

PHYSIK SOZIO-ÖKONOMISCHER SYSTEME (AKSOE)

Vorsitzender: Priv.-Doz. Dr. Dr. Frank Schweitzer
 Fraunhofer Institut für Autonome Intelligente Systeme
 Schloß Birlinghoven
 53754 Sankt Augustin
 E-Mail: schweitzer@ais.fraunhofer.de

ÜBERSICHT DER HAUPTVORTRÄGE UND FACHSITZUNGEN
 (Hörsäle)

Hauptvorträge

AKSOE 1.1	Mo	09:30	(H8)	Toward an Understanding of Market Behavior: A Physics Perspective, <u>Neil Johnson</u>
AKSOE 4.1	Di	09:30	(H8)	Stochastic Games: Theory and Simulation, <u>Kristian Lindgren</u>
AKSOE 6.1	Di	16:00	(H10)	The Dynamics of Information, <u>Bernardo Huberman</u>
AKSOE 10.1	Do	14:00	(H8)	Physicists' Insights into Wealth Distributions, <u>František Slanina</u>

Fachsitzungen

AKSOE 1	Finanzmärkte und Risikomanagement	Mo	09:30–12:30	H8	AKSOE 1.1–1.6
AKSOE 2	Urbane Systeme und Verkehrsdynamik	Mo	14:00–15:30	H8	AKSOE 2.1–2.3
AKSOE 3	Postersitzung	Mo	16:00–18:00	Poster D	AKSOE 3.1–3.13
AKSOE 4	Soziale Systeme und Entscheidungsmodelle I	Di	09:30–12:30	H8	AKSOE 4.1–4.6
AKSOE 5	Soziale Systeme und Entscheidungsmodelle II	Di	14:00–15:30	H8	AKSOE 5.1–5.3
AKSOE 6	Sondersitzung: Verleihung des Young-Scientist-Award for Socio- and Econophysics	Di	16:00–18:00	H10	AKSOE 6.1–6.3
AKSOE 7	Makro-ökonomische Modelle und Wirtschaftswachstum I	Mi	14:00–15:30	H8	AKSOE 7.1–7.3
AKSOE 8	Makro-ökonomische Modelle und Wirtschaftswachstum II	Mi	16:00–18:00	H8	AKSOE 8.1–8.4
AKSOE 9	Symposium: Fat Tail Distributions – Application from Physics to Finance	Do	09:30–12:30	H1	AKSOE 9.1–9.1
AKSOE 10	Mikro-ökonomische Modelle und Multi-Agenten-Systeme	Do	14:00–17:30	H8	AKSOE 10.1–10.7

<p>Sondersitzung: Verleihung des Young-Scientist Award for Socio- and Econophysics Di 16:00–18:00, H10 1. Hauptvortrag: Bernardo Huberman 2. Preisverleihung 3. Vortrag der Preisträgerin / des Preisträgers</p>

Mitgliederversammlung des Fachverbands Arbeitskreis Physik sozio-ökonomischer Systeme

Mi 18:00–19:00 H8

1. Bericht des Vorsitzenden des AKSOE
 2. Diskussion über geplante Aktivitäten
 3. Verschiedenes
- gez. Frank Schweitzer

Zeit	Montag	Dienstag	Mittwoch	Donnerstag
09:30–10:15	HV: Johnson	HV: Lindgren		Symposium: Fat Tail Distributions – Applications from Physics to Finance (AKSOE / DY)
10:30–11:00	F: Rosenow	S1: Hirtreiter		
11:00–11:30	F: Krink	S1: Schweitzer		
11:30–12:00	F: v. Bothmer	S1: Schönhof		
12:00–12:30	F: Remer	S1: Scharnhorst		
14:00–14:30	U: P. Wagner	S2: Scheffran	M1: Helbing	HV: Slanina
14:30–15:00	U: Spahn	S2: Trimper	M1: Schiegl	14:00-14:45
15:00–15:30	U: Kesting	S2: Schaale	M1: Ihrig	A: F. Wagner
15:30–16:00				A: Ehrenstein
16:00–16:30	Poster- sitzung	HV: Huberman	M2: Mimkes	A: Kreft
16:30–17:00		Young-Scientist- Award	M2: Danielmeyer	A: Ramirez
17:00–17:30			M2: Brenner	A: Schneider
17:30–18:00		V: Preisträger/in	M2: Reschke	
18:00–19:00			Mitglieder- Versammlung	

HV: Hauptvortrag, **F:** Finanzmärkte und Risikomanagement, **A:** Mikro-ökonomische Modelle und Multi-Agenten-Systeme, **M1-M2:** Makro-ökonomische Modelle und Wirtschaftswachstum I-II, **U:** Urbane Systeme und Verkehrsdynamik, **S1-S2:** Soziale Systeme und Entscheidungsmodelle I-II.

Fachsitzungen

– Haupt-, Kurzvorträge und Posterbeiträge –

AKSOE 1 Finanzmärkte und Risikomanagement

Zeit: Montag 09:30–12:30

Raum: H8

Hauptvortrag

AKSOE 1.1 Mo 09:30 H8

Toward an Understanding of Market Behavior: A Physics Perspective — ●NEIL JOHNSON — Physics Department, Oxford University U.K.

There is growing interest in agent-based market models within the physics community. In light of this, we give an overview of such physics-based approaches to self-consistent market modelling. We will focus on the physics community's search for a minimal market model, and examine the trade-off between the desire for simplicity, yet consistency with the known 'stylized facts' of markets. [For further details, see 'Financial Market Complexity' (Oxford University Press, 2003).]

We will then briefly explore related applications of these models in sociological and biological domains.

AKSOE 1.2 Mo 10:15 H8

Pause — ● —

AKSOE 1.3 Mo 10:30 H8

Modeling Correlations in Portfolio Credit Risk — ●BERND ROSENOW¹, RAFAEL WEISSBACH², and FRANK ALTROCK² — ¹Institut für Theoretische Physik, Universität zu Köln, 50923 Köln, Germany — ²Risk Management Support & Control, WestLB AG, Düsseldorf, Germany

The risk of a credit portfolio depends crucially on correlations between the probability of default (PD) in different economic sectors. Often, PD correlations have to be estimated from relatively short time series of default rates, and the resulting estimation error hinders the detection of a signal. We present statistical evidence that PD correlations are well described by a (one-)factorial model. However, when using the model to generate short time series and calculating their correlation matrix, one typically observes large statistical fluctuations in the correlation structure. Due to these fluctuations, the parameter estimation for a one-factor model is plagued by large uncertainties. When estimating the model parameters in such a way that the empirically observed ones appear as a worst case scenario, the reliability of the estimate is increased in a systematic way, leading to a moderately increased CreditVaR.

AKSOE 1.4 Mo 11:00 H8

Tackling Mutual Funds Style Analysis with Medoid Clustering and Differential Evolution — ●THIEMO KRINK¹, SANDRA PATERLINI², TOMMASO MINERVA², and FRANCESCO PATTARIN² — ¹EVALife Group, Dept. of Computer Science, Univ. of Aarhus, Denmark — ²Dept. of Political Economics, Univ. of Modena and Reggio Emilia, Italy

Mutual funds style analysis requires objective, representative, consistent and empirically testable classification schemes in order to give reli-

able information to investors and fund managers who are interested in evaluating and comparing different financial products. Institutional classification schemes, when available, do not always provide consistent and representative peer groups of funds. In this study, we introduce a classification algorithm, which identifies mutual funds styles by analysing the time series of past returns. The proposed classification procedure consists of three steps: (a) dimensionality reduction based on principal component analysis, (b) clustering by a novel medoid evolution approach utilizing differential evolution, and (c) style identification by a constrained regression model. We tested the algorithm regarding Italian mutual funds data and achieved satisfactory results with respect to the agreement with the existing institutional classification and the explanatory power of out of sample variability in the cross-section of returns.

AKSOE 1.5 Mo 11:30 H8

Significance of log-periodic signatures in cumulative noise — ●HANS-CHRISTIAN GRAF v. BOTHMER — Universität Hannover, Institut für Mathematik (C), Welfengarten 1, 30167 Hannover

Using methods introduced by Scargle we derive a cumulative version of the Lomb periodogram that exhibits frequency independent statistics when applied to cumulative noise. We show how this cumulative Lomb periodogram allows us to estimate the significance of log-periodic signatures in the S&P 500 anti-bubble that started in August 2000.

AKSOE 1.6 Mo 12:00 H8

Application of Heston and Hull-White model to German DAX data — ●RALF REMER and REINHARD MAHNKE — University of Rostock, Department of Physics, 18051 Rostock

We concentrate on the stock price dynamics described by the Heston and the Hull-White model [1]. We apply the model to the German tick-by-tick DAX data [2]. The data are from May 1996 to December 2001.

We compare the short and the long time solution of the Heston model [3] with the DAX data and with numerical simulations of the Heston model. Therefore we use the probability density distributions of the logarithmic returns, calculated out of the data, and fit these distributions with the theoretical distribution.

Finally we compare the short-time solution of the Heston model and of the Hull-White model as another example of the models with stochastic volatility.

[1] Fouque, J P, Papanicolaou G and Sircar K R 2000 *Derivatives in Financial Markets with Stochastic Volatility* (Cambridge: Cambridge University Press)

[2] Karlsruher Kapitalmarktdatenbank 2002 *DAX and its stock prices* (Universität Karlsruhe)

[3] Drăgulescu A A and Yakovenko V M 2002 *Quant. Finance* **2** 443

AKSOE 2 Urbane Systeme und Verkehrsdynamik

Zeit: Montag 14:00–15:30

Raum: H8

AKSOE 2.1 Mo 14:00 H8

New experimental results concerning the car-following dynamics — ●PETER WAGNER¹, GEORG HERTKORN¹, and IHOR LUBASHEVSKY² — ¹Institut für Verkehrsforschung, Deutsches Zentrum für Luft- und Raumfahrt, Rutherfordstrasse 2, 12489 Berlin — ²General Physics Institute, Russian Academy of Sciences, Vavilov Str. 38, Moscow, 119991, RUSSIA

Car-following experiments conducted recently with cars equipped with DGPS (differential GPS) deliver fairly accurate and highly interesting data. The distances Δx , the speeds $v(t)$ and the accelerations can be measured (or computed) making it possible to draw solid conclusion related to the car-following dynamic.

In contrast to almost all of the car-following models currently in use the data demonstrate that the behaviour of the drivers is described by fairly old (but rarely used) "action-point" models. These models claim that the acceleration is constant most of the time but is changing very fast at the action-points. The time between subsequent action-points is distributed exponentially, compatible with the assumption that the decision to change acceleration is drawn randomly.

It follows, that there is no fixed-point of the car-following dynamic. It can be hypothesized that this is due to driver's inability to regulate speed difference Δv and acceleration exactly to zero. Nevertheless, there is a strong attraction toward these values, as can be seen by the cusp in the frequency distribution of $\Delta v = 0$.

From these results, important consequences might be drawn for the

modeling of the car-following process.

AKSOE 2.2 Mo 14:30 H8

Phase diagram of a traffic flow model with a non-unique flow-density relation with open boundaries — ●MICHAEL SPAHN and PETER WAGNER — Institute of Transport Research, German Aerospace Center (DLR) in the Helmholtz Association, Rutherfordstrasse 2, 12489 Berlin, Germany

The phase diagram of a traffic flow model with a non-unique flow-density relation [1] in the case of open boundaries is presented. It exhibits the typical phases corresponding to free flow and jams. Additionally there is a region in the flow-density plane with a plateau in the mean velocity. This corresponds to a model rule introducing synchronized flow.

Furthermore results will be presented concerning the applicability of a general principle [2] connecting the phase diagram of a model in the case of open boundaries with the fundamental diagram in the case of periodic boundary conditions.

[1] B.S. Kerner et. al., Cellular automata approach to three-phase traffic theory, *J. Phys. A: Math. Gen.* **35** (2002)

[2] V. Popkov and G.M. Schütz, *Europhys. Lett.* **48**, 257 (1999)

AKSOE 2.3 Mo 15:00 H8

MOBIL – A Realistic Lane Change Strategy for Microscopic Traffic Modelling — ●ARNE KESTING, MARTIN TREIBER und DIRK HELBING — Institute for Economics and Traffic, Dresden University of Technology

An adequate description of multi-lane traffic and lane changes is a key ingredient for a realistic modeling of traffic dynamics on freeways. With MOBIL (“Minimizing Overall Braking Induced by Lane-Changes”), we propose a general strategy for lane changes that is based on the acceleration function of the used longitudinal model. To cope with situations with forced lane changes, e.g. at on-ramps or at lane closings, one has to model the occurring complex cooperative human behaviour. We model this longitudinal-transversal coupling in terms of physical repulsive next-neighbour interactions on neighbouring lanes. The resulting lane change behaviour is demonstrated for typical situations such as lane closings and merging at on-ramps.

AKSOE 3 Postersitzung

Zeit: Montag 16:00–18:00

Raum: Poster D

AKSOE 3.1 Mo 16:00 Poster D

Order book approach to price impact — ●PHILIPP WEBER and BERND ROSENOW — Institut für Theoretische Physik der Universität zu Köln, Zùlpicher Straße 77, 50937 Köln

Stock price changes due to an imbalance of supply and demand are described by the price impact function. We compare the actual price impact of market orders with the virtual price impact calculated from the limit order book. The latter one would be caused by a market order matched with limit orders from the order book. This impact is found to be four times stronger than the actual price impact of market orders. We explain this difference with a dynamical feedback mechanism related to strong anticorrelations between returns and limit orders. Including this dynamical effect, we present a quantitative explanation of the price impact function using order book information.

AKSOE 3.2 Mo 16:00 Poster D

Evidence of Markov properties of high frequency exchange rate data — ●A. P. NAWROTH¹, CH. RENNER¹, J. PEINKE¹, and R. FRIEDRICH² — ¹Institut für Physik, Universität Oldenburg, D-26111 Oldenburg, Germany — ²Institut für Theoretische Physik, Universität Münster, D-48149 Münster, Germany

We present a stochastic analysis of a data set consisting of 10^6 quotes of the US Dollar-German Mark exchange rate. Evidence is given that the price changes $x(\tau)$ upon different delay times τ can be described as a Markov process evolving in τ . Thus, the τ -dependence of the probability density function (pdf) $p(x, \tau)$ on the delay time τ can be described by a Fokker-Planck equation, a generalised diffusion equation for $p(x, \tau)$. This equation is completely determined by two coefficients $D_1(x, \tau)$ and $D_2(x, \tau)$ (drift- and diffusion coefficient, respectively). We demonstrate how these coefficients can be estimated directly from the data without using any assumptions or models for the underlying stochastic process. Furthermore, it is shown that the solutions of the resulting Fokker-Planck equation describe the empirical pdfs correctly, including the pronounced tails.

AKSOE 3.3 Mo 16:00 Poster D

No profit in spite of a perfect prediction? How interaction destroys arbitrage. — ●ROLAND ROTHENSTEIN and KLAUS PAWELZIK — University Bremen, Institute for Theoretical Physics, Otto-Hahn-Allee 1, D-28359 Bremen, Germany

The efficient market hypothesis stated, that -because markets anticipate future returns of stock markets- nobody is able to make a profit using past (public) informations. However not all markets are all the time efficient. Under the assumption that markets are not efficient, many traders try to find inefficiencies in the market and use them to build forecast systems. But every order has an influence to the market, which changes the price and contradicts the original prediction. Can a trader neglect its own influence to the market or is this influence so important that it has to be considered in the prediction of the future? Can interaction destroy arbitrage opportunities? We study a evolutionary stock

market model with a trader (super agent), that is able to make a perfect prediction. In this market, we determine how the transactions of this superagent affects his ability to use his perfect knowledge to make a profit in this market. We measure this influence under different conditions in our market model like different number of agents, different memory of the agents or different evolutionary strategies.

AKSOE 3.4 Mo 16:00 Poster D

An Indication for Qualitative Change of Economic Relations at about 1985 for the USA — ●KARL-FRIEDRICH ALBRECHT¹, WERNER MENDE², and DIRK ORLAMUENDER³ — ¹TU Dresden, Inst. f. Allg. Oekologie und Umweltschutz, Dozentur fuer Umweltsystemanalyse, Piennner Str. 8 , 01737 Tharandt — ²Berlin-Brandenburgische Akademie der Wissenschaften, Jaegerstr. 22-23, 10117 Berlin — ³TU Dresden, Lehrstuhl fuer Volkswirtschaftslehre insbes. Allokationstheorie, Mommsenstr. 13, 01062 Dresden

Because of the 2-nd law of thermodynamics the electricity consumption (EC) should be an important indicator for the economic growth of an industrialised country. Comparing the results on EC-growth with the GDP-growth (Gross Domestic Product) two remarkable facts have been found: (1) a linear relation between the EC and the GDP holds from 1955 to 1985 for the countries considered, (2) in 1973 when the growth of primary energy consumption decoupled from GDP growth the EC-growth started a strong coupling to the GDP growth. This has been reported earlier. The present question is: What is the reason for the two mentioned facts. To solve the question why the linear relation ends up at about 1985 the data for the USA have been analysed more in detail. The growth trend was determined by fitting the EC-data (up to 1981) by a growth model. In about 1985 both EC- and BIP-data leave this trend and indicate a qualitative new behavior. An other but connect fact is the approximate proportionality between EC and GDP starting in 1973. This leads to the question: What is the reason for a coupling between EC and GDP since the First World Energy Crisis?

AKSOE 3.5 Mo 16:00 Poster D

Interaction of heterogeneous socio-economic cycles — ●ANDREAS BOHN — TU Darmstadt, FB Biologie - Graduiertenkolleg, Schnittspahnstr. 10, 64287 Darmstadt

Oscillatory dynamics are a fundamental phenomenon in physics, biology as well as sociology and economics. Over the past 20 years, a number of models describing socio-economical periodic phenomena such as, e.g., dynastic or business cycles, have been developed using methods from nonlinear dynamics. The present work investigates the aggregated dynamics of a multitude of such oscillating systems being coupled to each other. A focus is on the effects of parametric heterogeneity in the oscillator ensemble, i.e. assuming that the amplitude and frequency of the individual systems are non-identical.

AKSOE 3.6 Mo 16:00 Poster D

Investors' Game Strategies using Genetic Algorithms — ●J. EMETERIO NAVARRO B.¹ and FRANK SCHWEITZER^{2,3} — ¹Institute for Informatics, Humboldt University, Berlin — ²Institute for Physics, Humboldt University, Berlin — ³Fraunhofer Institute for Autonomous Intelligent Systems, Schloss Birlinghoven, Sankt Augustin

We use an Investors' Game model to study two kind of strategies investors can use: the first one is based on feedback information or previous experience and the second one is based on genetic algorithms. We compare these two approaches within a multi-agent system where agents play the role of investors and they interact with each other in order to establish projects. We investigate (i) the competition between these two different strategies, (ii) the formation of coalitions and (iii) how the learning process of agents depends on the genetic algorithm parameters.

AKSOE 3.7 Mo 16:00 Poster D

Evolution of Investor Coalitions in a Multi-Agent Market Simulation — ●ADRIAN MARCELO SEUFERT¹ and FRANK SCHWEITZER² — ¹Technische Universität Berlin — ²Fraunhofer Institut für Autonome Intelligente Systeme

We analyze the evolution of investor's preference networks by means of a multi-agent market simulation. In our model, N investors interact with I initiators over several periods of time. In each period, a randomly chosen initiator i proposes a *project* into which investors k decide to invest a proportion of their budget or not, depending on their "trust" in the initiator. That trust is quantified by a number w_{ki} , that depends on past experience with that initiator. The return on investment is then randomly picked from a distribution $r_i(t)$ that characterizes the particular initiator. A positive return boosts the trust of the investors in that initiator, a negative return diminishes it. Over time we observe the development of *preference networks*, that is, of investors interacting with certain initiators on a preferential basis, while largely ignoring others. Particular emphasis is placed on the analytical understanding of the Network dynamics using methods from statistical physics and the theory of stochastic processes.

AKSOE 3.8 Mo 16:00 Poster D

Fairness – The Paradise State in a Network of Trading Agents — ●JUAN G. DIAZ O., ELENA RAMIREZ BARRIOS, and JOHANNES J. SCHNEIDER — Institute for Physics, Johannes Gutenberg University, Staudinger Weg 7, D-55099 Mainz, Germany

The definition of fairness in economy is based on the comparison of the agents' goods, taking into account the preferences of each agent. The first ingredient is the exchange of goods in a space where there are only finite numbers of goods. The second ingredient is the possibility that each agent gets some goods from some markets as well as from the exchange with other agents. The third ingredient is the expression of the revealed agents' preferences. With this three ingredients, we developed a simulation of a net trade of agents in order to show that there is an equilibrium in the distribution of goods and eventually to demonstrate that we can define fairness in a multi-agent system.

AKSOE 3.9 Mo 16:00 Poster D

Networks in a simple freight transport demand model — ●MICHAEL SPAHN und PETER WAGNER — Institute of Transport Research, German Aerospace Center (DLR) in the Helmholtz Association, Rutherfordstrasse 2, 12489 Berlin, Germany

A simplistic model of freight transport demand and the resulting networks of producers and buyers is presented. Transport costs are initially determined stochastically from a given range and define a distance network.

Agents representing buyers of a single good repeatedly try to optimize their supplier network minimizing transport costs while also trying to stick to trusted suppliers. Trust is built up over time in an unchanged supplier-buyer relationship. Producers have a limited inventory of the good and don't accept further buyers when sold out. Stochastic fluctuations prevent the system from reaching a completely static state.

The resulting transport networks are analyzed in regimes of low and high transport costs. The dynamics of the transport network evolution towards the static distance network are described.

AKSOE 3.10 Mo 16:00 Poster D

Characterization of networks from nondiagonal elements of node-node link cross-distribution — ●JENS CHRISTIAN CLAUSSEN — Institut für Theoretische Physik und Astrophysik, Universität Kiel

A vast variety of biological, social, and economical networks shows

topologies drastically differing from random graphs; yet the quantitative characterization remains unsatisfactory from a conceptual point of view.

Motivated from the discussion of small scale-free networks, a biased link distribution entropy is defined, which takes an extremum for a power law distribution. This approach is extended to the node-node link cross-distribution, whose nondiagonal elements characterize the graph structure beyond link distribution, cluster coefficient and average path length. From here a simple (and computationally cheap) complexity measure can be defined. This complexity measure is compared with alternative approaches to complexity measures, entropies and hierarchy estimators.

AKSOE 3.11 Mo 16:00 Poster D

Food-web representation of agent interaction in a spatial IPD — ●ROBERT MACH^{1,2} and FRANK SCHWEITZER^{1,3} — ¹Fraunhofer Institute for Autonomous Intelligent Systems, Schloss Birlinghoven, D-53754 Sankt Augustin, Germany — ²Institute for Theoretical Physics, Cologne University, D-50923 Koeln, Germany — ³Institute of Physics, Humboldt University Berlin, D-10099 Berlin, Germany

We use a two-dimensional cellular automaton to investigate an iterated Prisoner's Dilemma (IPD) game with 8 different strategies and one-step memory. The agents are distributed on a 2D grid and are assumed to interact a number of n_g times with their four nearest neighbors during each generation. The agents try to increase their individual payoff by adopting the strategy of their most successful neighbor at the end of each generation. This adaptation process leads to a global pattern formation of strategy distribution. For $n_g = 2$ and an initial population consisting of three strategies, a food-web representation can be found by means of a local configurations analysis, describing the relationship between agents. This food-web representation is suitable to explain a crossover dynamics, in which a strategy after an initially strong decline becomes the majority in the end. Dependent on the local frequencies of the strategies, two consecutive stages can be distinguished until the dynamics become stationary.

AKSOE 3.12 Mo 16:00 Poster D

The Probability of Traffic Violations and Criminal Acts: a Model of Agent Behavior — ●JÜRGEN MIMKES — Physik Department Universität Paderborn

Traffic is a system of traffic agents under constraints of traffic laws. The system corresponds to atomic systems under constraint of energy laws. The Lagrange LeChatelier principle of statistics corresponds to Gibbs free energy and leads to a model of agent behavior. We always find three different kinds of agent behavior, corresponding to the solid, liquid and gas states of materials.

1. For a few rich, individual agents the probability of traffic violations is a Boltzmann distribution and depends on the punishment (in money) compared to income.

2. Most agents are less affluent individuals and the probability of traffic violations depends on the punishment and the risk of being caught.

3. For poor hierarchic agents the probability depends only on the hierarchic pressure.

In contrast to traffic violators criminal agents make a profit in criminal acts like bribing. This leads to a modified behavior of the second state: nearly every agent may be bribed, if the risk is low and the bribe is high enough compared to the punishment. However, no data are available, yet.

AKSOE 3.13 Mo 16:00 Poster D

Stochastic Description of Traffic Breakdown: Langevin Approach — ●JULIA TOLMACHEVA^{1,2}, REINHARD MAHNKE², HANS WEBER³, and JEVGENIJS KAUPUŽS⁴ — ¹Res. Inst., Nat. Acad. Sci., 61001 Kharkov, Ukraine — ²FB Physik, Univ. Rostock, D-18051 Rostock — ³Physics Dept., Luleå Univ., Sweden — ⁴Univ. Latvia, LV-1459 Riga, Latvia

We analyze the characteristic features of jam formation on a circular one-lane road. We have applied an optimal velocity model including stochastic noise, where cars are treated as moving and interacting particles. The motion of N cars is described by the system of $2N$ stochastic differential equations with multiplicative white noise. Our system of cars behaves in qualitatively different ways depending on the values of control parameters c (dimensionless density), b (sensitivity parameter characterizing the fastness of relaxation), and a (dimensionless noise intensity).

In analogy to the gas-liquid phase transition in supersaturated vapour at low enough temperatures, we observe three different regimes of traffic flow at small enough values of $b < b_{cr}$. There is the free flow regime (like

gaseous phase) at small densities of cars, the coexistence of a jam and free flow (like liquid and gas) at intermediate densities, and homogeneous dense traffic (like liquid phase) at large densities.

The stochastic noise allows us to calculate the distribution of headway distances and time headways between the successive cars, as well as the distribution of jam (car cluster) sizes in a congested traffic.

AKSOE 4 Soziale Systeme und Entscheidungsmodelle I

Zeit: Dienstag 09:30–12:30

Raum: H8

Hauptvortrag

AKSOE 4.1 Di 09:30 H8

Stochastic Games: Theory and Simulation — •KRISTIAN LINDGREN — Physical Resource Theory, Chalmers University of Technology, Gothenburg, Sweden

Recent results regarding games in an evolutionary context is presented. The main part of the talk deals with the evolution of cooperative behaviour in a random environment, using evolution of finite state strategies. The interaction between agents is modelled by a repeated game with random observable payoffs. The agents are thus faced with a more complex situation, compared to the Prisoner's Dilemma that has been widely used for investigating the conditions for cooperation in evolving populations. Still, there is a robust cooperating strategy that usually evolves in a population of agents. In the cooperative mode, this strategy selects an action that allows for maximizing the payoff sum of both players in each round, regardless of the own payoff. Two such players maximize the expected total long-term payoff. If the opponent deviates from this scheme, the strategy invokes a punishment action, which may be to aim for minimising the opponent's score for the rest of the (possibly infinitely) repeated game.

AKSOE 4.2 Di 10:15 H8

Pause — • —

AKSOE 4.3 Di 10:30 H8

Inter-Party-Movements in Bavaria and Germany — •CHRISTIAN HIRTREITER¹ and JOHANNES J. SCHNEIDER² — ¹Institute of Organic Chemistry, University of Regensburg, D-93040 Regensburg — ²Department of Physics, Johannes Gutenberg University of Mainz, Staudinger Weg 7, D-55122 Mainz

The major parties in Germany lose or gain party members depending on the results of their current policies. Many people join or leave a party often immediately after a scandal or a won/lost election. This results in inter-party-movements: parties losing members can be considered as the providers for other parties which get additional members. However, in real life, only seldomly people change directly from their current membership-book to another one. This is due to the fact that because of a „diffusion barrier“ a conservative party member is seldomly tempted to join a left-wing party and vice versa. Thus, new party members are mostly recruited from formerly not in parties organized but not apolitical persons. We will present historical and recent movements based on data both from Bavaria and from the Federal Republic of Germany and will discuss these movements from a physical point of view. Furthermore, we will present computational results for a model simulating these movements.

AKSOE 4.4 Di 11:00 H8

Invasion of Cooperation in Heterogeneous Populations — •FRANK SCHWEITZER^{1,2} and LAXMIDHAR BEHERA^{1,3} — ¹Fraunhofer Institut for Autonomous Intelligent Systems, Schloss Birlinghoven, D-53754 Sankt Augustin — ²Institute of Physics, Humboldt University, Newtonstraße 15, D-12489 Berlin — ³Department of Electrical Engineering Indian Institute of Technology, Kanpur, 208 016, India

We consider a population of agents interacting in an iterated prisoner's

dilemma (IPD) game. Using a one-step memory agents can play different strategies, thus the population becomes heterogeneous. Further it is assumed that after each generation agents adopt another strategy proportional to the relative performance (average payoff) of the respective strategy. We investigate under which conditions a stable coexistence of subpopulations playing different strategies can be found and how this depends on the number of interactions within each generation. We further discuss a model where agents are spatially separated on different “islands” and are allowed to migrate after each generation. Here we find a critical migration rate at which e.g. an island dominated by non-cooperating agents can be transformed into a cooperative one. Thus, optimal (im)migration may enhance cooperation!

AKSOE 4.5 Di 11:30 H8

Cooperation in a Dynamic Route Choice Experiment — •MARTIN SCHÖNHOF^{1,2}, DIRK HELBING¹, HANS-ULRICH STARK¹, and JANUSZ HOLYST² — ¹Institute for Economics and Traffic, Dresden University of Technology, Andreas-Schubert-Str. 23, D-01062 Dresden, Germany — ²Faculty of Physics, Warsaw University of Technology, Koszykowa 75, Pl-00-662 Warsaw, Poland

The efficient usage of road infrastructures requires an optimal distribution of vehicles on alternative roads. The corresponding route decision problem for drivers relates to the minority game. Recent decision experiments have shown that drivers tend to establish a user equilibrium characterized by equal travel times on alternative roads (according to the Wardrop equilibrium). We will present fair strategies that allow road users to establish even the system optimum, i.e. significantly better results with reduced travel times.

[1] D. Helbing, M. Schönhof, and D. Kern, *New J. Phys.* 4 (2002) 33

AKSOE 4.6 Di 12:00 H8

Modelling the role of competencies in a complex problem solving process - a new model for flexibility — •ANDREA SCHARNHORST¹ and WERNER EBELING² — ¹KNAW, NIWI, Joan Muyskenweg 25, 1090HC Amsterdam — ²HUB, Inst. f. Physik, Newtonstrasse 15, 12489 Berlin

Learning is both a process which takes place in individuals and in groups. In this paper we explore to which extend evolutionary models about the collective search of groups (or populations) in a multi-dimensional abstract problem space can be used to describe the role of individual competencies. In the model the formation of a group of individuals sharing a similar problem representation can be understood as effort of a collective search process. Additional to earlier models of search processes in complex fitness landscapes we assume that the group formation process (the occupation density) now also depends on the coordinates and the velocity in the problem space. The new model makes use of the formalism of active Brownian particles developed recently. The velocity-dependence means that the fitness of the individuals depends on the speed with which problem representations can be changed individually. We call this feature the flexibility of the individuals to develop alternative problem representations. We discuss the application of such types of models for learning and decision making processes in social systems.

AKSOE 5 Soziale Systeme und Entscheidungsmodelle II

Zeit: Dienstag 14:00–15:30

Raum: H8

AKSOE 5.1 Di 14:00 H8

Emissions Trading Between Multiple Regions and Firms — •JÜRGEN SCHEFFRAN — Potsdam Institute for Climate Impact Research, Telegrafenberg A31, 14412 Potsdam

Emissions trading is an instrument to achieve emission reductions in regions and business sectors where they are least costly. Emission paths and emission trading flows are analysed in a multi-agent framework of multi-

level decisionmaking in climate policy and market interaction among firms. The price mechanism depends on individual threshold prices, the level of required emission reduction and the capacity of economies to shift to a low-carbon mode of production. The model discusses the role of climate guardrails, equity principles on the allocation of emission rights, conditions for switching to low-emission goods and technologies, and benefits of cooperation between developing and industrialized regions.

AKSOE 5.2 Di 14:30 H8

Epidemics in hierarchical social networks — ●MARIAN BRANDAU and STEFFEN TRIMPER — Fachbereich Physik, Friedmann-Bach-Platz, 06108 Halle

Epidemiological processes in hierarchical social networks are studied within a so called susceptible–infected–refractory model (SIR). Within the network model, a population of individuals may be characterized by certain independent hierarchies H (or dimension) to which they belong it (family, the acquaintance, job etc.). The degree of homophily (relationship) in the hierarchy is determined by a parameter α . Detailed numerical simulations reveal that for $H > 1$, global spreading results regardless of the degree of homophily α . For $H = 1$, a transition from global to local spread occurs as the population becomes decomposed into increasingly homophilous groups. Multiple dimensions in classifying individuals (nodes) thus make a society (computer network) highly susceptible to

large scale outbreaks of infectious diseases (viruses). The SIR–model is extended to an SIRS–model, where already infected persons may enter the dynamical process after a finite waiting time.

AKSOE 5.3 Di 15:00 H8

About a new algorithm of the measurement of user interests in the Internet search — ●ANDREAS SCHAALE — Mulackstrasse 6, 10119 Berlin

The main idea of this algorithm is to extend the existing algorithms by a component, reflecting the interests of the users more than already existing methods. The VoxPopuli Algorithm creates a feedback of the users to the content of the search index. The information, derived from the users query analysis is used to modify the existing crawling algorithms. The VPA controls the distribution of the resources of the Internet crawler.

AKSOE 6 Sondersitzung: Verleihung des Young-Scientist-Award for Socio- and Econophysics

Zeit: Dienstag 16:00–18:00

Raum: H10

Hauptvortrag

AKSOE 6.1 Di 16:00 H10

The Dynamics of Information — ●BERNARDO HUBERMAN — hp labs, palo alto, ca 94304

The dynamics of information within social organizations is relevant to issues of productivity, innovation and the sorting out of useful ideas from the general chatter of a community. How information spreads and is aggregated determines the speed with which individuals and organizations can act and plan their future activities.

This talk will describe new mechanisms for automatically identifying communities of practice within organizations and for elucidating the spread of information spreads within those communities. In addition, a

new method for forecasting uncertain events using small groups of people will be presented, along with empirical results that show its efficacy at making predictions in the laboratory and in the real world.

AKSOE 6.2 Di 17:00 H10

Verleihung des Young-Scientist Award for Socio- and Econophysics — ● —

AKSOE 6.3 Di 17:15 H10

Vortrag der Preisträgerin / des Preisträgers — ● —

AKSOE 7 Makro-ökonomische Modelle und Wirtschaftswachstum I

Zeit: Mittwoch 14:00–15:30

Raum: H8

AKSOE 7.1 Mi 14:00 H8

Stability and Dynamics of Regular and Random Supply Networks — ●DIRK HELBING and STEFAN LÄMMER — TU Dresden, Institute for Economics and Traffic, Andreas-Schubert-Str. 23, 01062 Dresden

We investigate the stability and dynamic behavior of linear supply chains and supply networks of different topologies, including “supply circles”, “supply ladders”, and “supply hierarchies”. When the desired production rate is adapted to forecasted inventories rather than actual stock levels, the resulting equations turn out to be coupled sets of (damped) oscillator equations similar to those of electrical networks. Longer forecast time horizons τ have a stabilization effect. However, for a given supply matrix C , one normally cannot tune between unstable, damped, and overdamped behavior. Moreover, even in the damped case, one may face the “bull-whip effect”, according to which the oscillation amplitude is increased compared to the perturbations in the consumption rate. We will provide analytical solutions and discuss resonance phenomena in supply networks.

AKSOE 7.2 Mi 14:30 H8

The German Powermarkets - Timeseries Analysis and Pricing — ●MAGDA SCHIEGL — Versicherungskammer Bayern, Abt. 8MS02, Maximilianstr. 53, 80530 Muenchen

After the liberalisation of the German power market in 2000 a new market structure has developed which is determined by two major parts: The OTC- forward market and the exchange spot market (day ahead, equilibrium price by bilateral auctions)

There is no analytic formula that links the spot price to the forward price as it is the case in financial markets (“cost-of-carry” relationship). The reason for this is the inability of storing electricity in an efficient way therefore the no-arbitrage approach of pricing derivative securities cannot be applied in the usual manner. On the spot market energy volumes arising from misfits in hedges between short term electricity consumption on the one hand and long term, highly standardized forward products on

the other are dealt. We analyse the structure of spot prices and find it to be a combination of deterministic, time periodic motion and stochastic movements (f.i. weather dependent). The time periodic effects can be observed on different time scales. We use factor model, Fourier method and extreme value theory for our analyses.

As an application of your results we discuss a pricing formula for special products of the OTC non-standard power markets, so called “shaped deals”. This is of course the basis of an efficient risk management of power portfolios containing such contracts.

AKSOE 7.3 Mi 15:00 H8

A socio-economic model of the German energy market — ●DIETER IHRIG — FH Suedwestfalen, Iserlohn, Germany

Last year a socio-economic model of the German energy market was presented. This model is improved: Depreciation of power plants is realized in a bookkeeper sense. The loss of jobs in the classic energy sector is calculated more realistic. The data base is actualized.

The model is based on data of the study-group of energy balances at the VDEW (Organization of German energy supplier). The end energy consumption will be recorded in 4 sectors (households, low consumer, industries, traffic) and 4 service arrays (room heating, process heat, mechanical energy and light) specified for primary energy sources. To assess the primary energy requirement it is necessary to deal with more than 125 end primary energy consumption data each year. It is possible to define over 40 years objectives on higher energy saving in the most service arrays of each end energy consumption sector. The effects on CO₂-emission of several strategies of energy saving will be calculated including commercial data and socioeconomic aspects (investment, foreign trade, energy prizes, jobs etc.). The model is build by 45 EXCEL files including more than 400 corresponding work sheets.

A overview of the results of the model is given. A more detailed look of the ways of realization of the energy model is given.

AKSOE 8 Makro-ökonomische Modelle und Wirtschaftswachstum II

Zeit: Mittwoch 16:00–18:00

Raum: H8

AKSOE 8.1 Mi 16:00 H8

Thermodynamics of Economic Growth — ●JÜRGEN MIMKES — Physik Department Universität Paderborn

Thermodynamics is a statistical theory, that applies to all large systems with constraints (E). In liquids atoms are under constraints of energy (E). In economies people are under constraint of capital (E). According to the second law of thermodynamics,

$$dW = dE - T dS$$

Work (W) in atomic systems increases the amount of energy (E) and reduces the energy distribution (S). T is ordering parameter, in liquids T is the temperature or mean kin. energy. In Carnot cycles work may be applied to raise (heat pump) or reduce (refrigerator) the temperature (T).

Work (W) in economic systems increases the amount of capital (E) and reduces the capital distribution (S). The economic temperature T is the mean capital or standard of living. The economic cycle of goods and capital corresponds to the Carnot cycle. Production cycles lead to exponential economic growth, to saturation or reduction of the standard of living (T). The results are compared to data of East-West Germany and US-Japan.

AKSOE 8.2 Mi 16:30 H8

An Inquiry into the Nature of the Economy — ●HANS G. DANIELMEYER — Mozartstr. 69, 85521 Ottobrunn

After a brief review of macroeconomic theory a new, closed theory is presented that includes social order as input besides human ability and physical capital. As the lifetimes of the inputs are natural constants of the human species, they lend the economy an intrinsic dynamical behavior beyond economic control. Strong growth periods cause inevitably long range economic problems. The classical advice to invest physical capital is counterproductive. The correct production function is discovered. Former functions can be obtained as mathematical approximations for perfect social order. The development of the industrial society in general is as slow as it is because it requires the interactive removal of barriers to technical, educational, and social advances. Below that benchmark level, the development of a real nation can be dramatic, depending on the level of destruction afflicted to physical and social capital per capita. The latter has an inherited component and a direction. For the first time the global mixed social order economy is tractable. The quantitative agreement between the real long-term input and output trajectories for Germany, Japan and the USA is excellent although their input dynamics differ considerably.

AKSOE 8.3 Mi 17:00 H8

Konsumverhalten und die Dynamik der Mode — ●THOMAS BRENNER — Max-Planck-Institut zur Erforschung von Wirtschaftssystemen, Kahlaische Str. 10, 07745 Jena

Dieses Papier untersucht die Wechselwirkung zwischen Konsumenten und die daraus entstehende Modedynamik. Ziel ist es dabei zu prüfen, welche Aspekte eine wiederkehrende Veränderung von Mode zu erklären. Dazu wird ein Modell des Konsumverhaltens entwickelt, das auf dem Verstärkungslernen basiert. Es wird davon ausgegangen, dass der Konsum von Gütern verstärkt wird, die entweder ebenfalls von anderen Konsumenten gewählt werden oder neu sind. Den Konsumenten wird damit eine Präferenz für Konformität und Neuigkeit unterstellt. Eine Modellierung der entstehenden Interaktion zwischen Konsumenten zeigt, dass diese beiden Präferenzen nicht ausreichen, um eine wiederholte Veränderung der Mode zu erklären. Deshalb wird mit Hilfe eines Simulationsmodells untersucht, welche zusätzlichen Umstände die wiederkehrende Veränderung von Mode erklären. Es werden verschiedene Modelle untersucht, die eine Veränderung der Konsumentenpopulation, eine Wiedererlangung der Attraktivität durch Güter bei ausbleibendem Konsum oder eine Veränderung der angebotenen Güter beinhalten. Es zeigt sich, dass nur bestimmte Modellvarianten die wiederkehrende Veränderung der Mode erklären, und dass die Produzenten maßgeblich an der Dynamik der Mode beteiligt sind.

AKSOE 8.4 Mi 17:30 H8

Complexity and Evolutionary Economics — ●CARL HENNING RESCHKE — Mainzer Str. 80, 50678 Koeln, affiliation: Universitaet Witten/Herdecke

The aim of this paper is to sketch a strategic map of some of the relevant issues at the intersection of economics, sociology and evolutionary theories. Methodologically a successful integration of these areas requires a transfer of complexity methods and development of further methods in the complexity area. The paper therefore poses challenges to complexity researchers as well as discusses how these areas intersect conceptually. I review approaches to complexity from physics, computer science and biology.

Each of these disciplines offers a specific way of dealing with complex phenomena, with distinctive advantages and disadvantages. Physics measures potentially relevant characteristics. Computer science aims at algorithmic accounts of how complex systems can be artificially constructed. Evolutionary thinking asks for the adaptive value of specific characteristics. It shifts attention from a generalized standard optimality criterion to a differentiated account of selection criteria and selection conditions in specific circumstances. Hypotheses and are illustrated with examples from the pharmaceuticals market.

AKSOE 9 Symposium: Fat Tail Distributions – Application from Physics to Finance

Zeit: Donnerstag 09:30–12:30

Raum: H1

AKSOE 9.1 Do 09:30 H1

Symposium: Fat Tail Distributions – Applications from Physics to Finance — ● —

AKSOE 10 Mikro-ökonomische Modelle und Multi-Agenten-Systeme

Zeit: Donnerstag 14:00–17:30

Raum: H8

Hauptvortrag

AKSOE 10.1 Do 14:00 H8

Physicists' Insights into Wealth Distributions — ●FRANTIŠEK SLANINA — Institute of Physics, Academy of Sciences of the Czech Republic, Na Slovance 2, CZ-18221 Praha, Czech Republic

Distribution of wealth in human society was one of first features of socio-economic systems which was attempted to approach scientifically. Empirical analysis performed by Vilfredo Pareto lay down the foundation of the quantitative analysis of social inequality which was of first concern throughout the 19th century. The famous Pareto law, claiming power-law

distribution of wealth, robust in time and valid in all diverse societies, was re-examined many times since then. Several other functional dependencies were suggested, but the essential message that the tail of the distribution follows a power-law passed all tests.

However, the explanation of the Pareto tail was less straightforward than it might have seemed. In our talk we summarise several approaches, including Lotka-Volterra equations, random directed polymers and ideal-gas analogies. We will present a new model of wealth exchange which yields exact analytical solution for the wealth distribution.

We will be stressing that the essence of all these approaches can be

boiled down to random multiplicative processes with appropriate boundary conditions. In so doing we indirectly argue against the presence of self-organized criticality in economic systems and suggest the triviality of ubiquitous power-law distributions.

AKSOE 10.2 Do 14:45 H8

Pause — • —

AKSOE 10.3 Do 15:00 H8

Finite Size Effects in Herding Models — •FRIEDRICH WAGNER¹, SIMONE ALFARANO², and THOMAS LUX² — ¹Institut für theoretische Physik, Universität Kiel — ²Institut für Volkswirtschaft, Universität Kiel

Agent models to describe stock indices are usually applied at fixed number N of agents, as f.e. the Lux-Marchesi model (LMM) [1]. As shown in [2] LMM exhibits only gaussian fluctuations and no herding if $N \rightarrow \infty$. As a paradigm for herding we treat the ant model of [3]. In this model the herding parameters in the transition probability for one agent to change his opinion have to scale with N and do not depend only on the concentration as in LMM. If this N -dependence is omitted as one could do for fixed N , also this model becomes trivial for $N \rightarrow \infty$. This motivates our believe that the independence on N of the herding term in LMM is responsible for the triviality at large number of agents.

[1] T.Lux, M.Marchesi, Nature 397(1999)498

[2] E.Egenter, T.Lux, D.Stauffer Physica A 268(1999)250

[3] A.Kirman Quant. Journ. Econ. 108(1993) 137

AKSOE 10.4 Do 15:30 H8

Tobin tax and market depth — •GUDRUN EHRENSTEIN¹, DIETRICH STAUFFER¹, and FRANK WESTERHOFF² — ¹Institute for Theoretical Physics, Cologne University, Zùlpicherstr. 77, 50937 Köln — ²Department of Economics, University of Osnabrück, Rolandstrasse 8, 49069 Osnabrück

This paper investigates - on the basis of the Cont-Bouchaud model - whether a Tobin tax may stabilize foreign exchange markets. Compared to earlier studies, this paper explicitly recognizes that a transaction-tax-induced reduction in market depth may increase the price responsiveness of a given order. We find that the imposition of a transaction tax may still achieve a triple dividend: (1) exchange rate fluctuations decrease, (2) currencies are less mispriced, and (3) central authorities raise substantial tax revenues. However, if the price impact function is too sensitive with respect to the market depth, stabilization may turn into destabilization.

AKSOE 10.5 Do 16:00 H8

Knowledge agents represented by knowledge functions — •HANS-DIEDRICH KREFT — 21521 Dassendorf, Ecksweg 4

Specific knowledge characteristics can be described mathematically by the use of knowledge functions. In this sense we can speak of the operability of knowledge. The operability of knowledge enables us to combine the agent concept with knowledge functions. Thereby we get "knowledge agents" which can operate in an extended economic space. In this socio-economic space we can mathematically derive for the first time new micro and macro economic features like competence, rationalisation potential, innovation. These extension of the space of economic description

seems to be essential for explaining complex economic dependencies on an unique mathematical concept.

AKSOE 10.6 Do 16:30 H8

Fair or not fair? That is the question! – An Investigation based on a System of a Network of Trading Agents — •ELENA RAMIREZ BARRIOS, JUAN G. DIAZ O. und JOHANNES J. SCHNEIDER — Institute for Physics, Johannes Gutenberg University, Staudinger Weg 7, D-55099 Mainz, Germany

Imagine an economy with a finite number of agents, each owning an initial allocation of a finite number of commodities. There is no production, and a price system is given. The agents choose the best net trades according to their preferences, which are maximal in the limited budget sets the agents have. This results in an equilibrium under optimal conditions. In this equilibrium, we can find properties such as fairness, following the fact that all agents have the same trading possibilities and the same access to the entire set of commodities. A net trade is fair for any agent i , if no other agent j can perform a better net trade than possible for agent i , according to the preference list of agent i and according to his budget set. Usually, only a normative meaning and a low measurability of fairness are considered, as the concept of fairness is very difficult to describe in an exact mathematical way. On the other hand, the concept of fairness has occupied a good place in the political decisions trying to improve the social welfare. However, with mathematical methods, we try to simulate the economical agents' behaviors and measure the fairness in this system, finding a trend behavior such that their improved actions result in a justice horizon as suggested by the first and second welfare theorems.

AKSOE 10.7 Do 17:00 H8

Simulated Trading and Working — •JOHANNES J. SCHNEIDER — Department of Physics, Johannes Gutenberg University, Staudinger Weg 7, D-55122 Mainz

Simulated Trading is a multi agent approach to solve combinatorial optimization problems: the overall system shall be optimized by a set of agents who buy and sell parts of the problem, which are currently in their possessions, from or to each other [1,2]. The agents try to solve their system parts in a rather optimum way – but this way is only locally optimum. The results achieved with this approach depend strongly on the overall number N of agents and on the fraction q of agents taking part in a trading move. In order to improve results, the agents shall not only trade but also work in this new approach. This means that improvements are not only achieved with inter-agent trading moves but also with intra-agent local moves. I will show results for an application to the Traveling Salesman Problem and will compare this new approach to the original approach and also to global optimization algorithms like Simulated Annealing.

[1] A. Bachem, W. Hochstättler, M. Malich (1993), The Simulated Trading Heuristic for Solving Vehicle Routing Problems, Report No. 93.139, Institute of Mathematics, University of Cologne, Germany

[2] A. Bachem, W. Hochstättler, M. Malich (1994), Simulated Trading – A New Parallel Approach for Solving Vehicle Routing Problems, Parallel Computing: Trends and Applications: Proceedings of the International Conference ParCo93, Grenoble, France, 7–10 September 1993

