Abstracts of Posters

HURST PARAMETER IN PATTERN OF LASER HARDENED TOOL STEEL

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A rough surface can be observed in the microstructure of the robotically laser hardened material. We are interested in how to assess the roughness. The Hurst parameter is directly related to the "fractal dimension", which provides the measure of surface roughness. The Hurst parameter is understood as the correlation of two random steps X1 and X2 which follow one another with the time difference t. We analyzed 36 samples of the same hardness with different parameters of a robotic cell for laser hardening with the R/S method. The main findings can be summarized as follows: We observed a fractal structure in robotic laser hardening. By applying different calculation methods, we gauged the Hurst parameter H for various parameters of laser hardening of robotic cells. We found the most optimal Hurst parameter H for different parameters of robotically laser hardened tool steel. Using the RGB analysis we got three-dimensional graphs, which show a fractal structure. Because of the occurrence of self-similar deformations due to heat treatment in robotic laser hardening, the fractal dimension can be used to describe the level of irregularity.

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FRACTAL STRUCTURE OF ROBOT LASER HARDENED DIFFERENT MATERIAL

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Laser hardening is a metal surface treatment process complementary to conventional flame and induction hardening processes. A high-power laser beam is used to heat a metal surface rapidly and selectively to produce hardened case depths of up to 1,5mm with the hardness of the martensitic micro-structure providing improved properties such as wear resistance and increased strength. Fractal patterns are observed in computational mechanics of elastic-plastic transitions. The Fractal dimension is a property of the fractal, which is maintained through all the extensions and is therefore well defined. In addition, it shows how complex the fractal is. The Fractal dimension is generally not calculated by the above-mentioned procedure, as this is possible only on pure mathematical constructs, which do not exist in nature. We made samples on material GGG 70L and GGG 60L, where we observed a fractal pattern in the microstructure of the robotically laser hardened material.

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Time series analysis of turbulent systems

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Time series analysis has been widely used to determine the properties of turbulent systems in separate cases, in particular chaotic turbulence (Eckmann and Ruelle, 1985) and stochastic turbulence (Moss and McClintock, 1989). However, they are rarely analysed together or with the same methods. In addition, the application of time series analysis to turbulence from the emerging class of nonautonomous systems (Rasmussen and Kloeden, 2011) has yet to be fully considered.

The effectiveness of different time series methods is highly dependent on the source of the turbulence. This work emphasises the importance of using a wide range of techniques, especially in the case where turbulence is observed but the origin is unknown. The proper treatment of time series containing time-dependent dynamics (Jamšek, Paluš and Stefanovska, 2010) is also investigated.

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Semiclassical Propagator for Bosonic Quantum Fields based on Real Trajectories

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A powerful alternative to describe an interacting many-body quantum system is to study the quantum field theory of the asociated wave equation. In this approach, the path integral over configurations of the classical field is naturally constructed in the many-body eigenstates of the field operators, the so-called field coherent states, and the semiclassical program can be in principle carried on following a saddle point calculation of such path-integral representation. However, already at the single-particle level, the experience of the past decades shows the absolute necessity of including complex classical trajectories to get a consistent semiclassical theory based on the coherent sate representation. The complicated issues of analytical continuation, existence of well-behaved solutions and practical calculation of classical complex trajectories makes then the coherent state approach useless (as far as real-time propagation in the semiclassical limit is concerned) when going into interacting fields.

A possible solution for all this problems would be to start the semiclassical program with the strict analog for quantum fields of the Van-Vleck propagator, as from the begining this object is constructed out of real classical trajectories.

Using field states which are closely related with coherent states and may be seen as the formal analogue of position and momentum operators in the phase space where the classical field evolves, we show that a Van-Vleck propagator may be constructed out of real trajectories in field space. We discuss the formal properties of this object and apply the corresponding semiclassical theory for interacting bosons to some simple models.

FERMI ACCELERATION AND ITS SUPPRESSION IN A TIME-DEPENDENT LORENTZ GAS

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In our work, we revisit the problem of a Lorentz Gas [1] with time-dependent boundary. We assume that the radius of the scatters are fixed and the center of mass changes according to an harmonic function. Our main goal is, for the conservative case, to verify the validity of the Loskutov-Ryabov-Akinshin (LRA) conjecture [2] which states that: Chaotic dynamics of a billiard with a fixed boundary is a sufficient condition for the Fermi acceleration in the system when a boundary perturbation is introduced. It was confirmed when we studied the behaviour of the average velocity for an ensemble of particles. Since the phenomenon of Fermi Acceleration is present in this model our next step is to introduce dissipation into the model via damping coefficients. For dissipative billiards, Leonel proposed the following conjecture [3]: For one-dimensional billiard problems that show unlimited energy growth for both their deterministic and stochastic dynamics, the introduction of inelastic collision in the boundaries is a sufficient condition to break down the phenomenon of Fermi acceleration. In our approach, we are studying a two-dimensional system close to the transition from unlimited to limited energy growth. Our results allow us to confirm Leonel's conjecture for this new kind of time-dependent perturbation when dissipation is introduced. In both, conservative as well as dissipative case, we describe the behaviour of average velocity using scaling formalism [4,5].

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Time series analysis of molecular dynamics simulation: collective behavior and configuration changes

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Our study aims to analyze time series data of dynamics simulation for proteins to extract collective behavior which plays an important role in molecular functions. In a traditional idea of proteins, the most stable configuration is supposed to play an important role in their functions. In a stable configuration, the protein has hierarchical structures: the primary, the secondary and the tertiary ones. The primary structure of the protein is the chain of amino acids. The secondary structure of the protein is formed after folding processes, and consists of helix, sheets and loops. Its tertiary structure is constituted by these secondary structures.

However, recent studies suggest that some proteins exhibit dynamical changes of their structures and such dynamical behavior plays a crucial role in their functions. Our interest in dynamical behavior of proteins is stimulated by these recent studies. In particular, we focus our attention to collective behavior of proteins and seek to understand how such behavior is related to molecular functions.

Our system is chignolin, the first designed protein consisting of 10 amino residues. Up until now, 18 stable structures are found for chignolin. Moreover, the protein exhibits dynamical behavior where it wonders around several stable configuration. Thus, it is a convenient molecule to develop methods to analyze dynamical motions taking place around multiple configurations.

We analyze how the protein experience multiple stable configurations by calculating the Root Mean Square Deviation (RMSD). Our analysis reveals that some structures appear more often than the other structures. In addition, using wavelet transformation and singular value decomposition, we classify vibrational motions. We discuss possible relationship between collective motion revealed by these analysis and dynamical changes among multiple stable configurations.

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Diffusion in a Quasiperiodic Lorentz gas.

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The Lorentz Gas (LG) is a kind of open billiard where the obstacles are hard disks. Diffusion in these systems is an interesting topic of study and is related to the glassy state of hard disks in binary systems. In a periodic LG normal diffussion and super-diffusion have been found, while in random systems sub-diffusion occurs.

We are interested in an intermediate case, that of quasiperiodic systems. It is, however, much harder to make a computational study in this case, since it is not possible to use periodic boundary conditions.

This poster will present some results on diffusion in the quasiperiodic LGand a new method for studying such systems numerically.

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ANDERSON LOCALIZATION BREAKUP IN STRONGLY DISORDERED NONLINEAR LATTICES

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The general wave phenomenon of Anderson localization - the halt of wave-packets in linear disordered media - affects a variety of classical or quantum waves. In turn, it impacts electrical and thermal conductivities, promotes localization of light and matter waves in optical lattices. Nonlinearity can strongly alter Anderson localization and the question whether the Anderson localization survives the nonlinearity or not is under a hot debate in nonlinear science and condensed matter. We report that employing the perturbation theory techniques one can demonstrate a finite probability for an Anderson mode (a regular compact localized solution) of a finite energy to be destroyed by nonlinearity, whatever small it is, and, hence, a finite probability of spreading.

Numerical experiments confirm theoretical predictions and demonstrate a sensitive dependence of the wave-packet dynamics (spreading or non-spreading) on the disorder realization in case of small energies. They reveal a linear dependence of the non-spreading probability on the wave-packet energy. For higher energies the non-spreading probability asymptotically vanishes and, in numerics, all realizations of disorder supported spreading. Although the spreading process may be quite irregular and get slower with the decrease of the total energy, no sign of slowing down in course of wave-packet spreading as the energy density decays has been documented.

Invariant manifolds in chaotic advection-reaction-diffusion pattern formation

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Invariant manifolds are organizing structures central to the problem of transport in chaotic advection, having been applied extensively in periodically driven systems and more recently extended, in the form of Lagrangian coherent structures, to fluids that are not strictly time-periodic. Here, we consider reaction-diffusion dynamics in systems that are simultaneously undergoing chaotic advection. This can be viewed as a simplified model of such diverse systems as combustion dynamics in a chaotic flow, microfluidic chemical reactors, and blooms of phytoplankton and algae. Prior experimental and numerical work has shown that such systems generate "burning fronts" with a remarkably rich structure, including the mode locking of the front profile to the driving frequency. Here, we demonstrate how the invariant manifolds useful in chaotic advection can be generalized to accommodate the additional reaction-diffusion dynamics. The generalized manifolds exist in an extended phase space that is of larger dimension than the fluid itself. We show how these manifolds provide a clear criterion for the existence of mode-locking and are essential for explaining the patterns of the mode-locked fronts. Finally, we present recent experimental results on the direct laboratory measurement of such manifolds.

NUMERICAL STUDY OF SOME NONAUTONOMOUS NONLINEAR OSCILLATORS

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We consider some nonlinear (anharmonic) nonautonomous Hamiltonian oscillators of one degree of freedom, that change adiabatically in time, thereby generalizing the theory on the time dependent linear oscillator [2,6-10]. For these systems we make a numerical study using several symplectic integrators. Comparison of numerical approximations with analytical solutions is given. The (non)conservation of the adiabatic invariant, namely of the action J, is studied. For the long-term integration we have chosen the 8th order symplectic integrator due to McLachlan [4] (for more informations see also the review paper of McLachlan and Quispel [5]) and investigated some statistical properties of the nonautonomous systems adiabatically changing in time. A short review of the methods used will be given [1,3,10-13].

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Low-dimensional dynamics of large ensembles of globally-coupled non-autonomous phase oscillators

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The Kuramoto model (KM) is used today as general approach in tackling non-linear problems that can be reduced to large ensembles of coupled phase oscillators (Acebrón et al. 2005). We extend it to incorporate at a basic level one of the most fundamental properties of living systems - their inherent time-variability. This enables a wide field of real problems to be addressed, where the observed system's dynamics is influenced by some external field so that some of its inherent parameters become non-autonomous (NA).

Recent results by Ott and Antonsen demonstrate that systems of globally-coupled non-identical phase oscillators have low-dimensional dynamics (Ott and Antonsen 2008). We use their ansatz to derive an explicit finite set of nonlinear ordinary differential equations, to describe the macroscopic evolution of our NA system. Furthermore, we show that the classical approach to this problem, using self-consistency of the mean field, fails to unveil the real behavior of the system - where the dynamics of the external field is superimposed on the top of the original problem defined by the KM.

The differential equations describing the low-dimensional dynamics of the different NA KM, are linearized around fixed points $z = 0$. This allows the critical parameters at which perturbations become unstable to be tracked, as well as, the damping rates for stable perturbations. Since, this is a typical example of a system with NA dynamics, characterized by explicit time dependance of the fixed points and bifurcation parameters (Rasmussen 2007), further analysis of the attractors' stability, given by the dynamics of the complex order parameter evolution and its linearization will be of great importance for the general theory of NA systems.

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SYNCHRONIZATION OF INTERACTING OSCILLATORS SUBJECT TO EXTERNAL NON-AUTONOMOUS INFLUENCES

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Time-variability is almost universally present in the dynamics of interacting oscillators in nature. Thus in biological oscillators it is common for parameters such as the natural frequencies to vary in time, the human cardiovascular system providing a well-known example (Shiogai et al. 2010). This time-variability may arise due to intrinsic variations in a high-order system, or multi-stability, or can be due to external influences. The latter situation is most probable when the oscillatory systems are thermodynamically open and other (often oscillatory) processes coexist in the same environment. We consider the case of oscillators that are self-sustained when in isolation (Anishchenko et al. 2010), and which are subject to external influences that may be periodic, stochastic or chaotic. Where two or more oscillators mutually interact, synchronization may occur (Pikovsky et al. 2001), and one of our central purposes is to reveal and understand the synchronization of self-sustained oscillators while influenced by non-autonomous sources. Analytic and numerical methods are introduced to take explicit account of the non-autonomicity, and applied to describe synchronization between coupled Poincaré oscillators subject to non-autonomous fields that tend to influence the frequencies or amplitudes, and/or the strength of the inter-oscillator coupling (Stankovski et al.). In each case the stability of the synchronization is considered, together with that of the associated phase difference, which is now dynamically varying. Bifurcation diagrams are constructed to distinguish parameter ranges of synchronization, partial synchronization, and non-synchronization. Finally, we discuss a method (Duggento et al.) for the detection of synchronization, and characterisation of the underlying phase dynamics, through analysis of the time series generated by non-autonomous oscillators.

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Prevalent dynamics at the first bifurcation of the Henon map

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We study the dynamics of strongly dissipative Henon maps, around the first bifurcation parameter a* at which the uniform hyperbolicity is destroyed by the formation of tangencies inside the limit set. We prove that a* is a full Lebesgue density point of the set of parameters for which Lebesgue almost every initial point diverges to infinity under positive iteration. A key ingredient is that a* corresponds to "non-recurrence of every critical point", reminiscent of Misiurewicz parameters in one-dimensional dynamics. Adapting on the one hand Benedicks & Carleson's parameter exclusion argument, we construct a set of "good parameters" having a* as a full density point. Adapting Benedicks & Viana's volume control argument on the other, we analyze Lebesgue typical dynamics corresponding to these good parameters.

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