DY 3: Nonlinear dynamics, synchronization and chaos I

Time: Monday 11:00–13:00 Location: ZEU 118

DY 3.1 Mon 11:00 ZEU 118

Loading the Dice — •Jan Nagler[1] and Peter H. Richter[2] — [1]MPI DS, Göttingen & Georg-August-Univ. Göttingen, Germany — [2]Universität Bremen, Germany

Dice tossing is commonly believed to be random. However, throwing a fair cube is a dissipative process well described by deterministic classic mechanics. In [Phys. Rev. E 78, 036207 (2008); see also Research Highlights, Nature 455, p. 434 (2008)] we proposed a simplified model in order to analyze the origin of the pseudorandomness: A barbell with two marked masses at its tips with only two final outcomes. In order to keep things simple, we focused on the symmetrical case of equal masses. Here, we complete the picture by considering the general asymmetric case of unequal masses. We show how, depending on initial conditions, dissipation during bounces, and mass asymmetry, the degree of unpredictability varies. Our analysis reveals for our dice throwing model the effect of dice loading.

DY 3.2 Mon 11:15 ZEU 118

Floquet stability analysis of Ott-Grebogi-Yorke and difference control — •Jens Christian Claussen — Neuro-und Bioinformatik, U zu Lübeck — Theoret. Phys. & Astrophys., CAU Kiel

For stabilization of instable periodic orbits of nonlinear dynamical systems two classes of methods exist: time-continuous control schemes based on Pyragas, and the two Poincaré-based chaos control schemes, Ott-Grebogi-Yorke (OGY) and difference control. Difference control [1] is a control scheme that is especially interesting for drifting parameter conditions [2]. In this contribution [3] a new stability analysis of these two Poincaré-based chaos control schemes is given by means of the Floquet theory. This approach allows to calculate exactly the stability restrictions occurring for small measurement delays and for an impulse length shorter than the length of the orbit. This is of practical experimental relevance; to avoid a selection of the relative impulse length by trial and error, it is advised to investigate whether the used control scheme itself shows systematic limitations on the choice of the impulse length. To investigate this point, a Floquet analysis is performed [3]. For OGY control the influence of the impulse length is marginal. As an unexpected result, difference control fails when the impulse length is taken longer than a maximal value that is approximately one half of the orbit length for small Ljapunov numbers and decreases with the Ljapunov number [3].

[1] S Bielawski D Derozier P Glorieux, Phys. Rev. A 47, 2492 (1993)
[2] JC Claussen T Mausbach A Piel HG Schuster, PRE 58, 7256 (1998)
[3] JC Claussen New Journal of Physics 10, 063006 (2008).

DY 3.3 Mon 11:30 ZEU 118

Evolutionary phase space and its impact on Fermi acceleration in the driven elliptical billiard — •Florian Lenz[1], Christoph Petri[1], Florian N. R. Koch[1], Fotis K. Diakonos[2], and Peter Schmelcher[1,3] — [1]Physikalisches Institut, Universität Heidelberg, Philosophenweg 12, 69120 Heidelberg, Germany — [2]Department of Physics, University of Athens, GR-15771 Athens, Greece — [3]Theoretische Chemie, Physikalisch-Chemisches Institut, Universität Heidelberg, Im Neuenheimer Feld 229, 69120 Heidelberg, Germany

We perform the first long-time exploration of the classical dynamics of a driven billiard with a four dimensional phase space. The latter is shown to evolve with increasing velocity of the ensemble from a large chaotic sea with a rich structures of stickiness due to regular islands to a phase space consisting of thin velocity channels of diffusive motion that allow for acceleration and are bounded in the three remaining dimensions by large regular regions. As a surprising consequence, we encounter a crossover from amplitude dependent tunable subdiffusion to universal normal diffusion in momentum space. This crossover is traced back to the mentioned change of the structural composition of phase space with varying velocity. Since with increasing collision number an ensemble of particles accelerates, it effectively “sees” an evolutionary phase space which we analyze and understand in depth.

DY 3.4 Mon 11:45 ZEU 118

Compactons in Strongly Nonlinear Lattices — •Karsten Ahnert and Arkady Pikovsky — Universität Potsdam, Institut für Physik und Astronomie, Karl-Liebknecht-Strasse 24/25, 14476 Potsdam-Golm, Germany

We study localized traveling waves and chaotic states in strongly nonlinear one-dimensional Hamiltonian lattices. A specific realization of such a system might be the Hertz lattice that describes elastically interacting hard balls. We show that the solitary waves are strongly localized compactons, and present an accurate numerical method allowing to find them for an arbitrary nonlinearity index. Compactons evolve fromrather general initially localized perturbations and collide nearly elastically, nevertheless on a long time scale for finite lattices an extensive chaotic state is generally observed.

DY 3.5 Mon 12:00 ZEU 118

Spreading of wavepackets in one dimensional disordered chains - I. Different dynamical regimes — •Charalampos Skokos, Sergej Flach, and Dmitry Krimer — Max Planck Institute for the Physics of Complex Systems, Nothnitzer Str. 38, D-01187 Dresden, Germany

We present numerical results for the spatiotemporal evolution of a wavepacket in quartic Klein-Gordon (KG) and disordered nonlinear Schrödinger (DNLS) chains, having equivalent linear parts. In the absence of nonlinearity all eigenstates are spatially localized with an upper bound on the localization length (Anderson localization). In the presence of nonlinearity we find three different dynamical behaviors depending on the relation of the nonlinear frequency shift δ (which is proportional to the system's nonlinearity) with the average spacing $\overline{\Delta\lambda}$ of eigenfrequencies and the spectrum width Δ ($\overline{\Delta\lambda} < \Delta$) of the linear system. The dynamics for small nonlinearities ($\delta < \overline{\Delta\lambda}$) is characterized by localization as a transient, with subsequent subdiffusion (regime I). For intermediate values of the nonlinearity, such that $\overline{\Delta\lambda} < \delta < \Delta$ the wavepackets exhibit immediate subdiffusion (regime II). In this case, the second moment m_2 and the participation number P increase in time following the power laws $m_2 \sim t^{\alpha}$, $P \sim t^{\alpha/2}$. We find $\alpha = 1/3$. Finally, for even higher nonlinearities ($\delta > \Delta$) a large part of the wavepacket is selftrapped, while the rest subdiffuses (regime III). In this case P remains practically constant, while $m_2 \sim t^{\alpha}$.

DY 3.6 Mon 12:15 ZEU 118

Spreading of wavepackets in one dimensional disordered chains- II. Spreading mechanisms — •Dmitry Krimer, Sergej Flach, and Charalampos Skokos — Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Str. 38, D-01187 Dresden, Germany

As is discussed in the first part of this presentation, there are three different types of the evolution of a wavepacket in discrete disordered nonlinear Schrödinger and anharmonic oscillator chains: I) localization as a transient, with subsequent subdiffusion; II) the absence of the transient and immediate subdiffusion; III) selftrapping of a part of the packet, and subdiffusion of the remainder. Here we focus on the mechanisms that explain subdiffusive spreading of the wavepacket which is due to weak but nonzero chaotic dynamics inside the packet. Chaos is a combined result of resonances and nonintegrability. As a result the mode outside the packet is heated by the packet nonresonatly. We estimate the number of resonant modes in the packet and study the nature of resonant mode pairs by performing a statistical numerical analysis. The predicted second moment of the packet is increasing as $t^{1/3}$ which is in a good agreement with our numerical findings.

DY 3.7 Mon 12:30 ZEU 118

Nonlinear interaction in musical instruments — •Markus Abel — Universität Potsdam, Institut für Physik und Astronomie, Germany

Nonlinearities and nonlinear interactions are intrinsic to sound production let aeroacoustical let mechanical. We present very accurate experiments and corresponding theory on the sound production mechanism and the musical implications of nonlinear effects.

DY 3.8 Mon 12:45 ZEU 118

Dynamik und Struktur von Lyapunov-Vektoren in räumlich ausgedehnten chaotischen Systemen — •Ivan Georg Szendro Terán[1], Diego Pazó[2], Miguel Ángel Rodríguez[2] und Juan Manuel López[2] — [1]Max-Planck-Institut für Physik komplexer Systeme, Dresden, Germany — [2]Instituto de Física de Cantabria, Santander, Spain

In diesem Beitrag vergleichen wir die raumzeitliche Struktur und Dynamik verschiedener Arten von LV in räumlich ausgedehnten chaotischen Systemen (racS). Zu diesem Zweck verwenden wir eine Abbildung, die das Wachstum von Perturbationen in racS in Zusammenhang bringt mit dem Wachstum von selbstähnlichen, sog. rauen, Oberflächen.

Es wird gezeigt, dass die herkömmlich zur Charakterisierung von raumzeitlichen dynamischen Systemen verwendeten 'rückwärtigen' LV, welche als Nebenprodukte bei der Berechnung von LE abfallen, artifiziele Eigenschaften haben, die Folge ihrer Definition und nicht Ausdruck der intrinsischen Phyisk des untersuchten Systems sind. Wir schließen dass, um die Physik des Systems besser zu verstehen, die sogenannten charakteristischen oder kovarianten LV betrachtet werden sollten, welche spezielle Lösungen der linearisierten Bewegungsgleichungen sind. Weiterhin zeigen wir, dass für eine große Klasse von Systemen die Struktur und Dynamik der am schnellsten wachsenden Richtungen (d.h. LV die zu LE nahe dem größten Exponenten gehören) durch die Struktur des ersten (d.h. zum größten LE gehörenden) LV determiniert ist.