DY 19: Complex Systems

Time: Tuesday 11:45–13:00 Location: H6

DY 19.1 Tue 11:45 H6

Nodal modeling of a Vuilleumier refrigerator — •Raphael Paul, Abdellah Khodja, and Karl Heinz Hoffmann — Technische Universität Chemnitz, Institut für Physik, 09107 Chemnitz, Germany

Conventional cooling units of light and medium duty refrigerator trucks are commonly powered via the truck's electrical system, or by an auxiliary combustion engine. This raises the vehicle's overall fuel consumption and pollutant emissions. An innovative, sustainable approach to attenuate these disadvantages is to use a specially designed Vuilleumier refrigerator for mobile waste heat recovery. The aim is harnessing the residual exergy of the truck engine's exhaust gas for cargo cooling. In this contribution, a nodal simulation model is presented, which can be used for design optimization of a respective Vuilleumier refrigerator. The model is predicated on the concept of endoreversible thermodynamics. The bulk of the Vuilleumier machine is decomposed into a network of reversible subsystems with irreversible interactions. The formulation of conservation laws and interactions is based on fluxes of heat, mass, and enthalpy. The regenerators, however, are treated using a finite volume approach with central flux scheme. For an exemplary set of design parameters and operational conditions, preliminary simulation results and accordingly predictions for refrigerator performance measures are presented.

DY 19.2 Tue 12:00 H6

Perturbation characteristics of power grid models under stochastic power input — •Matthias Wolff, Pedro Lind, and Philipp Maass — Universität Osnabrück, Barbarastraße 7, 49076 Osnabrück

A higher percentage of electrical power provided by renewable energy sources is accompanied by increasing fluctuations in the power generation. This can have a negative effect on the frequency stability on different time scales ranging from sub-seconds to seasons. There are already studies that address the impact of these fluctuations on short time scales [1,2] as well as in the steady state limit [3].

We provide an extension of these studies by comparing different power grid realizations under a perturbation of the frequency and the power injection. The fluctuating power input is estimated from transforming wind velocities measured at a research platform located in the north sea (FINO1). Our stability analysis includes different treatments of the consumers, different voltage levels, as well as structural properties like internal nodes and the related Kron reduction.

It is shown that the results vary strongly, depending on the modeling level of the grid [4]. Not only the stability assessment can change but also the location of weak spots in the grid.

[1] S. Auer *et al.*, Chaos **27**, 127003 (2017).
[2] K. Schmietendorf *et al.*, Eur. Phys. J. B **90**, 222 (2017)
[3] C. Schiel *et al.*, Sci. Rep. **7**, 11562 (2017)
[4] M. F. Wolff *et al.*, Chaos **28**, 103120 (2018).

DY 19.3 Tue 12:15 H6

WKB-type-of approximation for probabilistic description of rare events in reaction systems — •Andreas Mühlbacher and Thomas Guhr — Fakultät für Physik, Universität Duisburg-Essen

We calculate the probabilities to find systems of reacting particles in states which largely deviate from typical behavior. The rare event statistics is obtained from the master equation which describes the dynamics of the probability distribution of the particle number. We transform the master equation by means of a generating function into a time-dependent "Schrödinger equation". Its solution is provided by a separation ansatz and a WKB-approximation for the stationary part. The classical equations of motions are formulated. We calcutate the probabilities employing a saddle-point approximation. Hereby, we switch from a deterministic to a probabilistic description which has important repercussions on the system dynamics. We present a method to calculate the rare event statistics for systems where the dynamics cannot be entirely analyzed in an analytical manner. The method is applied to a set of different examples.

DY 19.4 Tue 12:30 H6

Contracting projected entangled pair states is average-case hard — •Jonas Haferkamp, Dominik Hangleiter, Jens Eisert, and Marek Gluza — Dahlem Center for Complex Quantum Systems, Freie Universität Berlin, 14195 Berlin, Germany

An accurate calculation of the properties of quantum many-body systems is one of the most important yet intricate challenges of modern physics and computer science. In recent years, the tensor network ansatz has established itself as one of the most promising approaches. In higher dimensions, however, a connection to the field of computational complexity theory has shown that the accurate normalization of the two-dimensional tensor networks called projected entangled pair states (PEPS) is #P complete. Therefore, an efficient algorithm for PEPS contraction would allow to solve exceedingly difficult combinatorial counting problems, which is considered highly unlikely. Due to the importance of understanding two- and three-dimensional systems the question currently remains: Are the known constructions typical of states relevant for quantum many-body systems? In this work, we show that an accurate evaluation of normalization or expectation values of PEPS is as hard to compute for typical instances as for special configurations of highest computational hardness.

DY 19.5 Tue 12:45 H6

Laminar chaos in nonlinear delayed Langevin equations — •David Müller, Andreas Otto, and Günter Radons — Institute of Physics, Chemnitz University of Technology, 09107 Chemnitz, Germany

Due to environmental fluctuations, delays in nature are typically not constant but rather time-varying. Time-varying delays can be divided into different classes, which lead to different types of dynamics in the delay system [1,2]. Laminar chaos, for example, is a recently discovered type of chaotic dynamics, which arises in systems with a so-called *dissipative delay* [3]. It is characterized by nearly constant laminar phases, which are periodically interrupted by burst-like transitions. The intensity levels of these phases are connected by an iterated map, which can be derived from to the nonlinearity of the delay equation.

In this talk, we analyze laminar chaotic dynamics in the presence of noise. We derive robust features of laminar chaos, which persist even for relatively large noise strengths, where it is difficult to classify the time-series visually as laminar chaos. These features are exploited to provide a toolbox for the detection and the analysis of laminar chaos in experimental time-series, where noise is always present. We demonstrate that the nonlinearity of the delay equation and certain properties of the time-varying delay can be reconstructed easily, even for relatively strong noise.

[1] Otto, Müller, and Radons, Phys. Rev. Lett. 118, 044104 (2017).
[2] Müller, Otto, and Radons, Phys. Rev. E 95, 062214 (2017).
[3] Müller, Otto, and Radons, Phys. Rev. Lett. 120, 084102 (2018).