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ABSTRACTS

of contributions to the

26th International NTZ-Workshop on

New Developments in Computational Physics

CompPhys25

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Preface

Welcome to the 26th International NTZ-Workshop *CompPhys25* on *New Developments in Computational Physics*. As in previous years, also this year's Workshop will cover a broad spectrum of different fields ranging from general aspects of computational and statistical physics over computer simulation studies in condensed and soft matter physics, including applications to biological systems, and random networks to the intriguing properties of quantum systems and high-energy physics. Following the traditional setup of the Workshop, it is also this year designed to provide a forum for an informal exchange of ideas and to meet in a relaxed atmosphere in Leipzig during Christmas time.

The main part of the Workshop will take place on Thursday/Friday, 27 and 28 November 2025, this year in the seminar room SR 113 of the Institute for Theoretical Physics in Brüderstr. 16. As in previous years, the last day, Saturday, 29 November 2025, is devoted to various collaborative meetings and discussion rounds which will also take place in the seminar rooms of the Theoretical Physics building in Brüderstr. 16.

Finally, we and the Centre for Theoretical Sciences (NTZ) gratefully acknowledge financial support of the Workshop from the Doctoral College "$\mathbb{L}^4$" of Deutsch-Französische Hochschule (DFH-UFA) and the Leipzig Graduate School of Natural Sciences "BuildMoNa".

Leipzig,
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Abstracts

Pattern dynamics in living liquid crystals

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An amalgam of active matter (AM) and nematic liquid crystals (LCs), referred to as living liquid crystals (LLCs), is a promising self-healing material with futuristic applications for targeted delivery of information and micro-cargo. We provide a phenomenological model to study the symbiotic pattern dynamics in this contemporary system using the Toner-Tu model for AM, the Landau-de Gennes free energy for LCs, and an experimentally motivated coupling term that favours co-alignment of the active and nematic components. Our extensive theoretical studies unfold novel steady states, chimeras and solitons, with sharp regions of distinct orientational order that sweep through the coupled system in synchrony. By imposing surface-directed conditions, we show that the AM-LC coupling can be exploited to yield controlled pattern dynamics in the LLCs.

Ground-state properties of mean-field and lattice Ising spin glasses

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We will discuss recent efforts at developing and benchmarking vectorized heuristics for exploring ground states of Ising spin glasses and their application to the study of scaling properties in mean-field and lattice systems, such as the diluted Sherrington-Kirkpatrick model, its 3-spin version, and droplet excitations in the Edwards-Anderson model in 3 to 8 dimensions.

DIMOS: A fast, modular, and differentiable framework for machine learning-enhanced molecular simulations

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We present an end-to-end differentiable molecular simulation framework (DIMOS) for molecular dynamics and Monte Carlo simulations. DIMOS easily integrates machine-learning-based interatomic potentials and implements classical force fields including an efficient implementation of particle-mesh Ewald. Thanks to its modularity, both classical and machine-learning-based approaches can be easily combined into a hybrid description of the system (ML/MM). By supporting key molecular dynamics features such as efficient neighborlists and constraint algorithms for larger time steps, the framework makes steps in bridging the gap between hand-optimized simulation engines and the flexibility of a `PyTorch` implementation. We show that due to improved linear instead of quadratic scaling as function of system size DIMOS is able to obtain speed-up factors of up to for classical force field simulations against another fully differentiable simulation framework. The advantage of differentiability is demonstrated by an end-to-end optimization of the proposal distribution in a Markov Chain Monte Carlo simulation based on Hamiltonian Monte Carlo (HMC). Using these optimized simulation parameters a acceleration is observed in comparison to ad-hoc chosen simulation parameters.

Nonequilibrium dynamics of the helix-coil transition in polyalanine (P)

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In this work, the nonequilibrium pathways of the collapse of the helix-forming biopolymer polyalanine are investigated. To this end, the full time evolution of the helix-coil transition is simulated using molecular dynamics simulations. At the start of the transition, short 3_{10}-helices form, seemingly leading to the molecule becoming more aspherical midway through the collapse. After the completed collapse, the formation of π-helices becomes the prevalent ordering mechanism leading to helical bundles, a typical structural motif representative of the equilibrium behavior of longer chains. The dynamics of this transition is quantified in terms of the power-law scaling of two associated relaxation times as a function of chain length.

Universal exotic dynamics in critical mesoscopic systems

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We explicitly demonstrate the universality of critical dynamics through unprecedented large-scale GPU-based simulations of two out-of-equilibrium processes, comparing the behavior of spin-1/2 Ising and spin-1 Blume-Capel models on a square lattice [1]. In our protocol, a completely disordered system is instantaneously brought into contact with a thermal bath at the critical temperature, allowing it to evolve until the coherence length exceeds 10^3 lattice spacings. Finite-size effects are negligible due to the mesoscopic scale of the lattice sizes studied, with linear dimensions up to $L = 2^{22}$ and 2^{19} for the Ising and Blume-Capel models, respectively. Our numerical data, and the subsequent analysis, demonstrate a strong dynamic universality between the two models and provide the most precise estimate to date of the dynamic critical exponent for this universality class, $z = 2.1676(1)$. The results presented in this work leverage our CUDA-based numerical code, breaking the world record for the simulation speed of the Ising model.

[1] M. Bisson, A. Vasilopoulos, M. Bernaschi, M. Fatica, N. G. Fytas, I. González-Adalid Pemartín, and V. Martín-Mayor, Phys. Rev. Research **7** (2025) 033218.

Critical behaviour of non-reciprocal Ising models (P)

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Equilibrium statistical physics is based on symmetric, Hamiltonian interactions fulfilling Newton's third law. On the other hand, active matter like bacteria or other self-propelled particles such as bird flocks violates time-reversal symmetry and is often characterized by non-reciprocal interactions. Simple models are of interest for exploring fundamental features of such systems. We examine classical spin systems including the Ising model with non-reciprocal interactions, using Monte Carlo simulations to study criticality in such models. For several systems we determine critical exponents and compare the observed universality classes to those of the corresponding reciprocal, equilibrium models.

Small peptide modulation of amyloid formation and inhibition

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A detailed knowledge of how proteins fold, change their structure and function, or self-assemble and aggregate, is crucial for an understanding of disease pathways and the working of drugs at the level of cells. In this talk, I will focus on two examples: Amyloid formation mediated by viruses and other pathogens, and the opposite case of inhibition of amyloid formation by small peptides. We show that small protein fragments of the SARS-COV-2 virus modulate the distribution of known amyloid-forming proteins in a way that increases the chance for aggregation, potentially increasing the risk for amyloid diseases. In complementary research we have shown that the small peptide DRI-R5S inhibits Serum Amyloid A fibrils, as formed, for instance, in mice after myocardial infarction.

Large-deviation simulations for random matrices

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For random processes, one targets obtaining probability distributions $P(X)$, where X is a measurable property of interest. In many cases $P(X)$ cannot be obtained analytically, thus simulations are performed. By using large-deviation simulations, which are based on sampling biased distributions of the processes of interest instead of the original ones, one is often able to study $P(X)$ over a large range of the support, even over hundreds of decades in probability. Since direct sampling of the biasesd distributions is usually not possible, Markov chain Monte Carlo methods are often used. Here such an approach is applied to random matrices, where X is the largest eigenvalue. In the simulations different matrix sizes are considered, suitable empirical large-deviation rate functions are obtained, and it is tested whether a point-wise convergence of the rate functions can be observed. Here the Gaussian Orthogonal Ensemble (GOE) and a diluted GOE, where a fraction p of entries are zero, are considered. For the GOE a very fast convergence to the known analytical result is observed, while for the diluted GOE stronger finite-size dependences are visible.

Simulating next-to-next-to-nearest couplings with the worm algorithm

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We simulate the improved 3D XY model studied in "Eliminating leading and sub-leading corrections to scaling in the three-dimensional XY universality class", arXiv:2507.19265 by using the worm algorithm. We obtain accurate estimates of field dimensions for large charges. Our approach builds on Debasish Banerjee et al., Phys. Rev. Lett. **120** (2018) 061603.

Schrödinger-invariance in the voter model

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Exact single-time and two-time correlations and the two-time response function are found for the order-parameter in the voter model with nearest-neighbour interactions. Their explicit dynamical scaling functions are shown to be continuous functions of the space dimension $d > 0$. Their form reproduces the predictions of non-equilibrium representations of the Schrödinger algebra for models with dynamical exponent $z = 2$ and with

the dominant noise-source coming from the heat bath. Hence the ageing in the voter model is a paradigm for relaxations in non-equilibrium critical dynamics, without detailed balance, and with the upper critical dimension $d^* = 2$.

Random field Ising model and front propagation in random media (P)

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Two-phase flow in disordered media exhibits fascinating physical properties [1]. In this work we study such a flow in disordered media by using a zero-temperature dynamics of the random-field Ising model (RFIM) to capture essential features of this system. In particular we focus on several properties of the interface between the phases such as its fractal geometry which can be characterized by critical exponents [2]. Furthermore we investigate abrupt changes in the propagation of the interface also known as crackling noise. By applying the RFIM to this problem we hope to gain insights into the underlying mechanisms of two-phase flow in disordered media and to provide a framework for interpreting experimental observations.

[1] R. Holtzman, M. Dentz, R. Planet, and J. Ortin, Commun. Phys. **3** (2020) 222.
[2] B. Drossel and K. Dahmen, Eur. Phys. J. B **3** (1998) 485.

Si(001) surfaces and the anisotropic square lattice Ising model

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The coupling energies between the buckled dimers of the Si(001) surface were determined through analysis of the anisotropic critical behaviour of its order-disorder phase transition. Spot profiles in high-resolution low-energy electron diffraction as a function of temperature were analysed within the framework of the anisotropic two-dimensional Ising model. The validity of this approach is justified by the large ratio of correlation lengths, $\xi_\parallel^+/\xi_\perp^+ = 5.2$ of the fluctuating $c(4\times2)$ domains above the critical temperature $T_\mathrm{c} = (190.6\pm10)\,\mathrm{K}$. Using a mapping onto the exact solution of the anisotropic square lattice Ising model, we obtain effective couplings $J_\parallel = (-24.9\pm1.3)\,\mathrm{meV}$ along the dimer rows and $J_\perp = (-0.8\pm0.1)\,\mathrm{meV}$ across the dimer rows [1]. Several critical exponents as well as the exact scaling function of the k-dependent susceptibility are compared, with excellent agreement [2]. Finally, I give an outlook on the Kibble-Zurek mechanism in anisotropic Ising models [3].

[1] Ch. Brand *et al.*, Phys. Rev. Lett. **130** (2023) 126203.
[2] Ch. Brand *et al.*, Phys. Rev. B **109** (2024) 134104.
[3] G. Schaller *et al.*, Phys. Rev. Lett. **134** (2025) 246202.

Random quantum Ising model with three-spin couplings

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We apply a real-space block renormalization group approach to study the critical properties of the random transverse-field Ising spin chain with multispin interactions. First we recover the known properties of the traditional model with two-spin interactions by applying the renormalization approach for arbitrary size of the block. For the model with three-spin couplings we calculate the critical point and demonstrate that the phase transition is controlled by an infinite disorder fixed point. We have determined the typical correlation-length critical exponent, which seems to be different from that of the random transverse Ising chain with nearest-neighbor couplings. Thus this model represents a new infinite disorder universality class.

The Ising model under stochastic resetting (P)

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tba

Conditional no-jump dynamics of noninteracting quantum chains

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Lindbladian dissipative processes can be specified by stochastic samplings of individual trajectories, whose non-Hermitian evolution is perturbed by quantum jumps. In this talk, we present results on the conditional no-jump evolution of noninteracting chains, including partial missed detection of jumps. As a main result, for Gaussian-preserving Lindblad operators, the conditional dynamics is captured by a nonlinear Riccati-type differential equation for the correlation matrix.

Transfer-matrix approach to the Blume-Capel model on the triangular lattice

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We investigate the spin-1 Blume-Capel model on an infinite strip of the triangular lattice using the transfer-matrix method combined with a sparse-matrix factorization technique. Through finite-size scaling analysis of numerically exact spectra for strip widths up to $L = 19$, we accurately locate the tricritical point improving upon recent Monte Carlo estimates. In the first-order regime, we observe exponential scaling of the spectral gap, reflecting the linear growth of interfacial tension as the temperature decreases below the tricritical point. Finally, we validate our tricritical point estimate through precise agreement with conformal field theory predictions for the tricritical Ising universality class. Our results underscore the continued utility of the transfer-matrix approach for studying phase transitions in complex lattice models.

Short-time dynamics in phase-ordering kinetics

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Short-time dynamics in the 2D Blume-Capel model, with a non-conserved order-parameter and short-ranged interactions, is analysed. For non-equilibrium dynamics, both at a critical point in the 2D Ising universality class and at the tricritical point, we reproduce the values $\Theta = 0.190(5)$ and $\Theta = -0.542(5)$, respectively, of the critical initial slip exponent. These agree with more early estimates and with the Janssen-Schaub-Schmittmann scaling relation. In phase-ordering kinetics, after a quench into the ordered phase, we establish the validity of short-time dynamics. In the 2D Ising universality class, we find $\Theta = 0.39(1)$ in agreement with the scaling relation $\lambda = d - 2\Theta$.

Percolation and equilibrium ordering in the three-dimensional $\pm J$ Ising model

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We study the relation between cluster percolation and equilibrium ordering phenomena in the three-dimensional Ising ferromagnet and the three-dimensional bimodal Ising spin glass using Monte Carlo simulations. In particular, a specific type of two-replica clusters is analyzed [1, 2]. The density of these clusters is directly linked to the overlap order parameter. The analysis begins with the pure ferromagnet, where it is demonstrated that the percolation transition coincides with the ferromagnetic phase transition. The study is then extended to the spin-glass case, where half of all bonds are antiferromagnetic. The spin-glass transition manifests as an emerging density difference between the two largest clusters. Furthermore, a phase transition is identified in the subspace of spin configurations with constant sitewise overlap, occurring at temperatures higher than the spin-glass transition, which indicates an increasing stiffness of the system above the spin-glass temperature.

[1] J. Machta, C. M. Newman, and D. L. Stein, J. Stat. Phys. **130** (2008) 113.
[2] L. Münster and M. Weigel, Phys. Rev. E **107** (2023) 054103.

Challenges in coarse-grained simulation of dynamical properties of associating polymers (P)

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Scaling of the Mpemba effect in the Ising model

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The Mpemba effect – originally observed by Mpemba and Osborne for water [1] – describes the counter-intuitive situation in which a hotter system relaxes faster than an initially colder one when both are quenched into the same thermal reservoir. In recent years this phenomenon has been identified in various systems undergoing phase transitions [1, 2, 3]. In this work, we investigate the Mpemba effect in ferromagnetic models with a critical temperature T_c, focusing in particular on the 2D Ising model. Using Monte Carlo simulations with different update dynamics, we study how initial temperatures and initial magnetization influence the underlying coarsening dynamics while quenching below T_c of different structural properties. In detail we investigate observables such as the energy per spin $\langle e \rangle$ and the average domain length $\langle \ell \rangle$. While Mpemba-like curve crossings appear for several conditions, they seem to coincide with finite-size time scales and weaken with increasing system size L. In contrast, non-zero initial magnetization enhances the effect, producing robust inversions in relaxation behavior.

[1] E. B. Mpemba and D. G. Osborn, Phys. Educ. **4** (1969) 172.
[2] M. Baity-Jesi et al., PNAS **116** (2019) 15350.
[3] N. Vadakkayil and S. K. Das, Phys. Chem. Chem. Phys. **23** (2021) 11186.
[4] A. K. Chatterjee, S. Takada, and H. Hayakawa, Phys. Rev. Lett. **131** (2023) 080402.

Role of liquid crystalline textures on trajectories of active Brownian particles (P)

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The study by J. Toner et al. [1] has demonstrated that the texture of nematic liquid crystals (LC) can effectively manipulate and guide active Brownian particles (ABP) along the local director. Motivated, we study the ABP trajectories by numerically solving the over-damped Langevin equations and a generalized Lebwohl-Lasher (GLL) model to represent the LC medium [2]. The latter exhibits isotropic, nematic, and canted phases, which naturally allow diverse textures of the non-Newtonian environment. We carefully analyze the properties of the ABP trajectories in these three phases and can evaluate their Hurst exponents, diffusive properties, and step-size distributions showing anisotropic nature. Specifically, it is observed that ABPs demonstrate ballistic diffusion with exponential step sizes along the nematic director, while exhibiting anomalous slow diffusion with fractal paths and Rayleigh-distributed steps in perpendicular directions. These insights improve our understanding of ABP motility in complex environments.

[1] J. Toner, H. Löwen, and H. H. Wensink, *Following fluctuating signs: Anomalous active superdiffusion of swimmers in anisotropic media*, Phys. Rev. E **93** (2016) 062610.
[2] N. Birdi, V. Banerjee, and S. Puri, *Ordering kinetics of canted and uniform states in nematic liquid crystals*, Europhys. Lett. **132** (2021) 66002.

Prefreezing of alkanes: Flat-histogram Monte Carlo study and comparison with phenomenological theory

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Interactions between chain molecules and solid substrates can give rise to interfacial phenomena such as pre-wetting and the less common prefreezing transition – the formation of a crystalline molecular layer at the substrate prior to bulk freezing [1,2]. In this work, we employ Stochastic Approximation Monte Carlo (SAMC) simulations to examine how the strength of chain-substrate interactions affects the onset, thickness, and order of the prefreezing transition. The simulation results are compared with phenomenological theory [2] to extract the thermodynamic parameters governing interfacial ordering.

[1] M. Tariq, O. Dolynchuk, and T. Thurn-Albrecht, *Effect of substrate interaction on thermodynamics of pre-freezing*, Macromolecules **52** (2019) 9140–9148.
[2] O. Dolynchuk, M. Tariq, and T. Thurn-Albrecht, *Phenomenological theory of first-order prefreezing*, J. Phys. Chem. Lett. **10** (2019) 1942–1946.

Finite-temperature criticality through quantum annealing

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Critical phenomena at finite temperature underpin a broad range of physical systems, yet their study remains challenging due to computational bottlenecks near phase transitions. Quantum annealers have attracted significant interest as a potential tool for accessing finite temperature criticality beyond classical reach, but their utility in precisely resolving criticality has remained limited by noise, hardware constraints, and thermal fluctuations. Here we overcome these challenges, showing that careful calibration and embedding allow quantum annealers to capture the full finite-temperature critical behavior of the paradigmatic two-dimensional Ising ferromagnet. By tuning the energy scale of the system and mitigating device asymmetries, we sample effective Boltzmann distributions and extract both the critical temperature and the associated critical exponents. Our approach opens the study of equilibrium and non-equilibrium critical phenomena in a broad class of systems at finite temperature.

Cluster percolation and dynamical scaling in the Baxter-Wu model

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We investigate the percolation behavior of Fortuin-Kasteleyn-type clusters in the spin-1/2 Baxter-Wu model with three-spin interactions on a triangular lattice. The considered clusters are constructed by randomly freezing one of the three sublattices, resulting in effective pairwise interactions among the remaining spins. Using Monte Carlo simulations combined with a finite-size scaling analysis, we determine the percolation temperature of these stochastic clusters and show that it coincides with the exact thermal critical point of the model. The critical exponents derived from cluster observables are consistent with those of the underlying thermal phase transition. Finally, we analyze the dynamical scaling of the multi-cluster and single-cluster algorithms resulting from the cluster construction, highlighting their efficiency and scaling behavior with system size.

Crossover of critical behavior in dynamic phase transitions of multilayer Ising model systems

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We investigate the crossover of critical behavior for the dynamic phase transition (DPT) in ferromagnetic thin films using Monte Carlo simulations of the kinetic Ising model, focusing on the scaling behavior of the dynamic order parameter under a time-dependent external magnetic field. Specifically, we study the transition of the critical behavior of such multilayer film systems from two-dimensional (2D) to three-dimensional (3D) as a function of the film thickness and the distance to the critical point, which enables dimensional crossover observations. Our results indicate that the effective critical exponents exhibit a clear transition in their scaling behavior, with thinner films showing 2D-like characteristics and thicker films displaying 3D-like behavior, for both the DPT and the thermodynamic phase transitions (TPT). Quantitatively, the crossover from 2D to 3D behavior occurs at larger film thicknesses for the DPT compared to the TPT, suggesting that DPT and TPT are governed by distinctly different length scales and underlying surface effects. These findings are in agreement with experimental observations in ultrathin Co films, where dynamic and thermodynamic critical exponents were found to differ. Therefore, our study provides an in-depth explanation for critical phenomena in thin-film ferromagnets driven by a time-dependent magnetic field. By comparing the dimensional crossover properties of both TPT and DPT, we present a comprehensive understanding of how thin-film geometry and surface effects influence the scaling laws and critical behavior in nonequilibrium systems.

Monte Carlo study of the two-dimensional kinetic Ising model under a nonantisymmetric magnetic field

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We present a comprehensive numerical study of dynamic phase transitions in the two-dimensional kinetic Ising model under a nonantisymmetric time-dependent magnetic field including a sinusoidal term and a second harmonic component. We demonstrate that the expected antisymmetric property and the scaling behavior of the order parameter are maintained using the recently proposed generalized conjugate field approach. Via a detailed finite-size scaling analysis we compute, for zero-bias field, the set of critical exponents suggesting that the Ising universality class is conserved, even in the absence of half-wave antisymmetry in the time-dependent magnetic field. Our results verify up-to-date experimental observations and provide a deeper understanding of nonequilibrium phase transitions, establishing a broader framework for exploring symmetry-breaking phenomena in driven magnetic systems.

Local optimization in complex systems

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Limited resources motivate decomposing large-scale problems into smaller, "local" subsystems and stitching together the so-found solutions. We explore the physics underlying this approach and discuss the concept of "local hardness", i.e., complexity from the local solver perspective, in determining the ground states of both P- and NP-hard spin glasses and related systems. Depending on the model considered, we observe varying scaling behaviors in how errors associated with local predictions decay as a function of the size of the solved subsystem. These errors stem from global critical threshold instabilities, characterized by gapless, avalanche-like excitations that follow scale-invariant size distributions. Away from criticality, local solvers quickly achieve high accuracy, aligning closely with the results of the more computationally intensive global minimization. These findings shed light on how Nature may operate solely through local actions at her disposal.

Spatiotemporal patterns in adaptive networks

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In many complex networks, the node activity locally feeds back onto the network structure. The interplay between structure and dynamics determines the stability of spatiotemporal patterns. Changes in either dynamic can thus induce transitions between different dynamical phases. This general feature of excitable systems occurs in a varity of biology systems, examples including arrhythmis dynamics in the heart or learning in the brain. I will provide a brief overview of this perspective with new results for spatial neural networks.