DY 15: Delay and Feedback Dynamics

Time: Tuesday 9:30–10:30 Location: H19

DY 15.1 Tue 9:30 H19

Emergence of collective motion in two-dimensional colloidal systems with delayed feedback — •Robin A. Kopp and Sabine H. L. Klapp — ITP, TU Berlin, Berlin, Germany

In recent years, delayed feedback in colloidal systems has become an active and promising field of study [1], key topics being history dependence and the manipulation of transport properties. Here we study the dynamics of a two-dimensional colloidal suspension, subject to time-delayed feedback. To this end we perform overdamped Brownian dynamics simulations, where the particles interact through a Weeks-Chandler-Andersen potential. Furthermore, each particle is subject to a Gaussian, repulsive feedback potential, that depends on the difference of the particle position at the current time, and at an earlier time. We observe and quantitatively study the emergence of collective motion characterized by a nonzero mean velocity and provide a possible explanation combining single-particle and mean-field-like effects. Studying the corresponding one-particle system we obtain an understanding of the history dependence and the long-time behavior, in particular a nonzero stationary constant velocity state of the deterministic problem that translates to a constant average velocity magnitude in the stochastic system. By studying the mean square displacement we are able to point out how delayed feedback affects diffusion in the one-particle and the interacting system differently.

[1] S. A. M. Loos, S. Hermann, and S. H. L. Klapp, Entropy **23**, 696 (2021)

DY 15.2 Tue 9:45 H19

The role of the polarization dephasing time for stabilizing coupled nanolasers — •Aycke Roos[1], Stefan Meinecke[1], and Kathy Lüdge[2] — [1]Technische Universität Berlin - Institut für Theoretische Physik, Hardenbergstraße 36, 10623 Berlin — [2]Technische Universität Ilmenau - Institut für Physik, Fachgebiet Theoretische Physik 2, 98684 Ilmenau

As a prototypical model for on-chip laser networks, mutually coupled nanolasers attract attention in laser physics and dynamics. In the regime of small cavity lifetimes the carrier polarization essentially influences the dynamics of such lasers. We investigate the emission dynamics of two coupled lasers, modeled by Maxwell-Bloch type laser equations (class-C laser), and predict ways to optimize their stability, i.e., maximize their locking range. We find that tuning the cavity lifetime to the same order of magnitude as the dephasing time of the microscopic polarization yields optimal operation conditions, which allow for wider tuning ranges than usually observed in conventional semiconductor lasers. We present the steady state solutions and numerically characterize the emission dynamics via the underlying bifurcation structure. The dephasing time is found to be a crucial parameter, which impacts the observed dynamics in the parameter space spanned by frequency detuning, coupling strength and coupling phase.

DY 15.3 Tue 10:00 H19

Frequency combs and localized states in time-delayed Kerr-Gires-Tournois interferometers — •Thomas G. Seidel[1,2], Julien Javaloyes[2], and Svetlana V. Gurevich[1,2] — [1]Institute for Theoretical Physics & Center for Nonlinear Science (CeNoS), University of Münster, Schlossplatz 2, 48149 Münster, Germany — [2]Dpt. de Física, Universitat de les Illes Balears & IAC-3, Campus UIB, E-07122 Palma de Mallorca, Spain

We study theoretically the formation of phase-locked temporal localized states (TLSs) and frequency combs. Our system consists in an optically injected Fabry-Perot micro-cavity containing a Kerr medium that is coupled to an external cavity. Using a first-principles model based on delay algebraic equations (DAEs) and applying a combination of direct numerical simulations and path continuation methods, we disclose sets of multistable dark and bright TLSs coexisting on their respective bistable homogeneous backgrounds. We show that the detuning of the injection with respect to the micro-cavity resonance controls the region of existence of TLSs and its change can lead to a period-doubling route to chaos. Understanding the influence of the system parameters on physical mechanisms such as group delay dispersion and third order dispersion do not appear so obvious in the DAE model. Therefore, we transform the DAE into a real order parameter equation by using a rigorous multiple time scale analysis applied at the onset of bistability. The normal form given by a real Ginzburg-Landau equation and the full DAE model exhibit excellent quantitative agreement in both one- and two-parameter bifurcation diagrams.

DY 15.4 Tue 10:15 H19

Dynamics of square waves in a vertical external-cavity delayed Kerr-Gires-Tournois interferometer — •Elias R. Koch[1], Thomas G. Seidel[1,2], Julien Javaloyes[2], and Svetlana V. Gurevich[1,2] — [1]Institute for Theoretical Physics & Center for Nonlinear Science (CeNoS), University of Münster, Schlossplatz 2, 48149 Münster, Germany — [2]Dpt. de Física, Universitat de les Illes Balears & IAC-3, Campus UIB, E-07122 Palma de Mallorca, Spain

We study theoretically the mechanisms of square wave (SW) formation in a monomode micro-cavity, containing a nonlinear Kerr medium coupled to a long external feedback cavity under continuous wave injection. Employing a first-principle delay-algebraic equation (DAE) model in the long delay limit, we provide a simple analytical approximation of the SW's plateau intensities and the bifurcation points limiting the range of existence of the SWs. Using a combination of path-continuation techniques and direct numerical simulations, we show that depending on the system parameters SWs can exhibit homoclinic snaking leading to the formation of complex-shaped multistable SW solutions. Beyond that, more complex SW dynamics can be identified, including a period doubling route to chaos. The results obtained from the full DAE model and the simple analytical approximation are in excellent agreement. Furthermore, we demonstrate that SWs can be used as a platform to host other structures and we show that robust multiple bound states consisting of localized pulses can be formed on the SW plateaus.