DY 25: Nonlinear Dynamics 2 - organized by Azam Gholami (Göttingen)

Time: Tuesday 11:00–13:00 Location: DYc

DY 25.1 Tue 11:00 DYc

Social distancing in pedestrian dynamics and its effect on disease spreading — Sina Sajjadi, Alireza Hashemi, and •Fakhteh Ghanbarnejad — Physics Department, Sharif University of Technology, Tehran, Iran

Non-pharmaceutical measures such as social distancing, can play an important role to control an epidemic. In this paper, we study the impact of social distancing on epidemics for which it is executable. We use a mathematical model combining human mobility and disease spreading. For the mobility dynamics, we design an agent based model consisting of pedestrian dynamics with a novel type of force to resemble social distancing in crowded sites. For the spreading dynamics, we consider the compartmental SEI dynamics plus an indirect transmission with the footprints of the infectious pedestrians being the contagion factor. We show that the increase in the intensity of social distancing has a significant effect on the exposure risk. By classifying the population into social distancing abiders and non-abiders, we conclude that the practice of social distancing, even by a minority of potentially infectious agents, results in a drastic change on the population exposure risk, but reduces the effectiveness of the protocols when practiced by the rest of the population. Furthermore, we observe that for contagions which the indirect transmission is more significant, the effectiveness of social distancing would be reduced. This study can provide a quantitative guideline for policy-making on exposure risk reduction.

arXiv preprint: arXiv:2010.12839

DY 25.2 Tue 11:20 DYc

Damage-Resilient Computation in Spiking Neural Networks — •Fabio Schittler Neves, Georg Börner, and Marc Timme — Chair for Network Dynamics, Institute for Theoretical Physics & Center for Advancing Electronics Dresden (cfaed), TU Dresden, Dresden, Germany

Networks of spiking neurons with inhibitory coupling exhibit reconfigurable k-winner-take-all computations via changes to a single parameter [1], robustly determining the k strongest out of N analog inputs. Such partial rank ordering of signals provides a natural basis for computing arbitrary functions. Moreover, computations are completed within a few spikes (~k), thus requiring low power. Here we show that such networks are strongly resilient with respect to failure or removal of neural units. We develop strategies for immediate function recovery that work even after damage to an extremely large number of units. These networks exhibit two forms of resilience: first, the loss of less than N-k units do not translate in any change in dynamics, as the N-k neurons receiving the weaker inputs never spike, thus never contribute to any collective network dynamics; second, the systems provide great flexibility through symmetric coupling, because any unit in the network can functionally replace any other. Suitably interacting inhibitory neural networks may provide resilient and flexible analogue computations at low power and offer attractive solutions where unit repair or replacements are economically or practically infeasible, for example in autonomous and remote computing.

[1] F. S. Neves & M. Timme, IEEE Access 8:179648 (2020).

DY 25.3 Tue 11:40 DYc

Localization in the Kicked Ising Chain from a Dual Perspective — •Daniel Waltner[1], Petr Braun[1], Maram Akila[2], Boris Gutkin[3], and Thomas Guhr[1] — [1]Fakultät für Physik, Universität Duisburg-Essen, 47048 Duisburg, Germany — [2]Fraunhofer IAIS, Schloss Birlinghoven, 53757 Sankt Augustin, Germany — [3]Department of Applied Mathematics, Holon Institute of Technology, 58102 Holon, Israel

Determining the border between ergodic and localized behavior is of central interest for interacting many-body systems. We consider here the recently very popular spin-chain model that is periodically excited. A convenient description of such a many-body system is achieved by the dual operator that evolves the system in contrast to the time-evolution operator not in time but in particle direction. We identify by various methods the largest eigenvalue of the dual operator as a convenient tool to identify if the system shows ergodic or many-body localized features.

DY 25.4 Tue 12:00 DYc

Understanding the origin of line defects in heart tissue. — •Marcel Hörning[1], Alessandro Loppini[2], Alessio Gizzi[2], Flavio H Fenton[3], and Simonetta Filippi[2] — [1]Institute of Biomaterials and Biomolecular Systems, University of Stuttgart, Stuttgart, Germany — [2]University Campus Bio-Medico of Rome, Rome, Italy — [3]School of Physics, Georgia Institute of Technology, Atlanta, Georgia, USA

Spatiotemporal patterns are observed in a wide range of excitable systems. They have important and diverse regulatory functions. In the heart, excitable waves can form complex oscillatory and chaotic patterns even at an abnormally higher frequency than normal heart beats, which increase the risk of fatal heart conditions by inhibiting normal blood circulation. Previous studies suggested that the occurrence of line defects in alternans play a critical role in the stabilizion of those undesirable patterns. However, this nonlinear phenomenon is still poorly understood. It remains to be elucidated, how nodal lines form, what their origin is, and how they stabilise. Here we show new insights in the stability of those by observing and analysing nodal line dynamics in spiral waves (in-vitro) and entrained high-frequency waves (ex-vivo).

DY 25.5 Tue 12:20 DYc

Effects of social distancing and isolation modeled via dynamical density functional theory* — •Michael te Vrugt, Jens Bickmann, and Raphael Wittkowski — Institut für Theoretische Physik, Center for Soft Nanoscience, Westfälische Wilhelms-Universität Münster, D-48149, Münster, Germany

For preventing the spread of epidemics such as the coronavirus disease COVID-19, social distancing and the isolation of infected persons are crucial. However, existing reaction-diffusion equations for epidemic spreading are incapable of describing these effects. In this talk, we present an extended model for disease spread based on combining a susceptible-infected-recovered model with a dynamical density functional theory where social distancing and isolation of infected persons are explicitly taken into account [1]. We show that the model exhibits interesting transient phase separation associated with a reduction of the number of infections, and provides new insights into the control of pandemics. An extension of the model [2] allows for an investigation of adaptive containment strategies. Here, a variety of phases with different numbers of shutdowns and deaths are found, an effect that is of crucial importance for public health policy.

[1] M. te Vrugt, J. Bickmann and R. Wittkowski, Nature Communications 11, 5576 (2020)

[2] M. te Vrugt, J. Bickmann and R. Wittkowski, arXiv:2010.00962 (2020)

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DY 25.6 Tue 12:40 DYc

Information spread enhanced by criticality in high-responsive groups of fish — •Luis Gómez Nava[1,3], Robert T. Lange[2,3], Pascal P. Klamser[1,2], Henning Sprekeler[2,3], and Pawel Romanczuk[1,3] — [1]Institute for Theoretical Biology, Philippstrasse 13, Humboldt University of Berlin, 10115 Berlin, Germany — [2]Bernstein Center for Computational Neuroscience, 10115 Berlin, Germany — [3]Science of Intelligence (SCIoI), Marchstrasse 23, Technical University of Berlin, 10587 Berlin, Germany

Collective dynamics in animal groups has been studied in recent years intensively. Recent works have suggested that such multi-agent systems should operate in a special parameter region, close to critical points. This is relevant because critical systems exhibit unique properties like maximal responsiveness to external stimuli and optimal propagation of information within the group. In our work, we study a high-density system of sulphur mollies in their natural habitat. We measure the surface activity of the fish and characterize their response to external fluctuations. This surface activity results to be similar to the one observed in critical systems (we observe power law-distributed observables, as well as separation of time scales of the activity). We model the system dynamics using cellular automata and we conclude that this natural system operates indeed in a special parameter region. We provide as well a biological interpretation of the characteristic features of such a critical system.