DY 34: Nonlinear Dynamics, Synchronization and Chaos - Part II

Time: Wednesday 15:00–16:15 Location: BH-N 128

DY 34.1 Wed 15:00 BH-N 128

Unusually simple way to create spiral wave in an excitable medium — •Vladimir Zykov, Alexei Krechov, and Eberhard Bodenschatz — Max-Plank-Institute for Dynamics and Selforganization, Goettingen, Germany

It is demonstrated that a spiral wave can be easy created in a nonuniform excitable media where a wave break is due to sufficiently strong jumps in the diffusion coefficient. Our analytical and numerical results indicate that in a one-dimensional medium such a inhomogeneity can result in a unidirectional propagation block. It is also illustrated how this phenomenon can be used to create spiral wave in a two-dimensional medium with a specific size and geometry of the inhomogeneity. It is important to stress that following this way the spiral wave is created simply after a single excitation stimulus while others known methods need at least two stimuli.

DY 34.2 Wed 15:15 BH-N 128

Entraining and eliminating spiral waves in excitable media by secondary excitations — •T K Shajahan, Sebastian Berg, and Stefan Luther — Max Planck Institute for Dynamics and Self Organization, Am Fassberg, Göttinegn, Germany

Excitable media comprises of a wide variety of physical, chemical, and biological systems made of coupled networks of excitable elements. Heart is an example of an excitable medium; the individual cardiac myocytes have a characteristic response, the action potential, to an external stimulus. Such excitations in a two-dimensional medium can form traveling wave patterns including spiral waves and target waves. These patterns in a physiological system have implications for the healthy functioning of the system. For example, spiral waves of cardiac excitation waves in the heart can override the natural rhythm of the heart and lead to cardiac arrhythmias. We study control and elimination of spiral waves using secondary excitations in monolayers of cultured cardiac cells. Free spiral waves can be eliminated with a local electrode by stimulating the medium at a higher frequency than the spiral. But this method fails if the spiral is pinned to tissue heterogeneities. A pinned spiral wave can be controlled by electric field stimulus. Our theoretical and experimental studies indicate that periodic field stimuli at a frequency lower than the spiral frequency is more efficient to eliminate pinned spiral waves. I will discuss the implications of this result for low energy defibrillation.

DY 34.3 Wed 15:30 BH-N 128

Exact linearization of nonlinear optimal trajectory tracking problems — •Jakob Löber — Institut für Theoretische Physik, TU Berlin

We consider the task of forcing a phase space trajectory of an affine dynamical system as closely as possible along a desired trajectory. Using the regularization parameter of an appropriately formulated optimal control problem as the small parameter, we develop a perturbation approach which allows to interpret a singular optimal control problem as a singularly perturbed system of ODEs. Surprisingly, for a certain class of nonlinear control systems as e.g. one-dimensional mechanical systems, the perturbative treatment of this ODE reduces to exclusively linear equations. The nonlinearity is eaten by the control while the solution for the controlled trajectories, being independent of the nonlinearity, is universal for the control system at hand.

DY 34.4 Wed 15:45 BH-N 128

Route to chaos in optomechanics — Lutz Bakemeier, •Andreas Alvermann, and Holger Fehske — Institut für Physik, Ernst-Moritz-Arndt-Universität, Felix-Hausdorff-Str. 6, 17487 Greifswald

We establish the emergence of chaotic motion in optomechanical systems. Chaos appears at negative detuning for experimentally accessible values of the pump power and other system parameters. We describe the sequence of period doubling bifurcations that leads to chaos, and state the experimentally observable signatures in the optical spectrum. In addition to the semi-classical dynamics we analyze the possibility of chaotic motion in the quantum regime. We find that quantum mechanics protects the optomechanical system against irregular dynamics, such that simple periodic orbits reappear and replace the classically chaotic motion. In this way observation of the dynamical signatures makes it possible to pin down the crossover from quantum to classical mechanics.

DY 34.5 Wed 16:00 BH-N 128

Quantum synchronization of driven self-sustained oscillators — •Christoph Bruder[1], Andreas Nunnenkamp[1,2], and Stefan Walter[1,3] — [1]Department of Physics, University of Basel, Klingelbergstr. 82, CH-4056 Basel — [2]Cavendish Laboratory, J J Thomson Avenue, Cambridge CB3 0HE — [3]Institute for Theoretical Physics, Universität Erlangen-Nürnberg, Staudtstr. 7, D-91058 Erlangen

Synchronization is a universal phenomenon that is important both in fundamental studies and in technical applications. Here we study synchronization of two dissipatively coupled Van der Pol oscillators in the quantum regime and analyze synchronization in terms of frequency entrainment and frequency locking [1]. Due to quantum noise strict frequency locking is absent and is replaced by a crossover from weak to strong frequency entrainment. The differences to the behavior of one quantum Van der Pol oscillator subject to an external drive [2] are discussed. Moreover, a possible experimental realization of two coupled quantum Van der Pol oscillators in an optomechanical setting is described.

[1] S. Walter, A. Nunnenkamp, and C. Bruder, Ann. Phys. DOI: 10.1002/andp.201400144 (2014)

[2] S. Walter, A. Nunnenkamp, and C. Bruder, Phys. Rev. Lett. 112, 094102 (2014)