DY 21: Nonlinear dynamics, synchronization and chaos III

Time: Wednesday 16:45–18:00 Location: MA 001

DY 21.1 Wed 16:45 MA 001

Soliton ratchets in inhomogeneous sine-Gordon systems — •Vera Stehr, Patric Müller, and Franz G. Mertens — Physikalisches Institut, Universität Bayreuth, 95440 Bayreuth

In recent years the particle ratchet effect has been generalised to extended systems where solitons play the role of particles. Unidirectional motion of solitons can take place although the applied force $f(t)$ has zero average in time. In this talk we consider a damped and driven sine-Gordon-system with an additive inhomogeneity: $\phi_{tt} - \phi_{xx} + \sin\phi = -\beta\phi_t + f(t) + g(x)$. The periodically repeated function $g(x)$ consists of positive and negative boxes with zero spatial average. This inhomogeneity causes the spatial asymmetry which allows for the ratchet effect. We examine the ratchet transport in this system using a collective coordinate approach and analyse the influence of different collective coordinates on the dynamics of the soliton. The results are fully confirmed by simulations.

DY 21.2 Wed 17:00 MA 001

Absolute negative resistance in Josephson junctions — •Joachim Nagel[1], Tobias Gaber[1], David Speer[2], Ralf Eichhorn[2], Peter Reimann[2], Reinhold Kleiner[1], and Dieter Koelle[1] — [1]Universität Tübingen, Physikalisches Institut – Experimentalpysik II — [2]Universität Bielefeld, Fakultät für Physik

It has been predicted [1,2] that an underdamped Brownian particle, moving in a periodic 1D potential under the influence of both, a dc and ac driving force, can show absolute negative mobility (ANM), i. e., the particle moves opposite to the dc drive. Here, we present the experimental realization of this effect, using underdamped $Nb - AlO_x - Nb$ Josephson junctions, irradiated with microwaves up to $\sim 40\,\mathrm{GHz}$. In this system, described by the resistively and capacitively shunted junction model, the particle coordinate, its average velocity and the driving forces correspond to the Josephson phase, a dc voltage V, and applied dc and ac currents, respectively. Measuring the dc $I - V$ curves at 4.2 K, we demonstrate the appearance of ANM, or in our system, of absolute negative resistance (ANR) and determine its dependence on amplitude and frequency of the ac drive. As pointed out in [1], there are two basically different physical mechanism giving rise to ANM: one is governed by transient chaos [1], while the other essentially amounts to a noise induced effect [2]. Comparison of the experimental data with numerical simulations shows very good agreement and implies that the basic physical mechanism from [1] is at work in the present system.

[1] Speer *et al.*, Europhys. Lett. **79**, 10005; Phys. Rev. E **76**, 051110 (2007). [2] L. Machura *et al.*, Phys. Rev. Lett. **98**, 040601 (2007).

DY 21.3 Wed 17:15 MA 001

Analysing sliding and depinning drops using efficient time-integration and path-following — •Philippe Beltrame[1,2], Peter Talkner[2], Peter Haenggi[2], and Uwe Thiele[1,3] — [1]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Strasse 38, D-01187 Dresden — [2]Theoretische Physik I, Uni. Augsburg, Universitätsstr. 1, D-86159 Augsburg — [3]School of Math., Loughborough University, Loughborough, LE11 3TU, UK

Pattern formation in thin liquid films represents a highly nonlinear phenomenon far from equilibrium. Its study requires a numerical treatment of the fully nonlinear system allowing for time integration of the dynamics and path-following to directly track equilibria. We present a code unifying both tasks for lubrication-type equations in analogy to a similar approach for the Navier-Stokes equations. We show that time-stepping based on an *exponentiation propagation* scheme is much better adapted to the lubrication equation than the classically used semi-implicit scheme, especially for the automatic adaptation of the timestep. The developed common numerical framework is applied to the three-dimensional phenomena of (1) Stable sliding drops on an inclined homogeneous substrate and the transition to sliding drops that emit secondary droplets (time integration); (2) Depinning scenarios and stick-slip motion of ridges and drops on a heteregeneous (striped) substrate (path-following and time-integration).

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DY 21.4 Wed 17:30 MA 001

Measuring interaction complexity — Thomas Kahle, •Eckehard Olbrich, Nihat Ay, and Jürgen Jost — Max Planck Institute for Mathematics in the Sciences, Leipzig, Germany

We introduce a new vector valued complexity measure, which we will call interaction complexity, whose components quantify the complexity in terms of k-th order statistical dependencies that cannot be explained by interactions between $k - 1$ units. Formally the measure $I := (I_1, \ldots, I_N)$ is defined in terms of Kullback-Leibler distances to exponential families of k-interactions for $k = 1, ..., N$. By applying this measure on probability distributions generated by dynamical systems such as coupled map lattices and cellular automata, we demonstrate that these measure allows a refined analysis of complex dynamical regimes. We discuss possible applications for biological data, such as genomic sequences or multielectrode recordings in neural systems.

DY 21.5 Wed 17:45 MA 001

Multivariate Phase Rectified Signal Averaging - A tool for studying complex interrelated time series — •Aicko Y. Schumann, Jan W. Kantelhardt, and Fabian Gans — Institut für Physik Theorie, Martin-Luther University Halle-Wittenberg

Many natural systems generate periodicities on different time scales because some of their components form closed regulation loops in addition to causal linear control chains, e.g., cardio-respiratory rhythms in physiology or the El-Niño phenomenon in geophysics. In most cases non-stationary and noisy data from several simultaneously recorded signals is available for a multivariate analysis. In order to understand the underlying control chains and loops an time series analysis tool capable of identifying periodicities and the direction of causal relations in the presence of non-stationarities and noise is needed. In a previous work [1,2,3] we have therefor introduced the (monovariate) phase-rectified signal averaging technique (PRSA), which can distinguish effects caused by acceleration and deceleration of a signal in the signal itself. Further developing this approach for the study of two related signals, we propose the multivariate-PRSA method (MPRSA), which is capable of detecting and quantifying related quasi-periodic oscillations as well as causal interrelations in two signals masked by non-stationarities and noise.

[1] Bauer, A. et. al. Physica A, 2006,**364**, 423–434
[2] Bauer, A. et. al. The Lancet, 2006 **367**, 1674
[3] Kantelhardt, J.W. et. al. CHAOS, 2007 **17**(1), 015112