed 10:45 MA 001

Controlling percolation with limited resources — •Malte Schröder[1], Nuno Araújo[2], Didier Sornette[3], and Jan Nagler[3] — [1]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany — [2]Universidade de Lisboa, Lisboa, Portugal — [3]ETH Zürich, Zurich, Switzerland

Connectivity - or the lack thereof - is crucial for the proper functioning of many essential socio-economic processes, from financial and economic networks over epidemic spreading in social networks to technical infrastructure. Often, connections are deliberately established or removed by various parties to induce, maintain, or destroy global connectivity. Thus, there has been a great interest in understanding how to control percolation, the transition to large-scale connectivity. Previous work studied control strategies implicitly assuming unlimited resources, leading to a large number of models of "explosive" and discontinuous percolation. Realistically, however, such control is often subject to a limited budget. We derive an efficient control strategy to delay percolation under the constraint of limited resources and study its implications. We show that the transition can be significantly delayed even with scarce resources but remains smooth and in the same universality class as random percolation. In particular, the transition never becomes "explosive". We derive an approximation for the optimal control parameters and show how resource optimal delay of percolation leads to a sudden, discontinuous transition. Thus, the percolation transition becomes effectively uncontrollable as an unintended consequence of optimal control.

SOE 13.7 Wed 11:00 MA 001

Discrete reaction-diffusion models of innovations using multi-particles in networks. — •Yuki Kawasaki and Hirotada Ohashi — The University of Tokyo, Tokyo, Japan

Reaction-diffusion is a fundamental process underlying many social and economic phenomena. This process has been widely studied in continuous physical space. Different from physical and chemical phenomena, social and economic processes occur in networks connecting individuals, firms and organizations. In this study, we model reaction-diffusion processes of innovations in structured networks employing multi-particles that represent innovations and some kind of enzymes. The reaction process is that several particles react on nodes according to reaction rules and the diffusion process is that particles travel randomly to neighboring nodes. This model is able to reproduce macroscopic behaviors of systems taking account of microscopic relationships between individual particles. Simulation results are obtained for various network structures including small-world and scale-free networks. Next we extend our model to deal with simultaneous reaction and diffusion of different kinds of particles. This model can describe competition and cooperation between innovations in networks including predator-prey processes.

SOE 13.8 Wed 11:15 MA 001

Probabilistic Quantifiers for Deterministic Spreading — •Justine Wolter[1,2], Benedict Lünsmann[3], Xiaozhu Zhang[1,2], Malte Schröder[1,2], and Marc Timme[1,2,3] — [1]Chair for Network Dynamics, Institute for Theoretical Physics and Center for Advancing Electronics Dresden (cfaed), TU Dresden, Dresden, Germany — [2]Max Planck Institute for Dynamics and Self-Organization, 37077 Göttingen — [3]Max Planck Institute for the Physics of Complex Systems, 01069 Dresden

How do signals spread across dynamical systems? Spreading may be stochastic, e.g., during epidemic outbreaks or deterministic, e.g., in electrical or other supply networks. Due to mathematical challenges, it remains unknown how to robustly quantify even simple characteristics such as peak times or amplitudes of a spreading signal propagating across a network. Here we change the perspective and propose to analyze deterministic spreading dynamics employing concepts of probability theory. We characterize generic spreading dynamics by expectation values to work out a theory explicitly quantifying when and how strongly a perturbation initiated at one unit of a network impacts any other [1]. The theory provides this information as a function of the relative position of initially perturbed and responding unit as well as on the entire network topology. Furthermore, asymptotically exact approximation schemes enable to well predict previously inaccessible peak times and amplitudes. These insights may open up a new realm of quantifying characteristics of deterministic processes through probability theory. Ref.: [1] J. Wolter et al., http://arXiv.org/abs/1710.09687

SOE 13.9 Wed 11:30 MA 001

Perturbation spreading on diffusively-coupled networks and power grids — •Xiaozhu Zhang[1,2], Dirk Witthaut[3], and Marc Timme[1,2] — [1]Chair for Network Dynamics, Institute for Theoretical Physics and Center for Advancing Electronics Dresden (cfaed), TU Dresden, Dresden, Germany — [2]Network Dynamics, Max Planck Institute for Dynamics and Self-organization, 37077 Göttingen — [3]Institute for Energy and Climate Research - Systems Analysis and Technology Evaluation (IEK-STE), Forschungszentrum Jülich GmbH, 52425 Jülich, Germany

Spreading phenomena on networks essentially underlie the collective dynamics of systems across physics, biology and engineering. Yet, how local changes dynamically spread in such networked systems is still far from fully understood. Here we analyze the spreading dynamics for diffusively-coupled networks close to given operating points. We provide analytical solutions of transient nodal responses via linear response theory and approximate the perturbation arrival times via Taylor expansion. In homogeneous networks, we find the spreading speed based on the estimated arrival times decreases and converges to a constant at large distance. Intriguingly, the asymptotic spreading speed is essentially determined by the network topology, i.e. the limiting behavior of the number of shortest paths at large distance. These results shed light on the qualitatively universal asymptotic spreading behavior in networks and its quantitative dependence on the underlying network topology.

SOE 13.10 Wed 11:45 MA 001

Temporal networks with geometric constraints and protein folding — •Nora Molkenthin[1], Marc Timme[2,1], and Steffen Mühle[3] — [1]Network Dynamics, Max Planck Institute for Dynamics and Self-Organization, 37077 Göttingen — [2]Chair for Network Dynamics, Center for Advancing Electronics Dresden (cfaed) and Institute for Theoretical Physics, TU Dresden, 01062 Dresden — [3]Physics

Department III, University of Göttingen, D-37077 Göttingen, Germany

The structure of many complex networks is highly constrained by geometric factors, affecting a broad range of systems from polymer aggregates to traffic and supply networks. On the microscopic scale, folding proteins constitute paradigmatic systems for spatial network formation. They are well characterized as Protein Residue Networks (PRN) yet their statistical properties seem to be diverse and general rules are largely unknown. Here, advancing a recent graph-theoretical mapping [1], we develop a temporal network model for the aggregation of connected, spatially extended units, thereby reproducing key features of PRN*s. In stark contrast to network models without geometric constraints, we observe algebraic scaling of the network diameter with system size and predict the characteristic link length distribution, both features fitting with those experimentally observed in PRN*s.

[1] Molkenthin & Timme, Scaling Laws in Spatial Network Formation, Phys. Rev. Lett. 117:168301 (2016)

SOE 13.11 Wed 12:00 MA 001

Non-inertial reference frames for inferring networks from dynamics — •Jose Casadiego[1,2] and Marc Timme[1,2] — [1]Chair for Network Dynamics, Institute of Theoretical Physics and cfaed - Center for Advancing Electronics Dresden, Technical University of Dresden, Dresden, Germany — [2]Network Dynamics, Max Planck Institute for Dynamics and Self-Organization (MPIDS), Goettingen, Germany

The dynamics of complex networks are determined to a great extent by the connectivity of their units. Given that measuring the connectivity by direct methods is often infeasible, researchers typically apply inverse approaches to infer links between units from the collective dynamics. Current state-of-the-art methods rely on either (i) quantifying functional links through statistical dependencies, or (ii) approximating the possibly nonlinear interactions between units via modeling of differential equations. Yet, functional links frequently do not match physical links, and finding an appropriate model may be computationally demanding and also require a prior knowledge about the interactions. Here we develop a model-independent theory to reconstruct the connectivity of networks from transients states to stable dynamics. Specifically, we demonstrate that representing these transients with respect to non-inertial reference frames provides simple linear mappings between network connectivity and dynamics. Furthermore, we show the robustness of our framework by reconstructing the full connectivity of different network dynamical systems exhibiting phase-locking, periodic orbits and collective synchronization.

SOE 14: Annual Member's Assembly

Agenda: 1. Report on activities and general announcements 2. Elections 3. Miscellaneous

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

Annual assembly of members of SOE (all interested participants are welcome to join).

SOE 15: Dynamics in Real-World Multiplex Networks (Invited Talk Vito Latora) (joint session DY/SOE)

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

Invited Talk SOE 15.1 Wed 15:00 MA 001

Network structure and dynamics: when and how multiplex really matters? — •Vito Latora — School of Mathematical Sciences, Queen Mary University of London, London E1 4NS, United Kingdom

After almost ten years of research on characterising the properties of real-world multiplex networks, describing mathematically their structure, and modelling different types of dynamical process occurring over them, it is now time to draw the first conclusions and to try to answer a fundamental question: Does multiplex really matter? Focusing here both on the structure and on dynamics of multiplex networks, we discuss some cases where multiplexity gives rise to the emergence of novel behaviors, otherwise unobserved in single-layer networks.

SOE 16: Networks: From Topology to Dynamics (joint session DY/SOE)

Time: Wednesday 15:30–18:00 Location: MA 001

SOE 16.1 Wed 15:30 MA 001

Mapping and discrimination of networks in the complexity-entropy plane — •Marc Wiedermann[1,2], Jonathan F. Donges[1,3], Jürgen Kurths[1,2], and Reik V. Donner[1] — [1]Potsdam Institute for Climate Impact Research — [2]Humboldt University of Berlin — [3]Stockholm Resilience Centre

Complex networks are usually characterized in terms of their topological, spatial, or information-theoretic properties and combinations of the associated metrics are used to discriminate networks into different classes or categories. However, even with the present variety of characteristics at hand it remains a subject of current research to appropriately quantify a network's complexity and correspondingly discriminate between different types of complex networks on such a basis. Here we explore the possibility to classify complex networks by means of a statistical complexity measure that has formerly been successfully applied to distinguish different types of chaotic and stochastic time series. It is composed of a network's averaged per-node entropic measure characterizing the network's information content and the associated Jenson-Shannon divergence as a measure of disequilibrium. We study 29 real-world networks and show that networks of the same category cluster in distinct areas of the resulting complexity-entropy plane. In particular, connectome networks exhibit among the highest complexity while transportation and infrastructure networks display significantly lower values. We further show that the proposed framework is useful to objectively construct threshold-based networks by choosing the threshold such that the statistical complexity is maximized.

SOE 16.2 Wed 15:45 MA 001

Renormalisation group theory for percolation in time-varying networks — •Jens Karschau, Marco Zimmerling, and Benjamin M. Friedrich — cfaed | TU Dresden, Dresden, Germany

Wireless communication networks require reliable routing of messages, despite the fact that individual networks links are unreliable. Multihop routing protocols propose a promising solution to overcome the issue of message loss. For these protocols, successful relay of a message defines a percolation problem.

Here, we present a percolation theory for a minimal model, where individual links switch between an active and an inactive state according to a two-state Markov process. Using renormalization group theory, we analytically compute the complete statistics of failure events. We show how the time-dependent probability to find a path of active links between two designated nodes converges towards an effective Bernoulli process, i.e. without memory, as the hop distance between the nodes increases. Our work extends classical percolation theory to the dynamic case. It elucidates temporal correlations of message losses with implications for the design of communication protocols and control

algorithms.

Reference: arXiv:1708.05704

SOE 16.3 Wed 16:00 MA 001

Self-organized cluster formation in neural networks — •Rico Berner[1,2], Eckehard Schöll[1], and Serhiy Yanchuk[2] — [1]Institut für Theoretische Physik, Technische Universität Berlin, Germany — [2]Institut für Mathematik, Technische Universität Berlin, Germany

We investigate collective behaviour in a network of adaptively coupled phase oscillators, where the coupling topology depends on the dynamics of oscillators. We show that such a system gives rise to numerous dynamics, including hierarchical multi-clusters and chimera states. Our numerical and analytical results are compared and interpreted with respect to pattern formation due to learning processes and the multi-layer structure of the human brain.

SOE 16.4 Wed 16:15 MA 001

Coarsening dynamics of ferromagnetic granular networks - experiment and simulation — •Pedro A. Sanchez[1], Armin Kögel[2], Robin Maretzki[2], Tom Dumont[2], Elena S. Pyanzina[3], Sofia S. Kantorovich[1], and Reinhard Richter[2] — [1]Univ. of Vienna, Sensengasse 8, Vienna, 1090, Austria — [2]Experimentalphysik 5, Univ. of Bayreuth, 95440 Bayreuth, Germany — [3]Federal Univ., Lenin av. 51, Ekaterinburg, 620000, Russia

We investigate the phase separation of a shaken mixture of glass and magnetised steel spheres after a sudden quench of the shaker amplitude. Then transient networks of steel spheres emerge in the experiment. For the developing network we observe an initial regime, where the network incubates, followed by a regime where network structures are elongated and broken, and finally a regime where the structures have relaxed to compact clusters of rounded shapes. This phaenomenology resembles the initial, elastic and hydrodynamic regimes observed by H. Tanaka [J. Phys.: Cond. Mat., 2000] during the viscoelastic phase separation for dynamically asymmetric mixtures of polymers. In order to unveil the three regimes we measure order parameters like the mean number of neighbors and the efficiency.

To eluzidate the origin for a viscoelastic phase separation, we use a simple simulation approach to define the key interactions in the experimental system. This way, we discover that along with dipolar and steric interactions, a central attraction between the magnetised spheres is decisive for the coarsening dynamics. Our simulations show three regimes in the evolution of characteristic order parameters.

SOE 16.5 Wed 16:30 MA 001

Coherence resonance in a network of FitzHugh-Nagumo systems: interplay of noise, time-delay and topology — •Maria Masoliver[1], Nishant Malik[2], Eckehard Schöll[3], and Anna Zakharova[3] — [1]Department of Physics, DONLL, Universitat Politècnica de Catalunya — [2]Department of Mathematics, Dartmouth College, Hanover, USA — [3]Institut für Theoretische Physik, Technische Universität, Berlin

The FitzHugh-Nagumo system is a paradigmatic model which describes the excitability and spiking behavior of neurons. This model, in the excitable regime under the influence of noise exhibits the counterintuitive phenomenon of coherence resonance: there exists an optimum intermediate value of the noise intensity for which noise-induced oscillations become most regular. We systematically investigate the phenomena of coherence resonance in time-delay coupled networks of FitzHugh-Nagumo elements in the excitable regime [1]. Using numerical simulations, we examine the interplay of noise, time-delayed coupling and network topology in the generation of coherence resonance. We demonstrate the possibility of controlling coherence resonance by varying the time-delay and the number of nearest neighbors. For a locally coupled ring, we show that the time-delay weakens coherence resonance. For nonlocal coupling with appropriate time-delays, both enhancement and weakening of coherence resonance are possible.

[1] M. Masoliver, N. Malik, E. Schöll, A. Zakharova, Chaos 27, 101102 (2017)

15 min. break

SOE 16.6 Wed 17:00 MA 001

A Network Approach to Spin Systems Beyond Nearest-Neighbor Interactions — •Kathinka Gerlinger[1], Julian Heiss[1], Matthias Weidemüller[1,2], Andreas Spitz[3], and Michael Gertz[3] — [1]Physics Institute, Heidelberg University, Heidelberg, Germany — [2]Shanghai Branch, University of Science and Technology of China, Shanghai 201315, China — [3]Institute of Computer Science, Heidelberg University, Heidelberg, Germany

Investigating spin systems as examples of strongly-interacting systems and determining their phase diagram is a central research challenge in complex many-body physics. For the 1D Ising model with only nearest-neighbor interactions, Valdez et al. (arXiv:1508.07041) have recently shown the veracity and efficiency of complex network models with regard to finite-size scaling. We expand the task of finding the quantum phase transition of such spin systems beyond nearest neighbor interactions. To this end, we discuss suitable mappings of spin systems to complex networks and their analysis based on complex network analytic methods. Furthermore we investigate the evolution of spin states on dynamic networks and their relation to physical systems.

SOE 16.7 Wed 17:15 MA 001

Self-consistent correlations of randomly coupled rotators in the asynchronous state — •Alexander van Meegen[1,2,3] and Benjamin Lindner[1,2] — [1]Humboldt Universität zu Berlin — [2]Bernstein Zentrum Berlin — [3]Forschungszentrum Jülich

We present a study of a network of unidirectionally coupled rotators with i.i.d. frequencies and i.i.d. coupling coefficients. Similar to biological networks, this system can attain an asynchronous state with pronounced temporal autocorrelations of the rotators.

Using an approach based on the system's generating functional, we derived a differential equation for the self-consistent autocorrelation function of the network noise. Its numerical solution has been confirmed by simulations of networks with Gaussian or sparsely distributed coupling coefficients. Explicit expressions for correlation function, power spectra, correlation time, noise intensity, and quality factor for the case of identical frequencies for all rotators in the limits of weak or strong coupling strength have been obtained.

This work paves the way for more detailed studies of how the statistics of connection strength, the heterogeneity of network parameters, and the form of the interaction function shape the network noise and the autocorrelations of the single element if this element has an predominantly oscillatory nature (e.g. a limit-cycle system).

SOE 16.8 Wed 17:30 MA 001

Long-lasting desynchronization by coordinated reset stimulation in neuronal networks with spike-timing dependent plasticity — •Justus A. Kromer and Peter A. Tass — Stanford University, Stanford CA, USA

Abnormally strong synchronization of neuronal activity plays an important role in several brain disorders such as Parkinson's disease, epilepsy, and tinnitus. Deep brain stimulation is a therapy that specifically counteracts neuronal synchronization in related brain areas. In contrast to standard high-frequency deep brain stimulation, which aims on the suppression of neuronal activity, coordinated reset deep brain (CR) stimulation is intended to cause overall desynchronization by introducing phase shifts between individual neuronal subpopulations. To this end phase-resetting stimuli are applied to different neuronal subpopulations at different times. This results in a reshaping of the synaptic weights and, for well-chosen stimulation patterns, causes a transition from a pathological state with high synaptic weights and strongly-synchronized neuronal activity to a physiological state with low synaptic weights and desynchronized activity.

Using computer simulations, we study desynchronization by CR stimulation in networks of leaky integrate-and-fire neurons with spike-timing dependent plasticity. We present a novel approach for CR stimulation that significantly increases the field of application. Furthermore, we discuss the robustness of long-lasting desynchronization effects with respect to changes in system parameters such as network connectivity and heterogeneity in neuronal firing rates.

SOE 16.9 Wed 17:45 MA 001

Wie klimawirksam ist der Photovoltaik-Zubau in Deutschland ? Verschwiegene Dynamik. — •Nikolaus von der Heydt — Umweltphysik Göttingen - Physik zum Leben - , Landolfshausen

Neue Analysen der weltweit vernetzten Prozessketten zur Herstellung von Si-PV-Anlagen (IEA 2011 bis 2016) ergeben, dass dabei global je kWp etwa 2,6 t CO2eq in die Atmosphäre gelangen, bevor die Anlagen in Deutschland in Betrieb gehen. Danach können sie hier pro Jahr durchschnittlich 475 Kg/kWp vermeiden, indem sie den aktuellen deutschen Strommix ersetzen. Damit dauert es 5,5 Jahre, bis ein jedes Jahr gleicher PV-Zubau eine Kapazität aufgebaut hat, die pro Jahr

hier eben soviel CO2 vermeidet wie der Zubau global verursacht. Bis dahin wächst die CO2-Menge in der Atmosphäre an, bei z.B. 6 GWp/a auf 43 Mt. Danach überwiegt die Vermeidung, und nach 11 Jahren ist die CO2-Schuld getilgt. - Wirksamer Klimaschutz erfordert es, die CO2-Last des deutschen Strommix in 10 Jahren auf ca. 100 g/kWh zu senken, z.B. durch Ersatz von Braunkohle durch Windkraft mit Gas-KWK. Dann könnten deutsche PV-Anlagen je kWp nur noch 84 Kg/a vermeiden, und eine konstant wachsende PV-Kapazität könnte erst nach 30 Jahren die jährliche globale Herstellungs-Emission gerade kompensieren. Soll danach die erreichte Kapazität erhalten werden, müsste die bis dahin in der Atmosphäre angesammelte CO2-Menge für immer dort bleiben. Bei z.B. 6 GWp/a wären das 233 Mt. Mit Akkus und Freiland-Aufständerungen verdoppelt sich die Herstellungs-Emission mindestens, das bedeutet die 4-fache angesammelte CO2-Menge. Im Beispiel sind das 932 Mt - die deutsche Jahresemission.

SOE 17: Social Systems, Opinion and Group Dynamics II

Time: Wednesday 18:15–19:00 Location: MA 001

SOE 17.1 Wed 18:15 MA 001

How do firms collaborate? A data-driven model — •Giacomo Vaccario[1], Mario V. Tomasello[2], Claudio J. Tessone[3], and Frank Schweitzer[1] — [1]ETH, Zurich, CH — [2]E&Y, Zurich, CH — [3]UZH, Zurich, CH

How do firms collaborate? To address this question, we propose an agent-based model that replicates two important processes in firm collaborations: i) The selection of the collaborators and ii) The exchange of knowledge. To calibrate our model, we reproduce by computer simulations first the observed collaboration network and secondly the knowledge exchange. For the former, we estimate the collaboration probabilities among firms that best match the empirical network. For the latter, we embed the firms in a multidimensional knowledge space where their positions represent their expertise along technological dimensions. We assume that firms exchange knowledge only while collaborating and approach each other in the knowledge space at a rate *mu* for the duration of a collaboration *tau*. We estimate these two parameters by comparing simulated and observed knowledge distances. We find that the average collaboration lasts around two years and that the knowledge transfer occurs at a low rate. In other words, a firm's position hardly changes during collaboration and is not a consequence of its collaborations. Finally, we introduce a collaboration efficiency measure, that is the distance traveled by the firms in the knowledge space divided by the number of collaborations. We find that the model configuration that best reproduce the empirical data is close to the optimal configuration according to the introduced efficiency measure.

SOE 17.2 Wed 18:30 MA 001

A Comprehensive Analysis of Reaction to Disturbances through Social Learning in Networks — •Takuro Yamazaki and Hirotada Ohashi — University of Tokyo, Department of Systems Innovation, Tokyo, Japan

There are many social tasks involving decision making of multiple people who have their own interests, e.g. election, traffic and investment. In such situations, dilemmas between social and individual interests often occur, and the mechanism and dynamics of dilemmas are widely studied in evolutionary game frameworks. In these frameworks, agents behave according to predetermined rules, however, in real-world setting, people learn optimal behavior from their own experience and interactions with neighbors. We study repeated matrix games played by many agents with reinforcement learning, which corresponds to social learning frameworks. Each agent interacts with all neighboring agents in each round and learns his strategy from his and neighbor's payoffs. We analyze the learning processes of agents by changing learning parameters and connection structures among agents. We have particular interest in how reinforcement learning agents react to disturbances to conditions. We incorporate changes of payoffs during the learning process and observe the variation of agent's actions. Furthermore, we investigate the effect of network topology among agents. Simulation results show that the speed of reaction to disturbances changes with network topology and reinforcement learning parameters. And sharing information by sharing q value among neighbors and observing neighbor's action both increase robustness to disturbances.

SOE 17.3 Wed 18:45 MA 001

Dynamics of human interactions in conferences — •Mathieu Génois — GESIS - Leibniz Institut für Sozialwissenschaften

We present results from two different conferences, where interactions between individuals have been tracked using the SocioPatterns setup (www.sociopatterns.org). This setup allows for the recording of face-to-face physical proximity (1.5 m) with a high temporal resolution (20 s). Such contacts have proven to be a very good proxy for social interactions [1,2].

We show that both events present similar patterns for the dynamics of how connections are established between participants. In particular, we uncover mixing behaviours along with avoidance strategies, heterogeneities in the levels of interaction depending on sociodemographic characteristics, and signal of both social exploration and social filtering.

Such data-driven analysis of a social situation allows to directly observe objective quantities about human behaviour. Beyond the exploration of particular cases, comparison of such results from different social contexts enables the discovery of general mecanisms. We believe that this kind of approach is necessary to found any physical theory about social systems.

References:

[1] Contact patterns among high school students, Fournet et al., PLoS ONE 9(9):e107878 (2014).

[2] Gender homophily from spatial behavior in a primary school: a sociometric study, Stehlé et al., Social Networks 35(4):604-613 (2013).

SOE 18: Complex Contagion Phenomena I (Focus Session with EPS-SNPD) (joint session SOE/DY/BP)

Contagion processes are stochastic dynamical systems that are ubiquitous in natural and engineered systems and their fundamental understanding is of crucial importance for prediction and control of large-scale system behavior. A classical example of a contagion process is the spread of infectious diseases. In addition, in recent years, there has been also an increased scientific interest in so-called social contagion phenomena, which is largely fueled by the rise of digital communication in online social platforms. New challenges that arise due to the digital transformation of communication can be addressed by developing new concepts like collective risk perception.

(Session organizers and chairs: Philipp Hövel, Pawel Romanczuk, and Jonathan Donges)

Time: Thursday 9:30–13:15 Location: MA 001

Invited Talk SOE 18.1 Thu 9:30 MA 001

Epidemic threshold on temporal networks — •Vittoria Colizza — Inserm, Paris, France

Our understanding of communicable diseases prevention and control

is rooted in the theory of host population transmission dynamics. The network of host-to-host contacts along which transmission can occur drives the epidemiology of communicable diseases, determining how quickly they spread and who gets infected. A large body of epidemiological, mathematical and computational studies has provided a number of insights into the understanding of the process and the identification of efficient control strategies. The explosion of time resolved contact data has however opened the stage to new challenges. What are the structural and temporal aspects, and possibly their non-trivial interplay, that are critical for disease spread? To answer this question, I will introduce the infection propagator approach, a theoretical framework for the assessment of the degree of vulnerability of a host population to disease epidemics, once we account for the time variation of its contact pattern. By reinterpreting the tensor formalism of multi-layer networks, this approach allows the analytical computation of the epidemic threshold for an arbitrary time-varying network of host contacts, i.e. the critical pathogen transmissibility above which large-scale propagation occurs. I will apply this framework to a set of empirical time-varying contact networks and show how it can be used to test different intervention strategies for infection prevention and control in realistic settings.

Invited Talk SOE 18.2 Thu 10:00 MA 001
Critical regimes driven by recurrent mobility patterns of reaction-diffusion processes in networks — •Jesus Gomez-Gardenes — University of Zaragoza, Spain

Reaction-diffusion processes have been widely used to study dynamical processes in epidemics and ecology on networked metapopulations. In the context of epidemics, reaction processes are understood as contagions within each subpopulation (patch), while diffusion represents the mobility of individuals between patches. Recently, the characteristics of human mobility, such as its recurrent nature, have been proven crucial to understand the phase transition to endemic epidemic states. Here, by developing a framework able to cope with the elementary epidemic processes, the spatial distribution of populations and the commuting mobility patterns, we uncover three different critical regimes of the epidemic incidence as a function of these parameters. Interestingly, we show a regime of the reaction*diffussion process in which, counter-intuitively, mobility detriments the spreading of the disease. We analytically determine the precise conditions for the emergence of any of the three possible critical regimes in real and synthetic networks.

Invited Talk SOE 18.3 Thu 10:30 MA 001
Phase Transitions in Cooperative Coinfections — •Peter Grassberger[1], Li Chen[2], Fakhteh Ghanbarnejad[3], and Weiran Cai[4] — [1]Juelich Research Center, Juelich, Germany — [2]Northwestern Polytechnical University, Xi'an, Shaanxi, China — [3]Technische Universität Berlin, Berlin, Germany — [4]Technische Universität Dresden, Dresden, Germany

We study the spreading of two mutually cooperative diseases on different network topologies, with two stochastic versions of an SIR type model. Cooperativity can lead to hybrid spreading/extinction transitions, which show at the same time typical signatures both of first order (discontinuous) and second order (continuous) phase transitions. Details depend strongly on the underlying network(s), but also on some details of the algorithms.

As a rule, first order and hybrid transitions occur on networks with few short but many long loops, while continuous transitions are found when there are either many short or few long loops. The latter happens on 2-d lattices, while the former is typical for high-dimensional regular lattices or Erdős-Rényi networks. In three dimensions, the behavior is most rich, and a zoo of different first order / second order mixtures are observed.

15 min. break

Invited Talk SOE 18.4 Thu 11:15 MA 001
Linear and nonlinear scenarios of societal change — •Andrzej Nowak — University of Warsaw, Poland

We argue that is that rapid social changes occur rapidly in an abrupt and nonlinear manner resembling a phase transition. Societies in the midst of rapid change are characterized by dual realities corresponding to the new and the old, and the change occurs as the islands of the new expand at the expense of the islands of the new. The central notion is that social influence processes play a pivotal role in promoting social change. Dynamic Theory of Social Impact, which is based on numerous experiments, describes social influence of a group of sources on the target. The findings are based on computer simulations of the theory and confirmed by empirical data collected during the societal transitions that occurred in Poland in the late 1980s and early 1990s. We discuss the dynamics associated with rapid transitions in a society*s norms and attitudes, potential for rapid reversals and role of history is social dynamics.

Invited Talk SOE 18.5 Thu 11:45 MA 001
Collective Sensing and Decision-Making in Animal Groups: From Fish Schools to Primate Societies — •Iain Couzin — Dept. of Collective Behaviour, Max Planck Institute for Ornithology & Chair of Biodiversity and Collective Behaviour, University of Konstanz, Konstanz, Germany

Understanding how social interactions shape biological processes is a central challenge in contemporary science. Using an integrated experimental and theoretical approach I will address how, and why, animals exhibit highly-coordinated collective behavior. I will demonstrate new imaging technology that allows us to reconstruct (automatically) the dynamic, time-varying networks that correspond to the visual cues employed by organisms when making movement decisions. Sensory networks are shown to provide a much more accurate representation of how social influence propagates in groups, and their analysis allows us to identify, for any instant in time, the most socially-influential individuals within groups, and to predict the magnitude of complex behavioral cascades before they actually occur. I will also introduce a new fully-immersive Virtual Reality environment for freely-moving animals, and investigate the coupling between spatial and information dynamics in groups. Finally I will reveal the critical role uninformed, or unbiased, individuals play in social networks effecting fast and democratic consensus decision-making in collectives, including with experiments involving schooling fish and wild baboons.

SOE 18.6 Thu 12:15 MA 001
Quantitative assessment of import risks for emergent infectious disease outbreaks — •Olga Baranov[1] and Dirk Brockmann[1,2] — [1]Robert Koch-Institut, Berlin, Germany — [2]Humboldt-Universität zu Berlin, Germany

During the last decade outbreaks of emergent pathogens that potentially pose a risk of global dissemination have increased in number and magnitude. When new outbreaks occur, one of the key challenges is a quantitative assessment of the situation, especially concerning global spread. To this end, sophisticated computational models have been developed incorporating exact situation details, disease parameters and demographics. One of the key problems is that highly detailed models are difficult to gauge, because of the initial lack of parameters, substantially impacting the applicability of even the most sophisticated models. We propose an alternative approach for estimating relative import risk from network topology and outbreak origin. It is based on the assumption that during the initial outbreak phase, global import risk is determined by a low dispersal count regime. In this regime disease specific data play only a minor role. Using world aviation network, we demonstrate how import risk at any location can be inferred. We show that this method can be used to compute an airports dissemination profile as a function of outbreak location and how outbreaks in different regions lead to a different subset of key airports. Our method is fast and not limited to a particular type of infectious disease. It can be used as an initial risk assessment tool for public health researchers and policy makers that need to address a real world scenario.

SOE 18.7 Thu 12:30 MA 001
How to compete in a multi-pathogen system? — Francesco Pinotti[1], •Fakhteh Ghanbarnejad[2], Philipp Hövel[2], and Chiara Poletto[1] — [1]Sorbonne Universités, UPMC, INSERM, IPLESP UMRS 1136, Paris, France — [2]Institute of Theoretical Physics, TU Berlin, Berlin, Germany

In an ecological system pathogens often need to share their host with other pathogens, and therefore compete for the resources with different spreading strategies. Both cooperative and competitive interactions in bacterial infections have been observed. These two mechanisms have been studied separately in the majority of cases and non-trivial dynamical effects can be expected to arise from their combination. In this work, we study two strains competing with each other for host resources in the presence of a third pathogen cooperating with both of them. We first treat dynamics in a homogeneously mixed population by means of mean-field theory and stability analysis. We study the impact of cooperation on the outcome of the two-pathogen competi-

tion, which can be quantified in terms of dominance of one competing pathogen or the co-circulation of both of them. We show that the presence of a third cooperating pathogen can alter the outcome of competition as it may favor the more cooperative pathogen over the more infectious one. We then consider more complex contact structures among hosts and perform computer simulations to study the evolution of the diseases.

SOE 18.8 Thu 12:45 MA 001

Defining the scope: A context specific approach to identifying key airports during a pandemic — •Clara Jongen[1,2], Olga Baranov[2], and Dirk Brockmann[1,2] — [1]Humboldt-Universität zu Berlin, Germany — [2]Robert Koch-Institut Berlin, Germany

Human transportation and mobility networks play an important role in the global spread of infectious diseases. Network theory is one of the key methods to understand the nature of these phenomena. In this context, a family of node and link centrality measures has been devised to identify network elements that facilitate the spread and thus require particular attention in the development of containment strategies. However, most centrality measures are not context sensitive, e.g. they do not account for the location of an outbreak. Using the example of disease dynamics on the global air-transportation network we introduce the concepts of node *scope* and *confluence*. These quantities are context dependent centrality measures that are designed to account for the initial outbreak location. We show that scope and confluence can strongly depend on regional aspects of an outbreak and can therefore be adapted to specific outbreak scenarios. We show that each airport is characterized by a node specific scope and confluence profile as outbreak locations are varied. Scope and confluence also permit to address what outbreak locations are particularly threatening to specific nodes in the network. Our method can be used as an assessment tool for understanding global disease dynamics and permit a fast yet specific assessment of an airport's role in global disease dynamics.

SOE 18.9 Thu 13:00 MA 001

Comparison of Control Strategies for the Spread of *Bovine Viral Diarrhea*: A Stochastic Agent-Based Model — •Jason Bassett[1], Pascal Blunk[1], Thomas M. Isele[1], Hartmut H. K. Lentz[2], Jörn Gethmann[2], Philipp Hövel[1,3], and Franz J. Conraths[2] — [1]TU Berlin, Berlin, Germany — [2]Friedrich Loeffler Institute, Greifswald, Germany — [3]BCCN, Berlin, Germany

Bovine Viral Diarrhea (BVD) is an important cattle disease due to its global prevalence and its economic implications [1]. In this work we have developed a stochastic agent-based model to describe the spread of BVD in Thuringia through trade mediated contacts of animals. The agents act at the level of the animal, the herd or the farm on a network of farms connected according to a supply and demand managing system, while the BVD dynamics are based on a model by [2]. We initialise the simulation according to a realistic farm size distribution for Germany and the state of Thuringia, and compare the results of the simulation with demographic and endemic data solely for the state of Thuringia. We also run the simulation for different parameter settings (scenarios) including vaccination strategies and currently implemented or considered regulations. Finally, we present and discuss some network analysis results on the simulated network [3].

SOE 19: Chimera states: symmetry-breaking in dynamical networks (joint session DY/SOE)

Time: Thursday 10:00–13:00 Location: BH-N 128

SOE 19.1 Thu 10:00 BH-N 128

Optimal design of the Tweezer control for chimera states — •Iryna Omelchenko[1], Oleh E. Omel'chenko[2], Anna Zakharova[1], and Eckehard Schöll[1] — [1]Institut für Theoretische Physik, Technische Universität Berlin, Germany — [2]Weierstrass Institute, Berlin, Germany

Chimera states are complex spatio-temporal patterns which consist of coexisting domains of spatially coherent and incoherent dynamics in systems of coupled oscillators. In small networks, chimera states usually exhibit short lifetimes and erratic drifting of the spatial position of the incoherent domain. We introduce a tweezer feedback control scheme which can effectively stabilize and fix the position of chimera states in small systems [1]. We analyse the action of the tweezer control in small nonlocally coupled networks of Van der Pol and FitzHugh-Nagumo oscillators, and determine the ranges of optimal control parameters. We demonstrate that the tweezer control scheme allows for stabilization of chimera states with different shapes, and can be used as an instrument for controlling the coherent domains size, as well as the maximum average frequency difference of the oscillators.

[1] I. Omelchenko, O. E. Omel'chenko, A. Zakharova, M. Wolfrum, and E. Schöll, Phys. Rev. Lett. **116**, 114101 (2016).

SOE 19.2 Thu 10:15 BH-N 128

Asymmetric frequencies in symmetric oscillator networks — •Diemut Regel[1,2] and Marc Timme[1,2] — [1]Network Dynamics, Max Planck Institute for Dynamics and Self-Organization, 37077 Goettingen — [2]Chair for Network Dynamics, Center for Advancing Electronics (cfaed) and Institute for Theoretical Physics, TU Dresden, 01062 Dresden

The emergence of collective order fundamentally underlies the function of dissipative dynamical systems. Certain symmetries such as a continuous translation symmetry or a discrete permutation symmetry constitute common conditions to enable dynamical ordering processes. Homogeneous changes to local system properties do not affect such symmetries. Here we report that homogeneously decreasing the entirely local self-interactions in symmetrically pulse-coupled oscillator networks may remove constraints common in all oscillator networks coupled continuously in time and thereby enable increased disorder during collective transient dynamics. Moreover, the persistent long-term dynamics may exhibit asymmetrically disordered average frequencies despite the system being entirely symmetric. We explain and systematically evaluate this anomalous phenomenon of collective network dynamics.

SOE 19.3 Thu 10:30 BH-N 128

Chimeras in a minimal oscillator network and its thermodynamic counterpart — •Sindre W. Haugland[1,2], Felix Kemeth[1,2], and Katharina Krischer[1] — [1]Physik-Department, Nonequilibrium Chemical Physics, Technische Universität München, James-Franck-Str. 1, D-85748 Garching, Germany — [2]Institute for Advanced Study - Technische Universität München, Lichtenbergstr. 2a, D-85748 Garching, Germany

A network of nonlinear oscillators can exhibit chimera states, the coexistence of synchronized and desynchronized oscillation, for uniform parameters and symmetrical coupling. In the case of nonlinearly coupled Stuart-Landau oscillators, chimera states form spontaneously from generic initial conditions even when the coupling is purely global.

Here, we start by considering a minimal model of only four globally coupled Stuart-Landau oscillators, identifying a multitude of chimera and related states with a varying degree of symmetry, as well as the specific bifurcations in which these states are created and destroyed. Some of these states are also found to be co-stable. By systematically increasing the ensemble size, we subsequently trace how the minimal states develop and identify which of them give rise to the already known macroscopic chimera states.

SOE 19.4 Thu 10:45 BH-N 128

Symmetry-Broken Amplitude- and Phase-Locking in Two Identical Symmetrically Coupled Stuart-Landau Oscillators — •André Röhm and Kathy Lüdge — Institut für Theoretische Physik, TU Berlin

In the model system of two instantaneously and symmetrically coupled identical Stuart-Landau oscillators we demonstrate that there exist stable solutions with symmetry-broken amplitude- and phase-locking. Similar to Chimera States, these states are a simple and approachable example of symmetry-breaking in oscillatory systems. They are characterized by a non-trivial fixed phase and amplitude relationship between both oscillators, while simultaneously maintaining perfectly harmonic oscillations of the same frequency. This is despite the fact, that we do not employ a symmetry-breaking coupling. These states have potential applications as bistable states for switches in a wide array of coupled oscillatory systems.

While some of the surrounding bifurcations have been previously

described, we present the first detailed analytical and numerical description of these states and present analytically and numerically how they are embedded in the bifurcation structure of the system, arising both from the in-phase as well as the anti-phase solutions. The dependence of both the amplitude and the phase on parameters can be expressed explicitly with analytic formulas. As opposed to previous reports, we find that these symmetry-broken states are stable, which can we can show analytically.

SOE 19.5 Thu 11:00 BH-N 128

Experimental observation of spiral wave chimeras in coupled chemical oscillators — •Jan Frederik Totz[1], Julian Rode[1], Mark Tinsley[2], Kenneth Showalter[2], and Harald Engel[1] — [1]Technische Universität Berlin, Berlin, Germany — [2]West Virginia University, Morgantown, USA

In 2002, studying synchronization of nonlocally coupled oscillators, Kuramoto and coworkers made a remarkable observation: Although both the natural frequency of the individual oscillators as well as their coupling among each other were identical, for certain initial conditions some oscillators became phase-synchronized while others do not [1]. The discovery of this counterintuitive state, named chimera state, triggered an increasing number of studies on partial synchronization. I will present a versatile setup based on optically coupled catalytic micro-particles [2], that allows for the experimental study of synchronization patterns in very large networks of relaxation oscillators under well-controlled laboratory conditions. In particular I will show our experimental observation of the spiral wave chimera, predicted by Kuramoto [2]. This pattern features a wave rotating around a spatially extended core that consists of phase-randomized oscillators [3].

[1] Kuramoto in Nonlinear Dynamics and Chaos, CRC Press (2002)

[2] Taylor et al. PCCP (2015)

[3] Totz et al. Nature Physics (2017)

15 min. break

SOE 19.6 Thu 11:30 BH-N 128

Chimera states in multi-strain epidemic models with temporary immunity — •Philipp Hövel[1,2], Larissa Bauer[1], Jason Bassett[1], Yuliya Kyrychko[3], and Konstantin Blyuss[3] — [1]TU Berlin — [2]BCCN Berlin — [3]University of Sussex

We investigate a time-delayed epidemic model for multi-strain diseases with temporary immunity [1]. In the absence of cross-immunity between strains, dynamics of each individual strain exhibits emergence and annihilation of limit cycles due to a Hopf bifurcation of the endemic equilibrium, and a saddle-node bifurcation of limit cycles depending on the time delay associated with duration of temporary immunity. Effects of all-to-all and non-local coupling topologies are systematically investigated by means of numerical simulations, and they suggest that cross-immunity is able to induce a diverse range of complex dynamical behaviors and synchronization patterns, including discrete traveling waves, solitary states, and amplitude chimeras. Interestingly, chimera states are observed for narrower cross-immunity kernels, which can have profound implications for understanding the dynamics of multi-strain diseases.

Reference: [1] L. Bauer, J. Bassett, P. Hövel, Y. N. Kyrychko, and K. B. Blyuss, CHAOS **27**, 114317 (2017).

SOE 19.7 Thu 11:45 BH-N 128

Chimera states in brain networks: empirical neural vs. modular fractal connectivity — •Teresa Chouzouris[1], Iryna Omelchenko[1], Anna Zakharova[1], Jaroslav Hlinka[2,3], Premysl Jiruska[4], and Eckehard Schöll[1] — [1]Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin, Germany — [2]Institute of Computer Science, Czech Academy of Sciences, Pod Vodarenskou vezi 2, 18207 Prague, Czech Republic — [3]National Institute of Mental Health, Topolova 748, 250 67 Klecany, Czech Republic — [4]Institute of Physiology, Czech Academy of Sciences, Videnska 1083, 14220 Prague, Czech Republic

The interplay of synchrony and asynchrony in complex brain networks is an important aspect in studies of both brain function and disease. Motivated by its potential application to epileptology, we analyse and compare the collective dynamics of FitzHugh-Nagumo neurons in complex networks with two topologies: an empirical structural neural connectivity derived from diffusion-weighted magnetic resonance imaging and a mathematically constructed network with modular fractal connectivity [1]. We qualitatively simulate the dynamics of epileptic seizures and study the influence of the removal of nodes on the network synchronizability, which can be useful for applications to epileptic surgery.

[1] T.Chouzouris, I. Omelchenko, A. Zakharova, J. Hlinka, P. Jiruska, and E. Schöll, Chimera states in brain networks: empirical neural vs. modular fractal connectivity. arXiv:1710.08219 (2017).

SOE 19.8 Thu 12:00 BH-N 128

Chimera State in Neuron Populations with Dynamical Synapses — Ali Calim[1], Philipp Hövel[2], Mahmut Özer[3], and •Muhammet Uzuntarla[1] — [1]Department of Biomedical Engineering, Bulent Ecevit University, 67100 Zonguldak, TURKEY — [2]Institut für Theoretische Physik, Technische Universitat Berlin, Hardenbergstraße 36, 10623 Berlin, Germany — [3]Department of Electrical-Electronics Engineering, Bulent Ecevit University, 67100 Zonguldak, TURKEY

Current literature on Chimera state in neuronal populations mostly discusses the topic with dynamical system arguments which does not provide information about potential concrete biological reasons giving rise to emergence of Chimera in neural medium. With this motivation, our aim is to investigate the influence of short-term synaptic plasticity (STP) on Chimera state in a non-locally coupled network of spiking Morris-Lecar neurons. We first show that Chimera state can appear in population with static synapses (non-plastic) in case of either weak synaptic strength or sparse connectivity between neurons. When there exists strong synaptic strength and dense connectivity, the whole population exhibits synchronized behavior. But, we found that optimal levels of synaptic depression and facilitation at chemical synapses can induce Chimera and Multi Chimera states in such strongly and densely coupled neural populations. Notably, to the best our knowledge, we here show for the first time the existence of Chimera state with Morris-Lecar model neurons.

SOE 19.9 Thu 12:15 BH-N 128

Synchronization of chimera states in two-layer networks of nonlocally coupled chaotic maps — •Galina Strelkova[1], Andrei Bukh[1], Eckehard Schöll[2], and Vadim Anishchenko[1] — [1]Saratov State University, Saratov, Russia — [2]Technical University of Berlin, Berlin, Germany

We explore numerically synchronization effects and their dynamical and statistical properties in two different two-layer networks of nonlocally coupled chaotic maps. The first network is represented by two coupled one-layer networks of nonlocally coupled identical logistic maps with a control parameter detuning. The second two-layer network we study is made of two coupled one-layer networks of nonlocally coupled chaotic Henon and Lozi maps. We show that both two-layer networks under consideration can demonstrate the phenomena of external and mutual synchronization of various complex spatiotemporal structures, including different chimera states. We quantify the identity of synchronous structures by calculating the cross-correlation coefficient. In the synchronization regime this characteristic is very close to 1. We also show that the synchronization phenomena in the considered two-layer networks are observed within a finite region in the parameter space. To illustrate this we construct the synchronization regions for synchronized chimera structures in the plane of two control parameters of the considered networks.

SOE 19.10 Thu 12:30 BH-N 128

Impact of noise on the lifetime of chimera states and spatio-temporal intermittency in ensembles of nonlocally coupled chaotic oscillators — •Nadezhda Semenova[1], Galina Strelkova[1], Vadim Anishchenko[1], and Anna Zakharova[2] — [1]Department of Physics, Saratov State University, 83 Astrakhanskaya Street, Saratov 410012, Russia — [2]Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin, Germany

We describe numerical results for the dynamics of networks of nonlocally coupled chaotic oscillators. It has been demonstrated that elements in amplitude chimera clusters are characterized by a nonstationary dynamics. This process looks like nonperiodic switchings between amplitude and phase chimeras. It has been shown that in autonomous ensembles, the nonstationary regime of switchings has a finite lifetime and represents a transient process towards a stationary regime of phase chimera. Our numerical studies have shown that a single noise perturbation of the ensemble elements in the nonstationary regime can increase the lifetime (duration) of this mode and even revive the am-

plitude chimera. If single noise perturbations are introduced into the network elements constantly in certain time intervals, then the transient process can be observed for an infinite time. However, has been established that the noise source, which is constantly acting on the ensemble with the phase chimera, does not induce new regimes and structures and leads only to noisy snapshots. The stationary phase chimera regime turns out to be stable towards noise perturbations.

SOE 19.11 Thu 12:45 BH-N 128

Chimera states in networks of logistic maps with hierarchical connectivities — •Alexander zur Bonsen, Iryna Omelchenko, Anna Zakharova, and Eckehard Schöll — Institut für Theoretische Physik, Technische Universität Berlin, Germany

Chimera states are complex spatiotemporal patterns consisting of coexisting domains of coherence and incoherence. We study networks of nonlocally coupled logistic maps and analyze systematically how the dilution of the network links influences the appearance of chimera patterns. The network connectivities are constructed using an iterative Cantor algorithm to generate fractal (hierarchical) connectivities. Increasing the hierarchical level of iteration, we compare the resulting spatiotemporal patterns. We demonstrate that a high clustering coefficient and symmetry of the base pattern promotes chimera states, and asymmetric connectivities result in complex nested chimera patterns.

A. zur Bonsen, I. Omelchenko, A. Zakharova, and E. Schöll, *Chimera states in networks of logistic maps with hierarchical connectivities.* arXiv:1711.03287 (2017)

SOE 20: Reduction and Emergence in Econophysics (joint session AGPhil/SOE)

Time: Thursday 15:00–18:00 Location: H 2033

Invited Talk SOE 20.1 Thu 15:00 H 2033

Reduction, emergence and mechanisms in magnets and markets — •Meinard Kuhlmann — University of Mainz

Treatments of critical phenomena in physics but even more so in interdisciplinary applications exhibit a certain tension when we ask whether a micro reduction is possible: On the one hand, hardly anyone will doubt that these phenomena rest on (or "supervene" upon) the behaviour of the constituents parts. On the other hand, the universality of critical phenomena suggests that the dynamics is in some sense independent from its physical manifestation on the micro level. That is, critical phenomena seem to be "emergent" and thus defy reduction. I will argue that one can dissolve this tension by introducing the notion of "structural mechanisms". Explanations in terms of structural mechanisms are reductive in the sense that it is the interactive organisation of the micro constituents that matters. However, only certain structural features of the interaction are important whereas the nature of the micro constituents is otherwise irrelevant.

Invited Talk SOE 20.2 Thu 15:45 H 2033

Ising models of financial markets? Are we serious? — •Stefan Bornholdt — Institut für Theoretische Physik, Universität Bremen

Within one or two decades, a subdiscipline of socio- and econophysics emerged that uses the scientific approach of physics to explore the dynamics of markets and human society in a quantitative way. This subdiscipline is also present at the current DPG meeting: the division of physics of socio-economic systems, SOE. A wide range of physics methods from statistical physics and stochastic processes to agentbased (spin) models are applied to financial and behavioral themes. But how can we expect that a complex system as, for example, a stock market, embedded in the world's economy, could possibly be described by the simplest toy models? Universality, best known from statistical physics of matter, inspires a possible route to a new kind of reductionism: Instead of modeling an economy by the famous representative agent, as done for decades, falsely assuming statistical independence of agents, today's agent based models keep agents and their interactions in order to study the emergent dynamics of their collective dynamics. I will give a brief overview of current models and their limits.

Invited Talk SOE 20.3 Thu 16:30 H 2033

Emergent phenomena in physics and econophysics — •Radin Dardashti — IZWT, Wuppertal, Germany

Various kinds of phenomena and properties in physics are regarded as emergent in some sense or another. The temperature of a system, critical exponents or the Hawking effect are all discussed in this context. However, there can be significant differences in their realizations and theoretical treatment, with important consequences for their interpretation. In the econophysical literature the stylized facts of economics are also understood as emerging out of the complex system. But how should we understand the emergence of stylized facts and what does this mean for the treatment of these models?

I will discuss examples of emergent phenomena from fundamental physics and embed it into a general framework, which allows us to shed light on these questions.

Invited Talk SOE 20.4 Thu 17:15 H 2033

Stock market crashes as critical phenomena? Explanation, idealization, and universality in econophysics — •Patricia Palacios — Munich Center for Mathematical Philosophy, Munich, Germany

We study the Johansen-Ledoit-Sornette (JLS) model of financial market crashes (Johansen, Ledoit, and Sornette 2000) that treats market crashes as critical phase transitions.

On our view, the JLS model is a curious case from the perspective of the recent philosophy of science literature, as it is naturally construed as a 'minimal model' in the sense of Batterman and Rice (Batterman and Rice 2014) that nonetheless provides a reductive explanation and causal explanation of market crashes, in the sense of Woodward's interventionist account of causation (Woodward 2003).

SOE 21: Traffic Dynamics, Urban and Regional Systems (joint session SOE/DY)

Time: Thursday 15:00–16:15 Location: MA 001

SOE 21.1 Thu 15:00 MA 001

A planar growing network model for urban street network evolution — •Oliver Weisse and Reik V. Donner — Potsdam Insitute for Climate Impact Research, Potsdam, Germany

Historically grown cities can be at least partially understood as the result of self-organization principles without central planning authority. In order to understand the associated spatial settlement patterns, it is convenient to analyze the associated urban road networks providing the backbone of such cities. Recent work has demonstrated that the topological and geometric properties of such networks exhibit a surprising degree of universality, suggesting that the corresponding structure formation has been governed by relatively general principles.

Here, we propose an evolving planar network model based on a small set of simple rules that model stochastic network growth under local optimization of construction costs and travel efficiency. Specifically, we assume that the growth of cities follows a probability distribution of nodes in a two-dimensional Euclidean space with higher probability in areas where infrastructure already exists. In contrast to other existing models of urban road networks, this growth is recursive and depends on the existing city. Nevertheless, the geometric characteristics of the generated planar networks are statistically similar for sufficiently large cities, implying that they are largely independent of the specific evolution path. Moreover, the observed properties agree well with those of real-world cities.

SOE 21.2 Thu 15:15 MA 001

Dynamics of cities' population: relating Zipf's law and urban scaling — •José M. Miotto — LIACS, Universiteit Leiden, Netherlands

The distribution of city sizes in a country is characterized by having a

power-law tail (Pareto), a common feature of large social systems. Proportional effect -each city grows with the same rate- is a well-accepted growth model for cities that explains the emergence of this feature (Gabaix); however, data from cities gathered in historical scale (Italy, 1861-2011) shows important features that cannot be explained by this model. I will introduce a modified growth model where the growth rate of cities scales with city size, and show that this model can (a) reproduce quantitatively the cities' size distribution evolution in time, (b) provide a better null model for the time evolution of the population of single cities and (c) reveal patterns in the dynamics of internal migration.

SOE 21.3 Thu 15:30 MA 001

Urban Kaya relation: understanding urban CO2 emissions — Ramana Gudipudi[1], •Diego Rybski[1], Matthias K. B. Lüdeke[1], Bin Zhou[1], Zhu Liu[2,3,4], and Jürgen P. Kropp[1,5] — [1]Potsdam Institute for Climate Impact Research, 14473, Potsdam, Germany — [2]John F. Kennedy School of Government, Harvard University, Cambridge, Massachusetts 02138, USA — [3]Resnick Sustainability Institute, California Institute of Technology, Pasadena, California 91125, USA — [4]Cambridge Centre for Climate Change Mitigation Research, Department of Land Economy, University of Cambridge, 19 Silver Street, Cambridge CB3 9EP, UK — [5]Dept. of Geo- and Environmental Sciences, University of Potsdam, 14476, Potsdam, Germany

Given the strong global urbanization trend, it is crucial to understand whether large urban areas are more emission efficient in comparison to smaller ones. Recent literature on urban scaling properties of emissions as a function of population size led to contradicting results and more importantly lacked an in-depth investigation of the factors leading to such scaling properties. Therefore, in analogy to the well-established Kaya Identity, we developed an urban Kaya relation to investigate different scaling properties of the indicators within the Kaya Identity. Contrary to traditional urban scaling studies which use ordinary least squares regression, we show that orthogonal regression is necessary when complex relations among scaling exponents are to be investigated.

SOE 21.4 Thu 15:45 MA 001

The Urban form, quantifying population spatial distribution in cities — •Valerio Volpati and Marc Barthelemy — IPhT, Universite' Paris Saclay, France

In Urban Economics, the different forces playing a role in the development of a city have been described, leading to idealized models of cities such as the von Thunen monocentric model. In real data, the spatial distribution of activities inside cities is often more complicated and non monocentric. Here we study the population spatial distribution inside french cities, and we introduce measures to quantify how much each city is monocentric, polycentric or homogenous. We classify cities according to such measures and discuss how we can revisit classical models of Urban Economics in light of the empirical analysis.

SOE 21.5 Thu 16:00 MA 001

Antipersistence of traffic flow explains congestion durations — •Sebastian M. Krause, Lars Habel, Thomas Guhr, and Michael Schreckenberg — Faculty of Physics, University of Duisburg-Essen, Lotharstr. 1, 47048 Duisburg, Germany

Many highways are running above their capacity and therefore suffer congested traffic. The traffic breakdown from free flow becomes increasingly likely around a critical flow, a critical number of vehicles per minute. Here we discuss congestion durations which are distributed with a power law over three decades, from minutes to hours [1]. This finding suggests a robust mechanism behind it. Using antipersistent stochastic modeling of the traffic flow, we are able to explain the distribution of congestion durations: The traffic flow shows large fluctuations on short time scales which quickly trend back to the mean value. Consequently, it exceeds the critical flow for time spans which are power law distributed.

[1] S. M. Krause, L. Habel, T. Guhr and M. Schreckenberg, 'The importance of antipersistence for traffic jams', EPL 118, 38005 (2017).

SOE 22: Focus Session: Computational Social Science

Session organized by Ingo Scholtes.

Time: Thursday 16:15–18:00 Location: MA 001

SOE 22.1 Thu 16:15 MA 001

Understanding Social Organizations: From Sociophysics to Computational Social Science — •Ingo Scholtes — Chair of Systems Design, ETH Zürich, Zürich, Switzerland

The convergence of social and technical systems provides us with a wealth of data on the structure and dynamics of social organizations. It is tempting to utilize these data to better understand how social organizations evolve, how its structure is related to the "success" or "failure" of an organization, and how the position of individuals in the evolving social fabric affects performance, motivation, and productivity.

Taking a complex systems perspective, in this talk I will give an overview of recent results from the data-driven modelling of social organizations. A particular focus of this talk is on actionable and quantitative insights for project management, which have been obtained by studying large volumes of publicly available data on Open Source software development teams.

The results of these analyses confirm that computational methods from the study of complex systems and complex networks can help us to test long-standing theories from social psychology and organizational theory. At the same time I will discuss fallacies that arise when trying to explain complex phenomena in real-world social systems by means of overly simple, physics-inspired models.

SOE 22.2 Thu 16:30 MA 001

Visibility of Minorities in Social Networks — Fariba Karimi[2,3], Mathieu Genois[2], Claudia Wagner[2,3], Philipp Singer[2], and •Markus Strohmaier[1,2] — [1]RWTH Aachen University — [2]GESIS - Leibniz Institute for the Social Sciences — [3]University of Koblenz-Landau

Homophily can put minority groups at a disadvantage by restricting their ability to establish links with people from a majority group. This can limit the overall visibility of minorities in the network. Building on a Barabási-Albert model variation with groups and homophily, we show how the visibility of minority groups in social networks is a function of (i) their relative group size and (ii) the presence or absence of homophilic behavior. We provide an analytical solution for this problem and demonstrate the existence of asymmetric behavior. Finally, we study the visibility of minority groups in examples of real-world social networks: sexual contacts, scientific collaboration, and scientific citation. Our work presents a foundation for assessing the visibility of minority groups in social networks in which homophilic or heterophilic behaviour is present.

SOE 22.3 Thu 16:45 MA 001

Comparison of Baum Welch Algorithm and Simulated Annealing as training algorithms for Hidden Markov Models — •Kim Schmidt and Karl Heinz Hoffmann — TU Chemnitz, Institut für Physik, 09107 Chemnitz, Germany

In some situations, such as an old lady at a new ticket machine or a driver in a highly automated vehicle, it is very important to identify helplessness to offer assistance and avoid or reduce frustration. We intend to use facial expression, gestures, and voice or lip movement to train a Hidden Markov Model (HMM) that should identify conditions as joy, frustration and helplessness. The Baum Welch Algorithm (BW) is the common training algorithm with the drawback of getting stuck in local minima. An alternative algorithm can be Simulated Annealing (SA) that can overcome local minima and thus it can end in a better solution. In particular we focus on comparing both algorithms for a varied complexity of exemplary HMMs.

SOE 22.4 Thu 17:00 MA 001

Two types of seasonal words observed from Japanese blog data — •Kenta Yamada — National Institute of Informatics, Tokyo, Japan — Precursory Research for Embryonic Science and Technology

Japan Science and Technology Agency Saitama, Japan

I analyzed frequency of word appearances in Japanese blogs and introduced the method which detects two types of seasonal words using simple autocorrelation analysis: one is for seasonal words with a specific day such as Christmas basically having sharp growth and decay around the peaking day characterized by a power function, and the other one is for seasonal words without a specific day like ski. The algorithm caught not only words which are easily understood as seasonal words such as Christmas and ski but also words which are not well known by everyone such as words related to local customs. We also found the number of seasonal words with a highest frequency on the day is widely distributed and in the case of seasonal words with a specific day the distribution follows a power law. These findings would give support to writers about seasonal topics and to suggest seasonal items for shop staff.

SOE 22.5 Thu 17:15 MA 001

Next Generation Agent-Based Social Simulation — •Jan Ole Berndt and Ingo J. Timm — TriLabS@CIRT, Universität Trier, Germany

Agent-based social simulation (ABSS) has become a well-established research technique in computational social science (CSS). It complements network-theoretic and kinematics-inspired approaches to analysing emergent dynamics in complex systems. In addition, intelligent agents – as researched from a distributed artificial intelligence (DAI) perspective – provide information-processing, decision-making, and social interaction capabilities. Current ABSS is often either (a) limited in scale or (b) tends to oversimplify decision behaviour: (a) Cognitive models of motivations, emotions, and decisions adopted by DAI provide insights into comprehensible decision-making in small groups. (b) ABSS, e.g., with simple threshold models, enables analyses of large-scale networks. As CSS and DAI communities are rarely connected, this leads to a gap between simulations in DAI and social or cognitive sciences. We aim at bridging this gap to contribute to next generation social simulation. We discuss technical challenges of and methods for extending social simulation by sophisticated agent models, e.g., how to scale complex decision-making. Additionally, we address the problems of validating the resulting models and of using them to evaluate hypotheses in social simulations. We provide practical examples ranging from care demand forecasting and social media communication to social contagion of fertility.

SOE 22.6 Thu 17:30 MA 001

Avoiding Ethical Dilemmas of Autonomous Vehicles — •Jan Nagler — ETH Zurich

Soon Artificial Intelligence will decide about many issues, including life and death, how should autonomous systems faced with ethical dilemmas decide, and what is required from humans? We discuss this problem in connection with the accident management of autonomous vehicles. Today, more than 1 Billion vehicles are on our streets worldwide. Within the next 10-20 years, self-driving cars are expected to largely substitute these conventional vehicles. But how to engineer autonomous vehicles and, more generally, design artificially intelligent systems for safety and other moral values? Self-driving cars will have to deal with situations that result in 'moral dilemmas', and will sometimes have to autonomously decide who will be harmed. The challenge is usually discussed by means of the popular (but unrealistic) 'Trolley problem', where a choice is to be made whether to run into one group of people or severely harm another group of people, if an accident is unavoidable. This simple dilemma has been imported from moral philosophy into our thinking about systems engineering, policy and law (Deng, Nature 523: 24, 2015), but it has a number of pitfalls. Today's 'moral' algorithms are typically based on a deterministic minimization of harm. We challenge this myopic principle as - in the long-term - it may increase harm rather than minimize it, in particular in times of crisis, or in unsustained environments. We are unable to solve those dilemmas, or tell exactly what to do. We wish to discuss, however, what not to do.

SOE 22.7 Thu 17:45 MA 001

Towards "Valid" Agent-based Social Simulation — •Ingo J. Timm[1], Daniel Lebherz[1], Jan Ole Berndt[1], Simon Schmaus[2], Joscha Krause[2], and Ralf Münnich[2] — [1]Trier University, Trier Lab for Agent-based Simulation (TriLabS@CIRT), Trier, Germany — [2]Trier University, Economics and Social Statistics,Trier, Germany

The fruitful combination of social sciences and computer science, i.e., distributed artificial intelligence, has been researched for more than two decades now: E.g., in the DFG-priority research programme on "Socionics" (1999-2006), social theories and mechanisms have been formalized and integrated in multiagent systems to analyse these theories and mechanisms by agent-based social simulation (ABSS) as well as to improve multiagent systems themselves. In both approaches the actors have been derived from a theoretical deliberation process.

ABSS seems to have a potential to analyse decision-making in societies in real-world situations, e.g., in health care, mobility, or environmental protection. However, this requires the reconstruction of (parts of) the population based on the socio-economic disposition of the individuals leading to the challenge: where to get sufficient data and how to validate the model? Regionalization of survey data, reconstruction of an artificial population, and simulating population dynamics in context of microsimulation is part of the expertise and research focus of the Trier University social statistics department. Consequently, we are working together on this challenge to develop an integrated approach for microsimulation and ABSS. In the talk, we will outline a first step approach for modelling and simulation of care demand.

SOE 23: Complex Contagion Phenomena II (Focus Session with EPS-SNPD) (joint session SOE/DY/BP)

Session organizers and chairs: Philipp Hövel, Pawel Romanczuk, and Jonathan Donges. See part I of the session for a synopsis.

Time: Friday 9:30–13:15 Location: MA 001

Topical Talk SOE 23.1 Fri 9:30 MA 001

Network reconstruction for the prediction of spreading processes — •Diego Garlaschelli — Lorentz Institute for Theoretical Physics, University of Leiden, The Netherlands

Financial contagion is an epidemic-like phenomenon whereby financial distress can propagate across a network of banks connected by credit relationships, possibly leading to the collapse of the entire system. In order to estimate the systemic risk of financial contagion, the knowledge of the entire interbank network is required. However, due to confidentiality issues, banks only disclose their total exposure towards the aggregate of all other banks, and not their individual exposures towards each bank. A similar problem is encountered in epidemiology. Is it possible to statistically reconstruct the hidden structure of a network in such a way that privacy is protected, but at the same time higher-order properties are correctly predicted? In this talk, I will present a general maximum-entropy approach to the problem of network reconstruction and systemic risk estimation. I will illustrate the power of the method when applied to various economic, social, and biological systems. Then, as a counter-example, I will show how the Dutch interbank network started to depart from its reconstructed counterpart in the three years preceding the 2008 crisis. Over this period, many topological properties of the network showed a gradual transition to the crisis, suggesting their usefulness as early-warning signals. By definition, these signals are undetectable if the network is reconstructed from partial bank-specific information.

SOE 23.2 Fri 10:00 MA 001

Agent-based modeling of innovation spreading in ancient times — •Natasa Djurdjevac Conrad[1], Luzie Helfmann[1,2], Johannes Zonker[1,2], Stefanie Winkelmann[1], and Christof Schuette[1,2] — [1]Zuse Institute Berlin — [2]Freie Universitaet Berlin

Modeling of spreading processes has gained a lot of attention in the last decades, since these processes play a crucial role in understanding a wide range of real-world systems that span biological, technical,

economical and social sciences. However, very little is known about processes/systems that have happened in ancient times, available data is sparse and we can not observe these systems again.

In this talk, we will present an agent-based model for the spreading of the wool-bearing sheep in a population of herders in the Near East and Europe, between 6200 and 4200 BC. In our model, the herders are represented by agents moving diffusively in a geophysical landscape and simultaneously interacting with other agents. The diffusion of the innovation is thus happening on a spatial network that is changing in time, as the connections between the agents are changing in time due to their movements. We will use our model to explore the dynamical properties of the spreading process and to study the qualitative effect of different aspects affecting the speed and spatial evolution of this spreading process.

SOE 23.3 Fri 10:15 MA 001

Identifying the source of large-scale outbreaks of infectious disease — Abigail Horn[1] and •Hanno Friedrich[2] — [1]Bundesinstitut für Risikobewertung, Berlin, Germany — [2]Kühne Logistics University, Hamburg, Germany

We study the problem of identifying the source of emerging large-scale disease outbreaks: given a model of the underlying network and reports of illness, determine the outbreak source location. Existing work on the network source identification problem has focused on studying this problem in trees and extending to general network structures in an *ad hoc* manner; this is to assume the contamination travels along a specific set known paths through a network, which may be an unrealistic approximation. In this work we develop a novel, computationally tractable solution that accounts for all possible contagion transmission paths through the network. We formulate a probabilistic model of the contamination transmission process as a random walk on a network and derive the maximum likelihood estimator for the source location. If the temporal dimension of the spreading process is well understood, we also estimate the epidemic start time. We demonstrate the benefits of this approach to source detection through application to various real network and outbreak contexts, including the 2011 STEC outbreak in Germany spread through the food supply network and ongoing outbreaks of cholera in Mozambique spread through human travel, showing significant improvements in accuracy and robustness compared with the relevant state-of-the-art methods.

SOE 23.4 Fri 10:30 MA 001

Spreading of multiple pathogens and their evolutionary stable strategies — •Kai Seegers[1], Fakhteh Ghanbarnejad[1], Alessio Cardillo[2], and Philipp Hövel[1] — [1]Institut für Theoretische Physik, TU Berlin — [2]Institut Catalá de Paleoecologia Humana i Evolució Social (IPHES)

Different pathogens usually spread simultaneously in a host population and thus often influence each other. They can either be competitive, e.g. due to cross immunity, or cooperative, e.g. by suppressing the immune system of the host. The latter can lead to unexpectedly large outbreaks [EPL 104, 50001 (2013),Nature Physics 11, 936-940 (2015)] as it has been seen in the Spanish Flu pandemic in the early 20th century and it has been recently on serious warning alarm for co-infection of HIV and tuberculosis or hepatitis, for instance. However cooperation might not always be the best strategy for pathogens to survive, due to death of the host population or enforced countermeasures. Therefore we combine in a novel approach spreading dynamics of different strains of multiple pathogens with evolutionary game theory. We show bistability of strategies in the parameter space and finally discuss the emergence of competition and cooperation of pathogens.

SOE 23.5 Fri 10:45 MA 001

Complex Social Contagion of Structural Discrimination — •Gorm Gruner Jensen and Stefan Bornholdt — Institute for Theoretical Physics University of Bremen Otto-Hahn-Allee D-28359 Bremen Germany

One approach within evolutionary game theory study the spreading of contagious behaviors in populations of agents distributed on a graphs. Typically the agents interact in well defined games with their nearest neighbors, and the evolutionary dynamics are implemented by letting agents copying the behavior of their neighbors. Here we demonstrate that this modelling approach can be applied in studying the complex social contagion of structural discrimination. Starting from established models designed to study the evolution of behaviors like cooperation and altruism, we split the agents into groups distinguished only by an observable labels. This generally entails an increased strategy-spaces, as strategies may now be discriminating, ie. imply different behaviors towards agents from different groups. Our model approach is fundamentally different from previous theories of the emergence and persistence of discrimination, which usually rely on on an intrinsic preference for helping your own kind, on games with asymmetric Nash equilibria - like the Hawk-Dove Game, or on self-fulfilling prophecies. We do, however, find a strong connection between the evolutionary stability of discriminating strategies and the strength of the evolution pressure, which indicates that an evolutionary perspective coul be an important compliment to the existing theories.

SOE 23.6 Fri 11:00 MA 001

Making rare events happen: prediction and control of network extinction, switching, and other extreme processes. — •Jason Hindes — U.S. Naval Research Lab, Washington D.C., United States of America

Many complex networks must operate in uncertain and dynamic environments. Over long time scales, combinations of random internal interactions and dynamical perturbations can organize to drive a network from one collective state to another. Such noise-induced large fluctuations may be associated with desirable outcomes, such as epidemic extinctions, or undesirable ones, such as switching in collective order, or loss of network synchrony. In this talk I will discuss a general formalism for predicting rare events in networks with internal and external noise, the role of topology in facilitating the most extreme network events, techniques for optimal network control that leverage uncertainty, and numerical solutions for the aforementioned when explicit formulas are unknown. Along the way, I will consider many examples: from epidemic dynamics to opinion formation and synchronization of coupled oscillators.

15 min. break

SOE 23.7 Fri 11:30 MA 001

Complex contagion in social media — •Philipp Lorenz[1], Jonas Braun[2], and Philipp Hövel[1] — [1]Institute of Theoretical Physics, Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin, Germany — [2]Department of Physics, Humboldt-Universität zu Berlin, Newtonstraße 15, 12489 Berlin, Germany

Spreading processes on a network of individuals can be described either under the assumption of independent interaction with equal transmission rates, like the classic SIS/SIR models (simple contagion) or one can take the structure of an individual's neighborhood into account (complex contagion). A very interesting model is sociologically inspired and includes the relative threshold of a node's surrounding required to change its state to infected (convinced). For the online world, especially social platforms, which became the stage of opinion spreading, these models have to be extended. We propose two extensions of the classical threshold model:

- Reposting, the state of a node can be multiple infected (convinced) changing the binary state variable to an integer.
- Recovery, a saturation of exposure, introducing a second threshold that turns nodes into a recovered (immune) state.

We investigate the interplay of these ingredients, separated and in combination with respect to the spreading dynamics and the role of initiators by the quantitative comparison of various scenarios.

SOE 23.8 Fri 11:45 MA 001

Flockworks: A class of dynamic network models for face-to-face interactions — •Benjamin F. Maier[1,2] and Dirk Brockmann[1,3] — [1]Robert Koch-Institut, Nordufer 20, 13353 Berlin — [2]Institut für Physik, Humboldt-Universität zu Berlin, Newtonstraße 15, 12489 Berlin — [3]Institut für Theoretische Biologie, Humboldt-Universität zu Berlin, Philippstr. 13, 10115 Berlin

Studying the dynamics of face-to-face interaction networks is essential for a better understanding of contact mediated processes, contagion processes, and disease spreading. In many studies regarding social systems, networks are reconstructed using time averages in which links reflect an interaction likelihood, although this measures serves as a qualitative feature from which network properties are computed. During the last years a significant effort was made to resolve this issue by developing algorithms to analyze dynamic processes on the actual time-dependent contact patterns of social systems. However, there is still a lack of simple dynamic network models generating temporal networks of typical behaviour observed in real systems.

We introduce a class of minimal dynamic network models that naturally yield group formation and are easy to control with a small number of parameters. We discuss a variety of properties of those models and show that they reflect the character of real-world temporal data as well as the properties of dynamic processes on this data remarkably well, up to the prediction of epidemic curves.

SOE 23.9 Fri 12:00 MA 001

Cooperation vs. defection in an evolutionary ecological framework — •Felix Köster and Fakhteh Ghanbarnejad — Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin, Germany

In this work, we first extend the CGB model [1] by considering each pathogen has two different strategies: cooperation or defection. Then we analyse the fundamental properties of the interacting contagious processes in a well-mixed population, i.e. homogeneous mean field approximation. Altering parameters we discover new discontinuous phase transitions for which we investigate the multi-stability shift in the phase diagram. We show also qualitatively same results by stochastic simulations. Furthermore, an evolutionary game is introduced to mimic conditions, which force agents to adept their strategies by minimizing their payoff. This study improves our understanding of the natural dynamics of species populations in an evolutionary ecological framework

[1] L. Chen, F. Ghanbarnejad, D. Brockmann "Fundamental properties of cooperative contagion processes"; New J. Phys. 19, 103041(2017)

key words; SIS, interacting dynamics, co-infection, complex contagions, discontinuous transitions

SOE 23.10 Fri 12:15 MA 001

Effective Distances for Epidemic Spreading — •Andreas Koher[1], Flavio Iannelli[2], Igor M. Sokolov[2], and Philipp Hövel[1] — [1]Technische Universität Berlin — [2]Humboldt Universität zu Berlin

The analysis of global epidemics revealed that physical distances can hardly be used to forecast the arrival time of the first infected person. Instead, recent results on the global air traffic network suggest that network based measures, so called effective distances correlate well with actual detection times.

We compare numerical simulations on the global air traffic network with different measures that are based on shortest distances, parallel paths and the recently proposed random walk effective distance [1]. Furthermore, we extend the latter and propose an effective distance that is based on non-backtracking walks. This simple diffusion model allows to consider the directed nature of epidemic spreading and relates the hitting probability to the infection arrival time.

[1] F. Iannelli, A. Koher, D. Brockmann, P. Hövel, and I.M. Sokolov, Effective distances for epidemics spreading on complex networks, Phys. Rev. E 95, 012313 (2017).

SOE 23.11 Fri 12:30 MA 001

Modeling of Behavioral Cascades in Fish Schools — •Pawel Romanczuk[1,2], Matt Grobis[3], Bryan Daniels[4], Winnie Poel[1,2], Colin Twomey[5], and Iain Couzin[6,7] — [1]Institute for Theoretical Biology, Dept of Biology, Humboldt Universität zu Berlin, Germany — [2]Bernstein Center for Computational Neuroscience, Berlin, Germany — [3]Dept. of Ecology and Evol. Biology, Princeton University, USA — [4]ASU-SFI Center for Biosocial Complex Systems, Arizona State University, USA — [5]Dept. of Biology, University of Pennsylvania — [6]Dept. of Collective Behavior, MPIORN, Konstanz, Germany — [7]Dept. of Biology, University of Konstanz, Germany

Recently, it was shown that the spreading of stereotypical escape behavior (startle) in fish schools corresponds to a complex contagion process [1]. Here, we will discuss the modeling of such behavioral cascades using an extension of the generalized contagion model proposed by Dodds & Watts [2]. In particular, using networks extracted from experimental data, we will identify and discuss parameter regions providing best agreement with experimentally observed cascades. Furthermore, we will apply our modeling ansatz to new experiments on the impact of different risk perception on the behavioral contagion dynamics in fish schools.

[1] Rosenthal, S.B., et al., PNAS 112, 15, 4690-4695 (2015)
[2] Dodds, P. & Watts, D.J., Phys Rev Lett, 92, 218701 (2004)

SOE 23.12 Fri 12:45 MA 001

The effect of compatibility and heterogeneous adoptability in contagion processes — •Byungjoon Min and Maxi San Miguel — Instituto de Fisica Interdisciplinar y Sistemas Complejos (CSIC-UIB), Campus Universitat Illes Balears, E-07122 Palma de Mallorca, Spain

While competition and compatibility of multiple contagious entities and heterogeneous adoptability of agents are omnipresent in social contagions, so far these factors are overlooked in traditional models of contagion processes. Here, we study generalized contagion processes in two directions: i) unifying simple and complex contagions reflecting heterogeneous adoptability and ii) considering competition and compatibility among multiple transmittable entities. For a generalized contagion model unifying simple and complex contagion processes, we find a rich variety of phase transitions such as continuous and discontinuous phase transitions, criticality, tricriticality, and double transition. We also examine the role of dual users who possess multiple contagious technologies simultaneously, and find that the compatibility induced by the dual user facilitates spread of innovation and extinction of pre-existing technology.

SOE 23.13 Fri 13:00 MA 001

Modeling of startling cascades and information transfer in fish — •Haider Klenz[1] and Pawel Romanczuk[1,2] — [1]Department of Biology, Humboldt-Universität zu Berlin, Berlin 10115, Germany — [2]Bernstein Center for Computational Neuroscience, Humboldt-Universität zu Berlin, Berlin 10099, Germany

Animals come together in groups, e.g. school of bird or swarms of fish, in which information is processed collectively. Especially in situation where the collective is exposed to a threat, this information and the speed with which it propagates through the collective is of great importance to the individual.

This work focuses on shoals of *Poecilia Sulphuraria* and their reaction to danger. Through environmental dependencies the fish can only swim at the surface and therefore forms a 2D-system. When attacked by preying birds the fish dive down. This diving behavior then spreads through the swarm in a wave like fashion and is repeated for several minutes without further triggers.

We explored the mechanism behind wave spreading with agent-based modeling. We propose a stochastic contagion process and show that the speed of the wave depends on the underlying information network. Furthermore we study different possible explanations for repeated waves.

SOE 24: The Physics of Power-Grids – Fluctuations, Synchronization and Network Structures (joint session DY/SOE)

Time: Friday 10:00–12:15 Location: EB 107

SOE 24.1 Fri 10:00 EB 107

Qualitative Stability and Synchronicity Analysis of Power Network Models in Port-Hamiltonian form — •Simona Olmi[1], Volker Mehrmann[2], Riccardo Morandini[2], and Eckehard Schöll[1] — [1]Institut fuer Theoretische Physik, Sekr. EW 7-1, TU Berlin, Hardenbergstr. 36, D-10623 Berlin — [2]Institut fuer Mathematik MA 4-5, TU Berlin, Str. des 17. Juni 136, D-10623 Berlin

In view of highly decentralized and diversified power generation concepts, in particular with renewable energies such as wind and solar power, the analysis and control of the stability and the synchronization of power networks is an important task that requires different levels of modeling detail for different tasks. A frequently used qualitative approach relies on simplified nonlinear network models like the Kuramoto model. Although based on basic physical principles, the usual formulation in form of a system of coupled ordinary differential equations is not always adequate. We present a new energy-based formulation of the Kuramoto model as port-Hamiltonian system of differential-algebraic equations. This leads to a very robust representation of the system with respect to disturbances, it encodes the underlying physics, such as the dissipation inequality or the deviation from synchronicity, directly in the structure of the equations, it explicitly displays all possible constraints and allows for robust We demonstrate the advantages of the modified modeling approach with analytic results and numerical experiments.

SOE 24.2 Fri 10:15 EB 107

Influence of network topology in shaping the dynamics of power grid networks — •Halgurd Taher, Simona Olmi, and Eckehard Schöll — Institut fuer Theoretische Physik, Sekr. EW 7-1, TU Berlin, Hardenbergstr. 36, D-10623 Berlin

The increase of the inclusion of renewable energy sources into the power grid is rather a paradigm change for the entire European power grid, bringing new challenges for power grid operation. The reason behind this is the fact that the power output of renewable energy sources typically strongly fluctuates and, furthermore, the possible geographical locations for power plants based on renewable energies depend on geographical factors, thus including different forms of perturbations into the network. In this talk we investigate the role played by topology in shaping the dynamics of the German power grid and we present a new investigation method able to highlight the instabilities of the system. Based on the knowledge of the unstable nodes and directions suggested by the application of the Lyapunov vector, we are thus able to design a control method that enhances the synchronization and stabilizes the network, acting on small number of nodes/links. This minimal intervention suggests a procedure to control real grids that allows to save time, money and energy.

SOE 24.3 Fri 10:30 EB 107

Influence of noise in shaping the dynamics of power grids — •Liudmila Tumash, Simona Olmi, and Eckehard Schöll — Institut für Theoretische Physik, TU Berlin, Hardenbergstr. 36, D-10623 Berlin

The aim of this work is to investigate complex dynamic networks which can model high-voltage power grids with renewable, fluctuating energy sources. For this purpose we use the Kuramoto model with inertia to model the network of power plants and consumers [1]. In particular, we analyze the synchronization transition of random Erdös-Renyi networks of N phase oscillators with inertia (rotators) whose natural frequencies are bimodally distributed. We also implement Gaussian white noise and investigate its role in shaping the dynamics.

[1] Filatrella, G., Nielsen, A. and Pedersen, N. Eur. Phys. J. B (2008) 61: 485.

SOE 24.4 Fri 10:45 EB 107

Load Dependence of Power Outage Statistics — •Soumyajyoti Biswas[1] and Lucas Goehring[1,2] — [1]Max Planck Institute for Dynamics and Self-Organisation, Göttingen, Germany — [2]Nottingham Trent University, Nottingham, UK

The size distributions of power outages are shown to depend on the stress, or the proximity of the load of an electrical grid to complete breakdown. Using the data for the US and Canada between 2002-2017, we show that the outage statistics are dependent on the usage levels during different parts of the day. At higher load, not only are more failures likely, but the distribution of failure sizes shifts, to favor larger events. At a finer spatial scale, different regions within the US can be shown to respond differently in terms of the outage statistics to variations in the usage (load). The response, in turn, corresponds to the respective bias towards larger or smaller failures in those regions. We provide a simple model, using realistic grid topologies, which can nonetheless demonstrate such biases as a function of the applied load, as in the data. Given sufficient data, the method can be used to identify vulnerable regions in power grids prior to major blackouts.

15 min. break

SOE 24.5 Fri 11:15 EB 107

Asymptotic Dynamical States in Networks of Kuramoto Oscillators with Inertia — •Anton Plietzsch — Potsdam-Institut für Klimafolgenforschung — Humboldt-Universität zu Berlin

The frequency dynamics of power grids can be modeled by networks of oscillators. I will show analytic and numerical results on the possible asymptotic states in the Kuramoto model with inertia. These states include states that can be understood as synchronized, partially synchronized, and distinct novel states that have no analytic explanation so far. I will show some analytic criteria for the stability and existence of solitary states of single desynchronized oscillators as well as partially synchronized clusters with distinct frequency on networks.

SOE 24.6 Fri 11:30 EB 107

Modelling and Suppressing power output fluctuations of photovoltaic power plants — •Mehrnaz Anvari[1], Benjamin Werther[2], Gerald Lohmann[3], Matthias Waechter[3], Joachim Peinke[3], and Hans-Peter Beck[2] — [1]MPIPKS, Dresden, Germany — [2]TU Clausthal, Germany — [3]Institute of Physics and ForWind, Oldenburg, Germany

The use of solar photovoltaic (PV) power has recently increased in electric distribution grids. By the end of 2014, for example, PV power had already reached a total installed capacity of over 178 GW worldwide, which is expected to increase to between 396 and 540 GW by 2019. However, the stochastic properties of solar energy, such as intermittency can negatively affect power quality and cause grid instabilities, especially in microgrids. In this study, we use high resolution (i.e. 1 Hz) measured irradiance data in Hawaii (as an exemplary data) to study the stochastic behaviour of short-term PV fluctuations, and classify its states as cloudy, sunny and flickering. Our main aim is the construction of a simple dynamical equation (jump-diffusion stochastic equation) that governs the stochastic process of PV-fluctuations, so that the statistics of the modelled time series are identical to those of the measured ones. Using the obtained dynamical equation, we generate new synthetic data sets with varying jump rates. Finally, we implement a straightforward filtering method, i.e. a combination of an inverter and a battery storage system to show the applicability of our proposed stochastic method.

SOE 24.7 Fri 11:45 EB 107

Power Grid Stability: Bounding the First Exit from the Basin — •Paul Schultz[1,2], Frank Hellmann[1], Kevin N. Webster[1], and Jürgen Kurths[1,2,3,4] — [1]Potsdam Institute for Climate Impact Research (PIK), Member of the Leibniz Association, P.O. Box 60 12 03, D-14412 Potsdam, Germany — [2]Department of Physics, Humboldt University of Berlin, Newtonstr. 15, 12489 Berlin, Germany — [3]Institute for Complex Systems and Mathematical Biology, University of Aberdeen, Aberdeen AB24 3UE, United Kingdom — [4]Department of Control Theory, Nizhny Novgorod State University, Gagarin Avenue 23, 606950 Nizhny Novgorod, Russia

We study the stability of deterministic systems given sequences of large, jump-like perturbations. Our main result is the derivation of a lower bound for the probability of the system to remain in the basin, given that perturbations are rare enough. To quantify rare enough, we define the notion of the independence time of such a system. This is the time after which a perturbed state has probably returned close

to the attractor, meaning that subsequent perturbations can be considered separately. The effect of jump-like perturbations that occur at least the independence time apart is thus well described by a fixed probability to exit the basin at each jump, allowing us to obtain the bound. To determine the independence time, we introduce the novel concept of finite-time basin stability, which cor- responds to the probability that a perturbed trajectory returns to an attractor within a given time. The independence time can then be determined as the time scale at which the finite-time basin stability reaches its asymptotic value.

SOE 24.8 Fri 12:00 EB 107

Bridging from Kuramoto-like Networks to Real Power Grids: Lossy Grids, Voltage Regulation and Implementing Inverter Units — Katrin Schmietendorf[1], Joachim Peinke[1], and •Oliver Kamps[2] — [1]ForWind and Institute of Physics, Carl von Ossietzky Universität Oldenburg, Oldenburg, Germany — [2]Center for Nonlinear Science, Westfälische Wilhelms-Universität Münster, Münster, Germany

Kuramoto-like models of electric power grids give insights into power system dynamics on the short-term scale in terms of self-organized synchronization. From the applicational viewpoint, the most current issues in power system analysis concern grid decentralization and increasing feed-in fluctuations induced by renewables. In order to address these topics, certain complements to the basic Kuramoto approach have to be taken into account. We investigate three supplements, which are particularly relevant for the integration of renewable energy plants on the distribution grid level: (i) transferlosses due to non-zero line conductance on the low and medium voltage levels, (ii) local voltage regulation by means of a proportional controller, and (iii) different approaches on implementing inverter units into the Kuramoto-like framework. In this talk we present the implications of these model extensions on different aspects of system stability and power quality.