DY 6: Nonlinear Dynamics, Synchronization and Chaos

Time: Monday 10:00–11:15 Location: ZEU 147

DY 6.1 Mon 10:00 ZEU 147

Estimating Lyapunov exponents in billiards — George Datseris[1,2], •Lukas Hupe[1,2], and Ragnar Fleischmann[1,2] — [1]Max Planck Institute for Dynamics and Self-Organization, Am Fassberg 17, 37077 Göttingen — [2]Faculty of Physics, Georg-August-Universität Göttingen, 37077, Göttingen, Germany

Dynamical billiards are paradigmatic examples of chaotic Hamiltonian dynamical systems with widespread applications in physics. We study how well their Lyapunov exponent, characterizing the chaotic dynamics, and its dependence on external parameters can be estimated from phase space volume arguments, with emphasis on billiards with mixed regular and chaotic phase spaces. We show that in the very diverse billiards considered here the leading contribution to the Lyapunov exponent is inversely proportional to the chaotic phase space volume, and subsequently discuss the generality of this relationship. We also extend the well established formalism by Dellago, Posch, and Hoover to calculate the Lyapunov exponents of billiards to include external magnetic fields and provide a software implementation of it.

DY 6.2 Mon 10:15 ZEU 147

Dynamics of discrete light bullets in passively mode-locked semiconductor lasers — •Thomas Seidel[1], Julien Javaloyes[2], and Svetlana Gurevich[1,3] — [1]Institute for Theoretical Physics, University of Münster, Wilhelm-Klemm-Straße 9, 48149 Münster, Germany — [2]Departament de Física, Universitat de les Illes Balears, Carretera Valldemossa km 7.5, 07122 Palma, Spain — [3]Center for Nonlinear Science (CeNoS), University of Münster, Corrensstraße 2, 48149 Münster, Germany

We study the emergence and stability of discrete light bullets in the output of a passively mode-locked semiconductor laser array coupled to a distant saturable absorber. Fist, we investigate the dynamics of the tranverse field which can be modeled by a discretised version of the generalised Rosanov equation and next, we also include the longitudinal direction and thus, show the existence of three-dimensional dissipative localized structures with one discrete (transverse) and two continuous (longitudinal) directions. In both situations, we find the presence of multistability between solution branches consisting of different numbers of lasing lasers by numerical time integration. For the transverse case, a detailed bifurcation analysis by means of path continuation was conducted in order to study the transition between different solution branches.

DY 6.3 Mon 10:30 ZEU 147

Laminar Chaos in Experiments: Nonlinear Systems with Time-Varying Delays and Noise — Joseph D. Hart[1,2], Rajarshi Roy[1,2,3], •David Müller-Bender[4], Andreas Otto[4], and Günter Radons[4] — [1]Institute for Research in Electronics and Applied Physics, University of Maryland, College Park, Maryland 20742, USA — [2]Department of Physics, University of Maryland, College Park, Maryland 20742, USA — [3]Institute for Physical Science and Technology, University of Maryland, College Park, Maryland 20742, USA — [4]Institute of Physics, Chemnitz University of Technology, 09107 Chemnitz, Germany

A new type of dynamics called laminar chaos was discovered theoretically in scalar systems with time-varying delay [1]. It is a low-dimensional dynamics characterized by laminar phases of nearly constant intensity with periodic durations and a chaotic variation of the intensity from phase to phase. This is in contrast to the typically observed higher-dimensional turbulent chaos, which is characterized by strong fluctuations. In our present work [2] we provide the first experimental observation of laminar chaos by studying an optoelectronic setup. The noise inherent in the experiment requires the development of a nonlinear Langevin equation with variable delay. We show that laminar chaos can be observed in higher-order systems, and that it is robust to noise and a digital implementation of the variable time delay.

[1] Müller, Otto, and Radons, Phys. Rev. Lett. 120, 084102 (2018).
[2] Hart, Roy, Müller-Bender, Otto, and Radons, Phys. Rev. Lett. 123, 154101 (2019).

DY 6.4 Mon 10:45 ZEU 147

Synchronization and Frequency Pulling in Mutually Coupled Mode-Locked Lasers — •Clara R. Roca-Sastre, Jakob Eberhardt, Stefan Meinecke, and Kathy Lüdge — Institut für Theoretische Physik, Technische Universität Berlin, Berlin, Germany

Monolithic passively mode-locked semiconductors lasers (PMLLs) are simple and compact sources of high-frequency ultra-short light pulses. These devices can be utilized in novel secure communication schemes or optical clock synchronization. However, due to the absence of an external reference clock, this class of MLLs exhibits higher timing jitter than their active counterparts [1]. In order to overcome this detrimental effect, a mutual all-optical coupling can be introduced to reduce the timing jitter. This technique also gives access to different synchronization regimes of the laser outputs. In pursuance of a better understanding of the synchronization regime, we model numerically a coupled system by using delay differential equations [3]. For the mutual coupling of two non-identical lasers, frequency pulling in addition to a wide range of interesting dynamics can be found. At delay times around half of the cold cavity roundtrip time and in an intermediate feedback strength regime, regions of leap frogging arise where the lasers show an effective doubling of the pulse repetition rate, emitting pulses alternately at the fundamental repetition frequency.

[1] Otto et al., New J. Phys. 14, 113033 (2012).
[2] Simos et al., IEEE JQE 54, 2001106 (2018)
[3] Vladimirov et al., Phys. Rev. A 72, 3, 033808 (2005).

DY 6.5 Mon 11:00 ZEU 147

Dimensional Reduction in Coupled Heteroclinic Cycles — •Maximilian Voit and Hildegard Meyer-Ortmanns — Jacobs University Bremen, Bremen, Deutschland

Modeling complex systems as networks has recently received much attention, as real world systems usually consist of many coupled units. The dynamics of such coupled systems generically differs from the individual dynamics of single units and collective effects are in the focus of interest. Although heteroclinic cycles emerge robustly in various scenarios (e.g. in population dynamics, fluid dynamics, or game theory), systems of coupled heteroclinic cycles have not been extensively studied up to now. Here, we present results on small networks of coupled heteroclinic systems. In spite of their simple structure, they exhibit rich dynamics. Different kinds of dimensional reduction are identified, most prominently generalized synchronization. In addition, we investigate the arising chaotic transients and their scaling behaviour.