DY 17: Nonlinear Dynamics I

Time: Wednesday 10:15–13:15 Location: ZEU 255

Topical Talk DY 17.1 Wed 10:15 ZEU 255

Nonlinear Dynamics of Complex Hysteretic Systems — •Günter Radons — Institute for Physics, Chemnitz University of Technology, D-09107 Chemnitz.

Under the influence of external fields a large variety of materials and systems shows very complex hysteretic behavior. The latter means that in addition to major hysteresis loops, one finds many subloops or minor loops. Well-known examples range from the magnetization of magnetic materials and the deformation of shape memory alloys to capillary condensation in porous materials. Such a behavior is traditionally described by so-called hysteresis operators [1]. Correspondingly, the interaction of such hysteretic systems with its environment is naturally described by operator-differential equations. Despite its importance and its ubiquitous appearance, the dynamics resulting from such equations is not well understood.

In this talk I will review the working principles of the Preisach hysteresis operator and its applications. Subsequently recent results on dynamical systems with such hysteretic subsystems will be presented. They range from the appearance of 1/f-noise under simple input-output conditions [2] to the co-existence of infinitely many attractors for operator-difference equations or operator-differential equations describing e.g. the motion of an iron sphere in an inhomogeneous magnetic field.

[1] G. Bertotti, I.D. Mayergoyz (Eds.), The Science of Hysteresis, Vol. I-III, Elsevier, 2006. [2] G. Radons, Phys. Rev. Lett. 100, 240602 (2008), Phys. Rev E 77, 061133 (2008), Phys. Rev E 77, 061134 (2008).

DY 17.2 Wed 10:45 ZEU 255

Topological stability criteria for synchronized coupled systems of non-identical oscillators — •Anne-Ly Do[1], Stefano Boccaletti[2], and Thilo Gross[1] — [1]MPI for the Physics Complex Systems, Dresden, Germany — [2]CNR Istituto dei Sistemi Complessi, Sesto Fiorentino, Italy

Individual dynamical units that are coupled via an interaction network can synchronize spontaneously without central regulation. The propensity to synchronize depends on structural properties of the interaction network. The influence of certain network properties such as heterogeneity and diameter have extensively been studied, however sometimes with conflicting conclusions. This might indicate that beside global structural measures of the network also the actual local configuration plays a role that cannot be neglected. Here, we show that synchronization can only be achieved when the network obeys topological criteria that are independent of any statistical network measure. We analytically derive topological conditions for the stability of stationary and phase-locked states by constructing a graphical interpretation of Jacobi's signature criterion. Furthermore, we show that the proposed approach can be extended to an adaptive network version of the Kuramoto-model, in which the coupling topology co-evolves with the dynamics of the coupled units.

DY 17.3 Wed 11:00 ZEU 255

Nonlocal Generalized Models — •Christian Kuehn and Thilo Gross — MPI-PKS, Dresden

Generalized models have been applied successfully to understand the local dynamics of ordinary differential equations (ODEs) in equilibrium when the explicit functional forms of the ODE are only partially known. Hence the method is particularly successful in the context of biophysical problems. Generalized models allow us to draw conclusions about a large set of dynamical systems simultaneously using classical techniques from bifurcation analysis. In this talk, I will illustrate the mathematical and physical framework for generalized modeling and show that the method naturally applies to partial, stochastic and delay differential equations. Furthermore, a major extension to the analysis of periodic solutions will be introduced for ODEs. This new development marks the first step to a non-local dynamical analysis which is indispensable in many applications. The theory will be illustrated with a planar model system.

DY 17.4 Wed 11:15 ZEU 255

Boolean versus continuous dynamics on simple two-gene modules — •Eva Gehrmann and Barbara Drossel — Institut für Festkörperphysik, TU Darmstadt

We investigate the dynamical behavior of simple modules composed of two genes with two or three regulating connections. Continuous dynamics for mRNA and protein concentrations is compared to a Boolean model for gene activity. Using a generalized method, we study within a single framework different continuous models and different types of regulatory functions, and establish conditions under which the system can display stable oscillations. These conditions depend only on general features such as the ratio of the relevant time scales, the degree of cooperativity of the regulating interactions, and the logical structure of the interactions. Our results combine and generalize the findings of several disconnected previous studies.

DY 17.5 Wed 11:30 ZEU 255

Comparison of phase synchronization analysis methods in physiological data — •Anja Kuhnhold[1], Jan W. Kantelhardt[1], Aicko Y. Schumann[1,2], Axel Bauer[3], Petra Bartel[4], and Georg Schmidt[4] — [1]Institut für Physik, MLU Halle-Wittenberg, Halle (Saale), Germany — [2]Complexity Science Group, Dept. of Physics and Astronomy, Univ. of Calgary, Canada — [3]Med. Klinik, Abt. Kardiologie und Kreislauferkrankungen, Universitätsklinikum Tübingen, Germany — [4]1. Med. Klinik, Klinikum rechts der Isar, TU München, Germany

Phase synchronization between two weakly coupled oscillators occurs in many natural systems. Since it is difficult to unambiguously detect such synchronization in experimental data, several methods have been proposed for this purpose. Here, we systematically optimize and compare five approaches: the automated synchrogram method, the reduced synchrogram method, two variants of a very recently suggested gradient method, and the Fourier mode method. Studying real 24h data from 1455 patients recorded approximately one week after a myocardial infarction, real data with artificial inaccuracies, and corresponding surrogate data generated by Fourier phase randomization, we report characteristic differences as well as strengths and weaknesses of the five methods in detecting episodes of n:1 and n:2 cardio-respiratory phase synchronization. We also show that synchronization hardly depends on the patients' age in our large data base. However, a strong 24h cycle occurs with drastically increased n:1 and n:2 synchronization observed during night time by all five methods.

15 min. break.

DY 17.6 Wed 12:00 ZEU 255

Burst Event and Return Interval Statistics in Wikipedia Access and Edit Data — •Mirko Kämpf[1], Sebastian Tismer[1], Jan W. Kantelhardt[1], and Lev Muchnik[2] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, Halle/Saale, Germany — [2]Leonard N. Stern School of Business, New York University, USA

Internet-based social networks often reflect extreme events in nature and society by drastic increases in user activity. We study the dynamics of hourly user access and edit time series for articles in the online encyclopaedia Wikipedia. Daily and weekly activity patterns occur in addition to fluctuations and bursting activity. The bursts are characterised by a power-law distribution of durations of increases and decreases; both sides seem rather uncorrelated. For describing the reoccurrence and clustering of bursts exceeding certain thresholds we investigate the statistics of the return intervals between them. We find stretched exponential distributions of return intervals with identical parameters for all thresholds in access time series, while edit time series yield a simple exponential distribution. We apply detrended fluctuation analysis, finding that most article access time series are characterized by long-term correlations with fluctuation exponents $\alpha \approx 0.9$. Finally, we also analyse the cross-correlations between edits and access rates as well as multiple articles inside a subnet. The results help in understanding the complex process of collecting, processing, validating, and distributing information in self-organized social systems.

DY 17.7 Wed 12:15 ZEU 255

Pushing through the Arnold web: Hamiltonian ratchets in higher dimensions — •Armin Seibert, Sergey Denisov, and Peter Hänggi — Institute of Physics, University of Augsburg, Universitätsstr. 1, D-86135 Augsburg

In ac-driven, space-periodic Hamiltonian systems a ratchet effect [1] may occur: particles start to diffuse predominantly into one direction, producing constant flux, even when the driving field has a zero dc-component. This is a well-established phenomenon in the case of one-dimensional Hamiltonian transport, with experimental validations ranging from classical [2] to quantum [3] limits. Remarkably, two- and three - dimensional stationary transport is impossible {\it ab initio} in ac-driven Hamiltonian systems. The system can diffuse in its phase space - along resonance channels, which constitute the {\it Arnold web} [4], - so that even when the particle is initially placed at the bottom of a potential well, it can eventually be accelerated to any preassigned energy threshold. We demonstrate that although the ratchet current never saturates to an asymptotic value in the case of higher-dimensional Hamiltonian ratchets, the direction of the ratchet motion is fixed by the space-time symmetries of the underlying potentials, and can be predicted by using the symmetry analysis [5].

[1] P. Hänggi and F. Marchesoni, Rev. Mod. Phys. 81, 387 (2009) [2] M. Schiavoni et al., Phys. Rev. Lett. 90, 094101 (2003) [3] T. Salger et al., Science 326, 1241 (2009) [4] A. J. Lichtenberg and M. A. Lieberman, Regular and Chaotic Dynamics (New York, Springer-Verlag, 1992) [5] S. Denisov et al., Phys. Rev. Lett. 100, 224102 (2008)

DY 17.8 Wed 12:30 ZEU 255

Extractions of non-elliptic limit cycles from strong non-linear oscillations via the modified continuous wavelet transform — •Eugene Postnikov[1] and Elena Lebedeva[2] — [1]Kursk State University, Kursk, Russia — [2]St. Petersburg State Polytechnical University, St. Petersburg, Russia

Recently we have proposed the modification of the complex wavelet transform with the Morlet wavelet adapted for an analysis of strong non-linear oscillations [Phys. Rev. E 82, 057201 (2010)]. It has been shown that the rotation of transform modulus in a scale space allows to merge principal harmonics of non-sinusoidal oscillations into one line corresponding to the scale value coinciding with a main period.

The main goal of this presentation is to analyze the opportunity providing by this method to extract strongly non-elliptic instable limit cycles from chaotic signals. The following items are considered: restrictions, based on time-scale uncertainty, for the maximal number of loops extracted from a phase curve; correspondence between a global cascade of period-doubling bifurcations determined via the Fourier transform and a local loop decomposition based on the wavelet transform; the wavelet decomposition and bounding tori in a phase space.

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DY 17.9 Wed 12:45 ZEU 255

A technique for identifying chaos in many body systems from time series analysis — •Tarek Elsayed, Benjamin Hess, and Boris Fine — Institute of Theoretical Physics, Heidelberg, Germany

We report a new possible signature of chaos that can be easily extracted from a time series produced by physical systems having many degrees of freedom. This technique can be helpful when conventional entropic approaches fail to distinguish between chaotic and nonchaotic time series due to insufficient statistics. We apply this approach to signals generated by integrable and nonintegrable classical spin systems and support our results by Lyapunov and power spectrum spectral analysis.

DY 17.10 Wed 13:00 ZEU 255

Properties of multi-particle correlation measures in complex systems — •Tobias Galla[1] and Otfried Gühne[2] — [1]School of Physics and Astronomy, University of Manchester, Manchester M13 9Pl, UK — [2]Fachbereich Physik, Universität Siegen, Walter-Flex-Strasse 3, 57068 Siegen

The characterisation of multi-particle correlations in classical complex systems is a non-trivial task, several quantative measures have been proposed and investigated. Some of these approaches are based on ideas from information geometry, and classify the invariant measures of dynamical systems according to their distance from the space of probability distributions generated by k-particle interactions. These methods have for example been applied to coupled chaotic maps and cellular automata. Motivated by recent findings in quantum information we investigate the extent to which these quantities fulfill desirable properties of correlation measures. For example local transformations applied to individual particles or integrating out individual degrees of freedom should not increase overall multi-particle correlation. However for some current correlation measures such behaviour is found. We discuss possible remedies for this problem.