Chaos, Complexity and Transport: Theory and Application

June 4th to June 8th 2007
Le Pharo, Marseilles, France

Program

Monday June 04, 2007

08:00-08:50 : Registration

08:50-09:00 : Opening

09:00-09:45 : Y. Couder ***"Bouncing drops, various aspects of a wave/particle association at a macroscopic scale"***

09:45-10:15 : D. Shepelyansky ***"Directed transport and chaos in asymmetric nanostructures***"

10:15-10:40 : Coffee break (Salle des Voûtes)

10:40-11:10 : S. Rica ***"Condensation of classical nonlinear waves***"

11:10-11:30 : R. Manella ***"Adiabatic Divergence of the Chaotic Layer Width and Applications to Noise-Induced Phenomena***"

11:30-11:50 : Nils Berglund ***"Metastability in interacting nonlinear stochastic differential equations***"

11:50-12:10 : R. Vilela Mendes "***Stochastic representations and localized numerical codes***"

12:10-15:30 : Welcome buffet and free time

15:30-16:15 : E. Wesfreid

16:15-16:45 : O. Piro "***Dissipative embedding of conservative dynamics***"

16:45-17:15 : A. Luo "***On global transversality and chaos in two-dimensional nonlinear dynamical systems*****"**

17:15-17:40 : Coffee break (Salle des Voûtes)

17:40-18:00 : E. Serre ***"Transition to chaos in rotating Rayleigh-Bénard convection in cylinders*****"**

18:00-18:20 : D. Vainchtein "*Resonances-induced chaotic advection in a cellular flow*"

18:20-18:40 : M. Uleysky "*Wave chaos in an underwater sound channel*"

18:40-19:00 : D-G. Dimitriu *"Intermittency Scenario of Transition to Chaos in Plasma in Connection with the Nonlinear Dynamics of a Double Layer Structure"*

Tuesday June 05, 2007

09:00-09:45 : J. Laskar

09:45-10:15 : R. MacKay ***"Manifestations of chaos"***

10:15-10:45 : Coffee break (Le Chalet)

10:45-11:15 : V. Rom-Kedar "*Stable motion in high-dimensional steep repelling potentials*"

11:15-11:35: O. Merlo ***"Fine structure in narrow planetary rings"***

11:35-11:55 : A. Farres "*Nonlinear Dynamics for a Solar Sail Near an Equilibrium Point of the Sun-Earth System*"

11:55-12:15 : M. Romero-Gomez "*The formation of spiral arms and outer rings in barred galaxies*"

12:15-15:30 : Free Time

15:30-16:15 : C. Jaffé "*A Review of Transition State Theory with Applications*"

16:15-16:45 : A. Torcini "*Synchronization in spatially extended systems"*

16:45-17:15 : Maurice Courbage "*Complexity and Entropy in Colliding Particle Systems*"

17:15-17:50 : Coffee break (Le Chalet)

17:50-18:10 : R. Ball "*A world tour of dynamical systems, stability, and chaos*"

18:10-18:30 : P. Legal ***"Experimental evidence of the Strato-Rotationnal Instability in a Taylor-Couette flow"***

18:30-18:50 : A. Apte ***"A Bayesian approach to Lagrangian data assimilation"***

Wednesday June 06, 2007

09:00-09:45 : G. Zaslavsky *"Three-dimensional stochastic web with quasicrystal symmetry"*

09:45-10:15 : R. Artuso "*Deterministic ratchets and beyond: zeta functions techniques*"

10:15-10:40 : Coffee break (Salle des Voûtes)

10:40-11:10 : D. Treschev "*Travelling waves in one-dimensional lattices*"

11:10-11:30 : D. Fanelli *"On the emergence of Quasi-Stationary States: the case of the Free-Electron Laser"*

11:30-11:50 : C. Eloy *"Flag flutter"*

11:50-12:10 : M. Lefranc *"Topological characterization of chaos: orientation preservation vs. non-intersection of trajectories"*

12:10-16:00 : Half Way Buffet and free time

16:00-16:45 : T. Evans "*Implications of Topological Complexity and Hamiltonian Chaos in the Edge Magnetic Field of Toroidal Plasmas*"

16:45-17:15 : R. Sanchez "*Non-diffusive modeling of strange transport in magnetically-confined, turbulent plasmas*"

17:15-17:40 : Coffee break (Salle des Voûtes)

17:40-19:20 : POSTER SESSION

Thursday June 07, 2007

09:00-09:45 : S. Ruffo *"Quasi-stationary states in mean-field dynamics"*

09:45-10:15 : P. H. Chavanis *"Self-gravitating Brownian particles"*

10:15-10:50 : Coffee break (Le Chalet)

10:50-11:10 : G. Zimbardo *"Kolmogorov entropy of magnetic field lines in the percolative regime: numerical computation and application to electron transport in solar coronal loops"*

11:10-11:30 : M. Rajkovic *"Clustering properties of plasma turbulence"*

11:30-11:50 : K. Rypdal *"Turbulence, critical fluctuations, and scale-free avalanching in a dusty plasma mono-layer"*

11:50-12:10 : R. Paskauskas *"Sticky obstacles to relaxation in coupled oscillators: the OCS molecule"*

12:10-15:00 : Free Time

15:00-15:45 : S. Fauve *"Chaotic dynamos generated by turbulent flows"*

15:45-16:15 : G. Morfill *"Nonlinear Processes in Complex Plasmas"*

16:15-16:35 : N. N. Choi *"Triple collision orbits in photo-ionisation of two-electron atoms"*

16:35-16:55 : P. Martin *"Exponentially small splitting of separatrices in perturbations of the McMillan family"*

16:55-17:15 : A. Vasiliev *"Change in the adiabatic invariant at separatrix crossing"*

17:15-23:00 : Banquet Chateau d'IF

Friday June 08, 2007

09:00-09:45 : E. Villermaux "*Mixing by random stirring*"

09:45-10:15 : T. Solomon "*Experimental studies of advection-reaction-diffusion systems*"

10:15-10:40 : ***Coffee break*** **(Salle des Voûtes)**

10:40-11:10 : J-L. Thiffeault "*A Topological Theory of Rod Stirring*"

11:10-12:30 : Round Table Discussion "*Common characteristics of several dynamical mechanisms in different physical problems*" Organisers: C. Simo, D. Treschev and G. Zaslavsky

12:30-14:00 : Farewell Buffet and free time

14:00-16:00 : Coffee break (Salle des Voûtes) and Conference closing

Abstracts

Review talks

- **Y. Couder** (ENS Paris, France) Bouncing drops, various aspects of a wave/particle association at a macroscopic scale
- **T. Evans** (General Atomics, USA) : Implications of Topological Complexity and Hamiltonian Chaos in the Edge Magnetic Field of Toroidal Plasmas
  Magnetically confined toroidal plasmas, such as in tokamaks and stellarators, are particularly attractive for fusion research because of their potential for obtaining steady-state plasma pressures and confinement times needed to achieve substantially self-driven burning plasmas. Fusion plasma discharges, in the first generation of experimental tokamak reactors such as ITER, are expected to last up to 500 s with thermal output powers of 400 MW. This implies steady-state thermal loads, on the solid surfaces of power exhaust components, reaching 5 MW/m^2 under ideal conditions. Using the most heat tolerant materials currently available, these components will fail at 10?15 MW/m^2 leaving only a factor of 2-3 for error. Research in the current generation of tokamak has shown that non-ideal effects such as small resonant and non-resonant magnetic perturbation from external field coils and internal MHD modes significantly alter the edge magnetic topology producing relatively complex 3D structures. These structures create asymmetries in the magnetic footprints that define heat flux distributions on power exhaust components and imply peak power loads that approach steady-state material failure limits (10?15 MW/m^2) in fusion reactors. The topology of these structures plays an important role in the nature of the transport and the stability of the boundary plasmas. For example, resonant magnetic fields applied to high confinement (H-mode) plasmas in poloidally diverted plasmas create magnetic footprints consistent with bifurcations in the topology of the separatrix and stochastic field line excursion. This results in a reduction of the effective particle confinement without affecting the energy confinement and stabilizes large, repetitive, MHD instabilities know as edge localized modes (ELMs) that drive heat and particle impulses capable of quickly damaging power exhaust components in fusion reactors. In addition, observations of edge plasmas in tokamaks, using high speed cameras, reveal an array of complex dynamic processes such as the formation of rapidly growing coherent filaments during ELMs and active bursts of intermittent turbulence associated with the rapid ejection of high density plasma clumps. The topological properties of the complex structures, observed in the active region of the plasma edge, are qualitatively consistent with that of homoclinic tangles defined by invariant manifolds of the system and Hamiltonian chaos resulting from intersections of stable and unstable manifolds. Nevertheless, a quantitative description of the dynamics involved in these processes requires developing a better understanding of the plasma response to such complex topologies. A review of the recent experimental observations and progress on 3D fluid, kinetic and extended MHD modeling of the edge plasma in tokamaks will be given in this talk. These will be related to the topological structure of the invariant manifolds and the chaotic structure of the field lines based on conservative dynamical system theory. *Work supported by the U.S. Department of Energy under DE-FC02-04ER54698.
- **S. Fauve** (ENS Paris, France) : Chaotic dynamos generated by turbulent flows
  We first report the observation of a magnetic field generated by a turbulent von Karman flow of liquid sodium (VKS dynamo experiment). Small changes of the flow driving parameters generate different dynamical regimes of the magnetic field: oscillations, intermittent bursts and field reversals. In a second part, we discuss the effect of turbulence on the nature of the dynamo bifurcation, on the geometry of the generated magnetic field and on scaling laws for the magnetic energy

density. We show that the dynamics of the large scale magnetic field result from a small number of competing modes.

- **C. Jaffé** (University of West Virginia, USA) : A Review of Transition State Theory with Applications
  In this talk I will review the the mathematical foundations of transition state theory and will present a variety of applications. These will include mass transport in the solar system, ionization of atomic systems by crossed electric and magnetic fields, and laser driven chemical reactions.

- **J. Laskar** (IMCCE, France)

- **S. Ruffo** (University of Florence, Italie) : Quasi-stationary states in mean-field dynamics
  I will review the topic of quasi-stationary states. These states are often encountered in mean-field Hamiltonian dynamics and are robust to external and stochastic perturbations. Examples of systems where they appear are: the Hamiltonian Mean-Field (HMF) model, the Colson-Bonifacio model of a free-electron laser, Escande's wave-particle Hamiltonian, mean-field self-gravitating systems, 2D hydrodynamics and Onsager's vortices. A feature of such states, which makes them truly thermodynamic, is that their lifetime typically increases as a power of system size. Besides that, they are "attractive", since one observes covergence from a different initial state. Recently, the use of Lynden-Bell entropy has been advocated to describe such states. In this talk, I will discuss the merits and drawbacks of this approach.

- **E. Villermaux** (University of Provence, France) : Mixing by random stirring
  The principles of scalar mixing in randomly stirred media are discussed, aiming at describing the overall concentration distribution of the mixture, its shape, and rate of deformation as the mixture evolves towards uniformity. Two distinct experiments, one involving an ever dispersing mixture, the other a mixture confined in a channel, both in high Reynolds, three dimensional flows, behave quite differently. We show how these differences single two fundamental, and concomitant aspects of the process of mixing, namely the distribution of individual histories on one hand, and the interaction of the fluid particles in the medium on the other. The particles, elementary bricks of a mixture, are stretched sheets whose rates of diffusive smoothing and coalescence build up the overall mixture concentration distribution. Consequences of these processes on the spectral, and some geometrical facets of random mixtures are also examined.

- **E. Wesfreid** (ESPCI, France) :

- **G. Zaslavsky** (New York University, USA) - Three-dimensional stochastic web with quasicrystal symmetry
  We consider 4-dimensional map provided the weak chaos conditions, when the stochastic web emerges, and discuss the symmetry properties of the web. A brief review will be given for the problem of dynamical generation of different symmetric tiling of plane using the two-dimensional web map. This problem will be generalized to the four-dimensional web map that is different from the Arnold web. An averaging procedure permits to derive a generator of quasicrystal symmetry as a potential in three-dimensional space. In two-dimensional case such potentials are applied to optic lattices. We demonstrate the dynamics along the three-dimensional stochastic webs.

Focus talks

- **R. Artuso** (University of Cômo, Italy) : Deterministic ratchets and beyond: zeta functions techniques
  We illustrate the use of non perturbative techniques in the study of deterministic ratchets by working out an exactly solvable model, inspired by the so-called Parrondo games.

- **P. H. Chavanis** (University Paul Sabatier, France) : Self-gravitating Brownian particles
  We discuss the dynamics and thermodynamics of a gas of self-gravitating Brownian particles. We consider a strong friction limit and a mean field approximation where the problem reduces to the study of the Smoluchowski-Poisson (SP) system. We show the existence of a canonical phase transition between a gaseous state and a condensed state below a critical temperature T_c. For T<T_c the system undergoes an isothermal collapse. The evolution is self-similar and leads to a finite time singularity. However, "the singularity contains no mass". In fact, the collapse continues after the singularity has arisen and a Dirac peak is formed in the post-collapse regime by accreting the mass of the halo. We mention different extensions of this problem: self-gravitating fermions, multi-species systems, generalized thermodynamics, influence of the dimension of space, etc. We also discuss the analogy between the collapse of self-gravitating Brownian particles and the chemotactic aggregation of bacterial populations in biology.

- **M. Courbage** (University Paris VII, France) : Complexity and Entropy in Colliding Particle Systems
  We develop quantitative measures of entropy evolution for particle systems undergoing collision process in relation with various unstability properties.

- **A. Luo** (Southern Illimois University, USA) : On global transversality and chaos in two-dimensional nonlinear dynamical systems
  In this paper, the global transversality and tangency in two-dimensional nonlinear dynamical systems are discussed, and the exact energy increment function (L-function) for such nonlinear dynamical systems is presented. The Melnikov function is an approximate expression of the exact energy increment. A periodically forced, damped Duffing oscillator with a separatrix is investigated as a sampled problem. The corresponding analytical conditions for the global transversality and tangency to the separatrix are derived. Numerical simulations are carried out for illustrations of the analytical conditions. From analytical and numerical results, the simple zero of the energy increment (or the Melnikov function) may not imply chaos exists. The conditions for the global transversality and tangency to the separatrix may be independent of the Melnikov function. Therefore, the analytical criteria for chaotic motions in nonlinear dynamical systems need to be further developed. The methodology presented in this paper is applicable to nonlinear dynamical systems without any separatrix.

- **R. S. MacKay** (University of Warwick, UK) : Manifestations of chaos
  I will describe various systems for which good forms of chaos have been proved relatively recently and discuss their robustness: 1. Two charges of opposite sign in a uniform magnetic field and unequal gyrofrequencies exhibit "second species" chaos; 2. An exact area-preserving tilt map of the cylinder which is mixing and has diffusion constant a certain expression involving $2+\sqrt{3}$, approximately 0.14434; 3. Three mixing volume-preserving vector fields in 3D containers with no-slip boundaries.

- **G. Morfill** (Max-Planck Institute, Germany) : Nonlinear Processes in Complex Plasmas
"Complex Plasmas" are strongly coupled systems, consisting of ions, electrons, charged microparticles and some neutral gas. The dynamically dominant microparticles are individually visualised and due to their comparatively large mass (many billions atomic masses) characteristic dynamical time scales are in the 10's of msec range, easily resolved with CCD cameras. Thus complex plasmas are ideal systems for studying some fundamental physics questions, such as the onset of cooperative phenomena, the kinetics of phase transitions and other critical phenomena, nanofluidic properties as well as many other hydrodynamic processes ? all at the most elementary kinetic level. After a brief introduction into the properties of this interesting state of matter, some examples of recent research results in the above-mentioned fields will be presented.

- **O. Piro** (IMEDEA, Spain) : Dissipative embedding of conservative dynamics
In a number of apparently unrelated problems, Hamiltonian or volume preserving dynamics takes place on an invariant, eventually attracting, sub-manifold of a dimensionally larger dissipative system. Examples of such situations are a) the motion of neutrally bouyant finite size particles, b) controlled Hamiltonian systems, c) tidally synchronized celestial bodies, etc. I will try to present an integrated view of this class of problems and show a number of phenomena that are likely to appear in all its instances.

- **S. Rica** (ENS Paris, France) : Condensation of classical nonlinear waves
We study the formation of a large-scale coherent structure (a condensate) in classical wave equations by considering the defocusing nonlinear Schrödinger equation as a representative model. We formulate a thermodynamic description of the condensation process by using a wave turbulence theory with ultraviolet cut-off. In 3 dimensions the equilibrium state undergoes a phase transition for sufficiently low energy density, while no transition occurs in 2 dimensions, in analogy with standard Bose-Einstein condensation in quantum systems. Numerical simulations show that the thermodynamic limit is reached for systems with 16^3 computational modes and greater. On the basis of a modified wave turbulence theory, we show that the nonlinear interaction makes the transition to condensation subcritical. The theory is in quantitative agreement with the simulations.

- **V. Rom-Kedar** (Institut Weizmann, Israël) : Stable motion in high-dimensional steep repelling potentials
The appearance of elliptic periodic orbits in families of n-dimensional smooth repelling billiard-like potentials that are arbitrarily steep and close to dispersing billiards is established for any finite n. The width of the stability regions in the parameter space scales as a power-law in 1/n and in the steepness parameter. Thus, it is shown that even though these systems have a uniformly hyperbolic (albeit singular) limit, the ergodicity properties of this limit system are destroyed in the more realistic smooth setting. The considered example is highly symmetric and is not directly linked to the smooth many particle problem. Nonetheless, the possibility of explicitly constructing stable motion in smooth n-degrees of freedom systems limiting to strictly dispersing billiards is now established. Thus, it is shown that the billiards instability mechanism cannot justify by itself the observed ergodicity of smooth many particle systems.

- **R. Sanchez** (Oak Ridge National Laboratory, USA) : Non-diffusive modeling of strange transport in magnetically-confined, turbulent plasmas
The most promising route for the successful production of large amounts of energy from fusion requires the containment of a hot plasma by magnetic fields with the topology of nested, toroidal magnetic surfaces. Understanding the transport properties of these configurations is essential to the success of the fusion energy program, since they can help us to control the leak of particles and energy out of the system. However, multiple experiments carried out during the last two decades in this type of magnetic trap have revealed that the confined plasma is in a strong turbulent state in which transport phenomena exhibit a strange, non-diffusive nature. The observation of a degradation of confinement with increasing external power suggests that the plasma profiles tend to stay close to some critical threshold for the onset of instabilities. In addition, the observed scaling of the energy/particle confinement times and the detection of "avalanche-like" transport events suggest that the dominant transport mechanism may lack a characteristic length scale. Similar evidence also suggests that a characteristic temporal scale may also be missing. In this focus talk, I will discuss some recent work that aims at

improving our understanding of the dynamics of transport in these plasmas as much as at constructing mathematical models better suited to capturing them then the ones currently available. The basic tools used are continuous-time-random walks (CTRWs) and/or fractional differential equations (FDEs), both of which can accommodate this lack of characteristic scales. Numerous examples obtained from numerical simulations and experiments will be used to illustrate the main ideas.

- **D. L. Shepelyansky** (Univ. Paul Sabatier, France) : Directed transport and chaos in asymmetric nanostructures
A board of rigid disks on a triangular lattice has been invented by Galton in 1889 to demonstrate the appearance of statistical laws from dynamical motion. This system, also called periodic Lorentz gas, has been proved to be completely chaotic by Sinai in 60th. The dynamics remains chaotic also for semi-disks scatterers oriented in one direction. In this case the inversion symmetry is broken but the directed transport remains forbidden by the detailed balance principle. This remains true also in presence of polarized monochromatic force produced by microwave radiation. However, when dissipation is present, a new stationary state is born from chaos as shown in [1]. It is characterized by a directed transport which can be efficiently controlled by the microwave polarization even if mean force is zero. Being universal this effect exists for Maxwell or Fermi-Dirac thermostatted gas moving between semi-disks in presence of a microwave field [2-5]. Nowadays technology allows to realize the semi-disk Galton board with a two-dimensional electron gas in a superlattice of micron size antidots. In this case the theory predicts appearance of strong currents induced by microwave fields. This opens new possibilities for creation of room temperature detectors of terahertz radiation.

- **T. H. Solomon** (Bucknell College, USA) : Experimental studies of advection-reaction-diffusion systems
We present the results of experiments on the effects of chaotic fluid mixing on the dynamics or reacting systems. The flows studied include a blinking vortex flow and a chain of alternating vortices. The reaction is the oscillatory or excitable state of the well-known Belousov-Zhabotinsky chemical reaction. Three sets of experiments are described. (1) Experiments in a blinking vortex flow demonstrate that chemical patterns for the oscillatory reaction reflect the structures predicted by numerical models of the mixing fields for the flow. (2) Synchronization of oscillating reactions in an extended flow (a chain of vortices) is found to be enhanced significantly by the presence of superdiffusive transport characterized by Levy flights that connect different parts of the flow. (3) Front propagation is investigated in a chain of alternating and oscillating vortices that are coupled by chaotic mixing. It is found that the fronts mode-lock onto the frequency of the oscillation of the vortices. The effects of superdiffusion on the mode-locking is also investigated.

- **V. Tarasov** (State University of Moscow, Russia) : Fractional Dynamics of Systems with Long-Range Space Interaction and Temporal Memory
Field equations with time and coordinates derivatives of noninteger order are derived from stationary action principle for the cases of power-law memory function and long-range interaction in systems. The method is applied to obtain a fractional generalization of the Ginzburg-Landau equation and nonlinear Schrodinger equation, and dynamical equations for particles chain with power-law interaction and memory. In more details, we consider two different applications of the action principle: generalized Noether's theorem and Hamiltonian type equations. In the first case, we derive conservation laws in the form of continuity equations that consist of fractional time-space derivatives. Among applications of these results, we consider a chain of coupled oscillators with a power-wise memory function and power-wise interaction between oscillators. In the second case, we consider an example of fractional action and find the corresponding Hamiltonian type equations. The obtained fractional equations and conservation laws can be applied to complex media with/without random parameters or processes.

- **J. L. Thiffeault** (Imperial College, UK) : A Topological Theory of Rod Stirring
In a fluid, stirring is usually necessary to overcome the slow diffusion of most substances. This is important in a wide range of applications, from industry to geophysics. Here I focus on a prototypical application, the stirring of a two-dimensional viscous fluid with rods. Mathematically, stirring rods can be viewed as 'punctures' in a two-dimensional surface: they present topological obstructions to material lines in the fluid. The theory developed by Thurston and Nielsen to classify the possible periodic rod motions in such a system can be used to decide which stirring methods are best, in the sense

of generating chaotic trajectoris that lead to chaotic advection. Global aspects of the concentration field of a substance in the stirring device can then be determined via 'train tracks', which are skeletons of an important underlying structure called the unstable foliation. Since there are only a limited number of possible train tracks, all stirring protocols can be classified, as well as their properties. This can be extended to completely general situations where rods are replaced by periodic orbits. I will present experimental and numerical examples of all these concepts. Finally, I will introduce a rod stirring device designed and optimized using these topological principles.

- **A. Torcini** (CNR Florence, Italy) : Synchronization in spatially extended systems
  The mechanisms responsible for the synchronization of chaotic extended systems with short-range interactions are revised. Moreover recent results concerning power-law coupled systems are presented. In particular, chaotic synchronization of replica of coupled map lattices is considered. The spatial extension allows to interpret the synchronization transitions (STs) as nonequilibrium critical phenomena: namely, as absorbing phase transitions. Within this framework two different kind of continuous transitions have been identified for nearest-neighbour coupling : one ruled by linear mechanisms and one by nonlinear effects. In the first case the ST belongs to the multiplicative noise universality class, while if nonlinear effects prevail the critical exponents coincide with those measured for directed percolation (DP). More recently spatially extended chaotic systems with algebraically decaying interactions have been considered. Also in this situation the STs appear to be continuous, while the critical indexes vary with continuity with the power law exponent characterizing the interaction. Moreover, strong numerical evidences indicate that the transition belongs to the "anomalous directed percolation" family of universality classes previously found for Levy-flight spreading of epidemic processes.

- **D. Treschev** (Steklov Mathematical Inst., Russie) : Travelling waves in one-dimensional lattices
  We construct a travelling wave in a one-dimensional lattice of identical classical particles, with potential interaction. Some possibilities concerning lattices with several different kinds of particles are discussed.

Oral communications

- **A. Apte** (MSRI, Berkeley, USA) A Bayesian approach to Lagrangian data assimilation
Lagrangian data assimilation aims at optimally combining the data about the ocean obtained from drifters and floats with state estimates from ocean models. I will discuss the problem of data assimilation from the Bayesian statistical perspective which leads to the posterior distribution of the state of the system given its noisy observations and a dynamical model. I demonstrate the application of three sampling methods, based on Langevin equation and Metropolis-Hastings algorithm, for sampling this posterior distribution, in the context of the Lagrangian data assimilation problem. This exact posterior is compared to the posterior implied by widely used approximate methods such as ensemble Kalamn filter.

- **Rowena Ball** (The Australian National University) A world tour of dynamical systems, stability, and chaos.
This journey begins with a visit to a large nineteenth century house in northern England, where we meet the residents. The route then takes us to a museum in Regensburg, Germany, thence to the 41st floor of an office tower in downtown Hong Kong, and finally to the port of Botany Bay where we take in the complicated chiaroscuro of an oil refinery. During the tour aspects of the mathematics of dynamical systems, stability, and chaos will be reviewed within a historical framework that draws together the two major threads of its early development: celestial mechanics and control theory, and focussing on qualitative theory. From this perspective we show how concepts of stability enable us to classify dynamical equations and their solutions and connect the key issues of nonlinearity, bifurcation, control, and uncertainty that are common to time-dependent problems in natural and engineered systems. Some new results on stability of complex networks and refined turbulence will be presented.

- **Nils Berglund** (CPT Marseille) Metastability in interacting nonlinear stochastic differential equations
We consider a chain of N overdamped bistable oscillators with nearest-neighbour coupling. Each site is perturbed by an independent white noise, modeling the influence of a heat reservoir. The system is described by a set of stochastic differential equations on R^{Z/N Z} . The metastable behaviour of the dynamics is encoded in the potential landscape, in particular its local minima and saddles of index 1. At small coupling, the system has 2 N local minima, while at sufficiently large coupling (of the order N^2), it synchronises: There are only two local minima, corresponding to all particles in the same state. We show that as the coupling decreases, the system desynchronises in a sequence of symmetry-breaking bifur-cations, which gradually increase the number of local minima from 2 to 2^N . We provide precise estimates on the activation energy and optimal transition paths and times from one synchronised state to the other, in particular in the large-N limit.

- **Nark Nyul Choi** (Kumoh National Institute of Technology), Triple collision orbits in photo-ionisation of two-electron atoms
The cross sections for single-electron photo-ionisation of two-electron atoms show fluctuations which decrease in amplitude when approaching the double-ionisation threshold. We show that the fluctuations can, semiclassically, be described in terms of contributions associated with classical orbits starting and ending in the triple collision.

- **Dan-Gheorghe Dimitriu** (Alexandru Ioan Cuza University of Iasi, Romania) Intermittency Scenario of Transition to

Chaos in Plasma in Connection with the Nonlinear Dynamics of a Double Layer Structure
Double layers are nonlinear potential structures in plasma consisting of two adjacent space charge layers with opposite charges (electrons and positive ions, respectively). The most common way to obtain such a structure is to positively bias an electrode immersed into plasma. In this case, up to a threshold value of the potential applied on the electrode, an intense luminous almost spherical complex space charge structure appears in front of the electrode, known as ball of fire or fireball. This structure consists of a positive "nucleus" (An ion-enriched plasma) confined by an electrical double layer. By increasing the voltage applied on the electrode, this structure passes into a dynamic state, in which the double layer periodically disrupts and re-aggregates, oscilations of the current collected by the electrode being recorded. Here we report on experimental results that emphasize the development of an intermittent scenario of transition to chaos in plasma in connection with the nonlinear dynamics of such a complex space charge structure, at the increase of the potential applied on the electrode. Regular oscillations interrupted by random bursts were observed in the time series of the current collected by the electrode. By increasing the voltage applied on the electrode, the random bursts appear more frequently, the final state of the plasma system being a chaotic one.

- **Christophe Eloy** (IRPHE, Uiversité de Provence) Flag flutter
When immersed in an axial fluid flow, a cantilevered plate can spontaneously exhibit flutter above a critical value of the flow velocity. We address this flag-type instability both experimentally and theoretically. We consider the effects of the three non dimensional parameters of this problem (non dimensional flow velocity, mass and aspect ratios) and specially focus on the effects of the finite span of the plate. Experiments are performed in the horizontal test section of a low turbulence wind tunnel. Rectangular sheets made of different materials are used. The upstream end of the plate is clamped into a vertical streamlined mast while the three other edges are free. For the theoretical point of view we consider a linear model which couples the plate elasticity and the hydrodynamic load. The flutter is supposed to be two dimensional in agreement with the experimental observations while, in order to derive the fluid load on the plate taking into account the finite span effect, the flow is considered as three dimensional. The flow is considered as potential and the fluid load is then expressed by means of an asymptotic theory. At the first order we recover the results of existing theories for plates of infinite span (for a review of previous studies see e.g. Watanabe et al. [1,2] corresponding to a two dimensional flow. Second and third orders induce a reduction of the pressure on the plate resulting in a stabilizing effect in agreement with the experimental results.
[1] Y. Watanabe, S. Suzuki, M. Sugihara, Y. Sueoka, An experimental study of paper flutter, Journal of Fluids and Structures, 16 (2002),529-542.
[2] Y. Watanabe, K. Isogai, S. Suzuki, M. Sugihara, A theoretical study of paper flutter, Journal of Fluids and Structures, 16 (2002), 543-560.
[3] Eloy, C., Souilliez, C. & Schouveiler, L. Flutter of a rectangular plate. (2006), To appear in Journal of Fluids and Structures.
[4] Souilliez, C., Schouveiler, L. & Eloy, C. Flutter modes of a flexible plate in an air flow. (2006) Journal of Visualization, 9(3), 242.

- **Duccio Fanelli** (University of Manchester) On the emergence of Quasi-Stationary States: the case of the Free-Electron Laser
Free-Electron Lasers (FELs) are coherent and tunable radiation sources. The physical mechanism responsible for light emission and amplification in a FEL is the interaction between the relativistic electron beam and a magnetostatic periodic field generated in the undulator. Due to the effect of the magnetic field, the electrons are forced to follow sinusoidal trajectories, thus emitting synchrotron radiation. This radiation is then amplified until the laser effect is reached. FELs represent one example of systems with long-range interactions, where the interplay between collective (wave) and individual (particles) degrees of freedom is well known to be central. As reported for other physical systems where long-range couplings are active, FELs are also predicted to display a short-time relaxation towards intermediate Quasi-Stationary States (QSSs), whose lifetime increases with the system size. In this paper, I shall discuss the emergence of QSSs in FELs, review the

associated phenomenology and propose a possible interpretative framework inspired to Lynden-Bell's maximum entropy principle. The possibility of experimentally proving the existence of QSSs will be also addressed.

- **Ariadna Farrés** (Universitat de Barcelona) Nonlinear Dynamics for a Solar Sail Near an Equilibrium Point of the Sun-Earth System
  A Solar Sail is a probe that carries a large reflecting surface to obtain a small but continuous impulsive force from the Solar light. The model considered for the motion of the probe is the Restricted Three Body Problem (RTBP) plus the effect of the Sail. It is known that this model has more equilibria than the classical RTBP. In the presentation we will describe the nonlinear dynamics around one of these equilibria, by computing the main invariant objects nearby. The tools used are the computation of normal forms and centre manifols.

- **Marc LEFRANC** (Laboratoire de Physique des Lasers, Atomes, Molécules (Université de Lille 1, CNRS)) Topological characterization of chaos: orientation preservation vs. non-intersection of trajectories
  Because determinism precludes that unstable periodic orbits embedded in a three-dimensional chaotic attractor intersect, the knots and links these orbits form are well-defined and provide signatures of the geometrical mechanisms organizing the dynamics. Unfortunately, knots fall apart in higher dimensions. We have recently proposed that preservation of phase-space volume orientation is a more general criterion than non intersection of trajectories, and have found that a simple formalism based on this criterion predicts correct topological entropies for horseshoe orbits. Extending these ideas to construct topological signatures of chaos for higher-dimensional systems will also be discussed.

- **Patrice Le Gal** (IRPHE, CNRS) Experimental evidence of the Strato-Rotationnal Instability in a Taylor-Couette flow
  In astrophysics, Keplerian flows are always stable to infnitely small perturbations in respect to the Rayleigh criterium. As a consequence of this stability, several scenario have been recently proposed to legitimate the existence of turbulence in accretion disk flows. Other ingredients than pure shear need to be taken into account in order to trigger instabilities and transition to turbulence in these flows: magnetic fields or elliptic streamlines for instance. In 2001, Molemaker et al. [1] predicted that cylindrical Couette flows in a stratified fluid may become unstable even if the Rayleigh criterium for stability was verified, i.e. in the corresponding stable regime of pure fluid flow. Moreover, and contrary to the classical Taylor vortices of the centrifugal instability, the most unstable modes should be non-axisymmetric. This theoretical analysis has then been continued in an astro-physical context by Shalybkov and Rudiger [2] and extended to the stability of accretion disk Keplerian flows by Dubrulle et al. [3]. To the best of our knowledge, and despite explicit calls from theoreticians, no detailed experimental validation of the theoretical predictions have been performed yet. We present here the first detailed and quantitative experimental evidences in a Taylor-Couette flow of the Strato-Rotationnal Instability and its expected helicoidal modes that may be relevant for accretion disks.
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- **Riccardo Mannella** (ICTP, Trieste, Italy) : Adiabatic Divergence of the Chaotic Layer Width and Applications to Noise-Induced Phenomena
  Consider a seemingly rhetorical question: "Can a weak perturbation lead to an arbitrarily wide chaotic layer and fast chaotic transport?" An educated guess, based on intuition and on the previous scientific literature, would be a sound "no". However, our recent work [1] proves that the answer is "yes" for an important class of systems. Namely, for a spatially periodic Hamiltonian system perturbed by an ac force i.e. a force which is time-periodic while being coordinate-independent, the width of the chaotic layer diverges as the frequency of the perturbation goes to zero. This divergence gives rise to the divergence of the maximum absolute value of the velocity, thus leading to an increasingly fast spatial chaotic transport on sufficiently large time-scales. I.e., paradoxically, the slower the perturbation is the faster the transport is. We have developed an analytic theory for the width of the layer, valid in the whole adiabatic range of frequency. Our results promise to have numerous applications in physics and technology. We shall concentrate in this presentation on

applications related to noise-induced phenomena. In particular, this concerns the noise-induced diffusion of particles on periodic surfaces, often called as "surface diffusion" - the subject which causes nowadays a big interest (see e.g. [2] and references therein) due to the use in modern technologies involving self-assembled molecular-film growth, catalysis, and surface-bound nanostructures [3]. Our results suggest a counter-intuitive simple method how to greatly increase the speed of diffusion by means of a weak perturbation whilst the weakness of the perturbation is principal from a technological point of view since a strong perturbation may lead to irreversible changes of the surface/particles. Such a great acceleration of the noise-induced diffusion has been demonstrated by us in computer simulations. Similarly, our results may be used in so called threshold devices (cf. [4]) which are based on structures periodic in any generalized coordinate. For the model of the threshold device based on the Josephson junction, we have demonstrated in computer simulations that the noise-induced flux through the voltage threshold may be drastically increased due to an addition of a weak slowly alternating current through the junction. Finally, we discuss various interesting open questions posed by our work.
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- **Pau Martin** (MA4-UPC) Exponentially small splitting of separatrices in perturbations of the McMillan family
  In this work we study the splitting of separatrices of the hyperbolic fixed point of the area preserving maps on the McMillan family under analytic perturbations. The problem depends on two parameters, the regular one controlling the size of the perturbation, and the singular one being the Lyapunov exponent of the hyperbolic fixed point. This problem was originally studied by Delshams and Ramirez-Ros. They obtained a formula for the splitting, which is exponentially small in the singular parameter, taking advantatge of this two parameter scheme, that is, assuming that the regular parameter is small in front of the singular one. Here we improve that result using very different techniques. We capture the exponentially small character of the splitting even for large values of the regular parameter with a formula that yields the one previously obtained when the regular parameter is small. Furthermore, our techniques, which include the resurgence study of the solutions of a family of inner equations, allow us to explain the appearence of the Borel transform of the perturbation in the leading term of the formula of the splitting.

- **Olivier Merlo** Fine structure in narrow planetary rings
  We address the occurence of narrow planetary rings and some of theit structural properties, in particular when the rings are sheparded. We consider the problem as Hamiltonian scattering of a large number of non-interacting massless pointlike particles in a effective potential. Using the existence of stable motion in scattering regions in this setup, we describe a mechanism in phase space for the occurance of narrow rings. We find eccentric narrow rings displaying sharp edges, variable width, appearance of of distinct ring components which are entangled and arcs.

- **Rytis Paskauskas** (Georgia Institute of Technology) Sticky obstacles to relaxation in coupled oscillators: the OCS molecule
  Energy transfer in coupled oscillators is a longstanding problem. Phase-space transport in realistic systems proceeds usually more slowly than predicted by statistical approaches. This anomalous diffusion is due to "sticky" phase spaces structures. The fundamental question in transport theory is: How is a trajectory trapped and how does it escape from the trap? Using time–frequency analysis, fast Lyapunov indicators, frequency map analysis and theory of dynamical invariants we answer this question for the transport dynamics of the carbonyl sulphide molecule.

- **Milan Rajkovic** (Institute of Nuclear Sciences Vinca) Clustering properties of plasma turbulence
  The presentation consists of two complementary parts. The focus in the first part is on the analysis of clustering properties of plasma density fluctuations in magnetic confinement devices while the second one analyzes locally stationary turbulent processes with power law spectral densities. Both cases are based on the analysis of temporal plasma density fluctuations

obtained by Langmuir probes in several magnetic confinement devices such as Tore Supra, MAST, and PISCES.
Part I
Intermittency, as one of the most important properties of turbulence, consists of two main components. The first is related to the amplitude of small-scale fluctuations and usually an underlying multifractal distribution exists for this component. The second consists of local oscillations frequency and may be associated with the monofractal property of clustering tendency. In order to discern between these two components we consider the telegraph approximation of plasma density fluctuations of various magnetic confinement devices by removing the amplitude variability and retaining only their zero-crossing information. A unique relationship is shown to exist between the spectral exponent of the signal and of its reduced (zero-crossing) information for L and H modes separately. We also show that there exist a cluster exponent for small scales while the large scales do not have clustering properties. We argue that the existence of hierarchy of scales whose members are in competition leads to clustering. We also analyze and discuss the relationship of clustering property with transport properties in plasmas.
Part II
The approach of plasma turbulence analysis is to divide the data into segments over which the process is essentially stationary and then use wavelet scale spectrum to estimate the effective local inertial range parameters, which are the scale factor and the exponent. The multifractality originates therefore not only from variations of these parameters but also from variation in the inertial range itself. We show that fluctuations around the Kolmogorov power law are significant and discernibly different for low confinement (L-mode) and high confinement (H- mode) regimes. We also show how a synthetic media with observed turbulent properties may be generated based on this approach in order to study wave propagation. In this case also we discuss transport properties of each regime in relation to the results of this analysis.

- **Mercê Romero-Gómez** (Observatoire de Marseille) The formation of spiral arms and outer rings in barred galaxies
We propose a new theory to explain the formation of spiral arms and of all types of outer rings in barred galaxies. We have extended and applied the technique used in celestial mechanics to compute transfer orbits. Thus, our theory is based on the chaotic orbital motion driven by the invariant manifolds associated to the periodic orbits around the hyperbolic equilibrium points. In particular, spiral arms and outer rings are related to the presence of heteroclinic or homoclinic orbits. Thus, R1 rings are associated to the presence of heteroclinic orbits, while R1R2 rings are associated to the presence of homoclinic orbits. Spiral arms and R2 rings, however, appear when there exist neither heteroclinic nor homoclinic orbits. We examine the parameter space of three realistic, yet simple, barred galaxy models and discuss the formation of the different morphologies according to the properties of the galaxy model. The different morphologies arise from differences in the dynamical parameters of the galaxy.

- **Kristoffer Rypdal** (Department of Physics and Technology, University of Tromso, 9037 Tromso, Norway) Turbulence, critical fluctuations, and scale-free avalanching in a dusty plasma monolayer
Dusty plasma monolayers realized under laboratory conditions have recently been shown to exhibit anomalous transport of dust particles by development of defects in the 2D hexagonal crystal lattice [1] and, under slightly weaker coupling conditions, vortical viscoelastic flows strongly reminiscent of those found in 2D Navier-Stokes turbulence [2]. It has also been demonstrated experimentally that global fluctuations in some bounded turbulent systems exhibit a universal non-gaussian probability density function (PDF) which it shares with fluctuations arising in models of equilibrium systems at criticality [3] and several sandpile type models exhibiting scale-free avalanches and self-organized critical dynamics (SOC) [4]. This universality suggests the existence of a fundamental relationship between some turbulent and avalanching systems. In this contribution we show by analysis of experimental data that a bounded dusty plasma monolayer can exhibit fluctuations in global kinetic energy following the mentioned universal PDF, and avalanches in particle motion with power-law PDFs in size, duration, and waiting time. Similar phenomenology is found in simulations of the 2D Navier-Stokes equations in a bounded domain, with energy input at small scales, and in a 2D sandpile model in an SOC-state. The results of our investigations point at the dust plasma monolayer as an interesting model system which displays, in a very illustrative manner, these different aspects of dynamical complexity.

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- **Eric Serre** Transition to chaos in rotating Rayleigh-Bénard convection in cylinders
  This article presents a numerical study of rotating Rayleigh-Bénard convection (RBC) in a fluid with the Prandtl number sigma = 5.3 confined in cylindrical enclosures. Using three-dimensional numerical solutions of the basic equations in the Boussinesq-Oberbeck approximation, we have explored the transition from an initially conductive state to a nonlinear aperiodic regime. The patterns have been investigated in two cylindrical cavities with a circular and with an annular cross section. A number of different aspect ratios have been used; in the case of the cylindrical box of height d and radius R the aspect ratio (R/d) = 5 has been assumed while in the case of annular channels with radial extent R = R1 ¡ R0; values L(=(R1-R0)/d)=5 and(R1/d)=12.5 have been considered. The pseudo-spectral numerical method allows the computation of three dimensional unsteady ?ows without any restriction on the patterns. Visualizations of the ?ow reproduce some experimentally observed patterns and agree with the results of linear stability analysis. The primary transition from the conductive state of no motion occurs in the form of rotating travelling waves. The secondary transitions show interesting dynamical processes, which vary with different boundary conditions. When the cylindrical sidewall is thermally insulating the primary travelling wave coexists with travelling wave convection in the bulk as the Rayleigh number is increased. In the case of a thermally well conducting sidewall the primary wave coexist with chaotic convection characterized by breaking rolls. In annular channels, two counter-rotating sidewall travelling waves are observed as predicted by theory. In narrower channels, these sidewall travelling waves interact and lead to a quasi-periodic time behaviour.

- **Michael Uleysky** POI FEBRAS, Vladivostok, Russia
  Wave chaos in an underwater sound channel Sound propagation in a oceanic waveguide with small inhomogeneity imposed is considered. It is shown that the rays propagating close to the waveguide axis are strongly chaotic due to resonant interaction with depth oscillations of inhomogeneity. Chaos of near-axial rays manifests itself in forming of wide bounded chaotic sea in phase space of the ray equations. We study evolution of a wavepacket initially placed inside the chaotic sea. Wavepacket dynamics at 100 Hz is found to be almost consistent with the ray-based approach. Husimi plots constructed with frequency of 50 Hz display presence of island-like structures within the chaotic sea. These structures are more pronounced if we construct Husimi plots for a wavefield averaged over horizontal period of the waveguide perturbation. Location and number of island-like structures indicate on their link with KAM resonance 1:8. This resonance is completely overlapped in the ray limit and cannot be seen via the Poincaré map. We link occurrence of island-like structures with stabilization of refraction due to weakening of wave sensitivity to small-scale features of environment.

- **Dmitri Vainchtein** (Georgia Institute of Technology) Resonances-induced chaotic advection in a cellular flow We present a quantitative theory of resonance-induced chaotic advection and mixing in time-dependent volume-preserving D$ flows using a model cellular flow introduced in [T. Solomon and I. Mezic, Nature, 425, 376 (2003)] as an example. Specifically, we show that chaotic advection is dramatically enhanced by a time-dependent perturbation for certain resonant frequencies. We compute the fraction of the total volume of the cell that participates in mixing as a function of the frequency of the perturbation and show that at resonance essentially complete mixing in 3D can be achieved.

- **Alexei Vasiliev** (Space Research Institute, Moscow, Russia) Change in the adiabatic invariant at separatrix crossing
  We consider a mean-field model of the Feshbach resonance passage from a quantum gas of fermionic atoms to BEC of diatomic molecules. The model can be formulated as a 1 d.o.f. Hamiltonian system depending on a slow varying parameter. On the phase portrait of the system there exists a separatrix. As the parameter varies, phase trajectories of the system

can cross the separatrix. At the separatrix crossing, the adiabatic invariant (action) changes quasirandomly. This change in the action corresponds to the remnant atomic fraction. We use the methods of adiabatic perturbation theory to find the asymptotic formula for the change of the adiabatic invariant at the separatrix crossing. If the parameter varies slow periodically, multiple separatrix crossings result in chaotic dynamics in a large domain of the phase space.

- **Rui Vilela Mendes** (Centro de Matematica e Aplicacoes, Univ. Lisboa) Stochastic representations and localized numerical codes
  Stochastic representations for the solutions of linear and nonlinear partial differential equations are reviewed. They are proposed as a basis for efficient numerical codes whenever one requires the solution just in a limited region of configuration or Fourier space.

- **Gaetano Zimbardo** (University of Calabria, Italy) Kolmogorov entropy of magnetic field lines in the percolative regime: numerical computation and application to electron transport in solar coronal loops
  We present the first numerical computation ever of the Kolmogorov entropy h of magnetic field lines, extending up to the percolative transport regime. A numerical realization of magnetic turbulence and the magnetic field Jacobian matrix, in which the parallel and perpendicular correlation lengths ($l_\parallel$ and $l_\perp$) can be varied within wide ranges, is used to perform the computations by means of the Wolf algorithm. Considering values of the Kubo number $R = (\\delta B /B_0) / (l_{\\paralle}/l_{\\perp})$ going from 0.01 to 100, we find that the Kolmogorov entropy follows the quasilinear scaling for $R<1$, while it grows very slowly in the percolative regime, when $R>10$. However, Isichenko's prediction that $h \\sim R^{1/2} \\ln R$ in the percolative regime is not verified, since the numerical values grow substantially less. These results are applied to the estimate of electron transport in solar coronal loops Recent observations by the TRACE spacecraft have shown that coronal emission in the extreme ultraviolet is characterized by filamentary structures within coronal loops, with transverse sizes close to the instrumental resolution. Assuming that emission is due to hot electrons, the observations imply that electron transport along the magnetic field is much faster than electron transport perpendicular to it. Considering a transport regime in which both magnetic turbulence and collisions play a role, known as Rechester and Rosenbluth diffusion, the value of the Kolomogorov entropy in the $l_{\\paralle}/l_{\\perp} \\gg 1$ regime is needed. Careful estimation of the relevant correlation lengths allows to obtain, when comparing with the observations, an estimate magnetic turbulence level of the orde of $\\delta B / B_0 = 0.2$, in agreement with turbulence dissipation models.

Posters

- **O. Agullo** (PIIM, Uniersité de Provence) Lagrangian Chaos of magnetic field lines
  A numerical method is proposed in order to track field lines of three-dimensional divergence free fields. Field lines are computed by performing a locally valid Hamiltonian transformation, which is computed using a symplectic scheme. The method is theoretically valid anywhere but at points where the field is null or infinite. For sufficiently smooth fields for which problematic points are sufficiently sparse a systematic procedure has been proposed. Construction of field lines is achieved by means of tracers and introducing various Hamiltonians, depending in which {}"state" each line or tracer is. The states being artificially defined by an a priori given frame of reference and Cartesian coordinates, and refers to which Hamiltonian is currently locally valid for the time step to be computed. This procedure ensures the preservation of the volume (flux condition) during the iteration. This method is first tested with an ABC-type flow. Its benefits when compared to typical Runge-Kutta scheme are demonstrated. Potential use of the method to exhibit "coherent" Lagrangian structures in a chaotic setting is shown. An illustration to the computation of magnetic field lines resulting from a three-dimensional MHD simulation is also provided.

- **Amir Mohammad Ahadi** Generalized Langmuir condition for strong double layer formation in multicomponent plasmas
  One condition for the formation of a double layer is Langmuir condition which shows the existence of a net current through the double layer. In other words, the self-consistent structure of a double layer is provided by the motion of particles in the electric field. Using Langmuir criterion, one may determine the double layer's position. Earlier results in ordinary electron-ion plasmas show that the Langmuir condition for the formation of the strong double layers depends only on the mass ratios of the components. We try in this paper to investigate the possibility of double layer formation in a multicomponent plasma. This kind of plasmas forms an important part of the astrophysical plasmas. We obtain the generalized Langmuir condition in this kind of plasmas using a simple model. The obtained results show that the flux inside the double layer depends, under general conditions, on the mass ratios of ion species and electron and also on the ratio of different ion densities to the electron density. This flux depends also on the velocity of the double layer motion. One the other hand, generalizing the special condition to a more general case one may confirm the previous results.

- **R. Bachelard** (CPT, Universté de la méditerranée) Stabilizing a wave amplified by a beam of particles with test-waves
  The intensity of an electromagnetic wave interacting self-consistently with a beam of charged particles as in a free electron laser, displays large oscillations due to an aggregate of particles, called the macro-particle. In this article, we propose a strategy to stabilize the intensity by destabilizing the macro-particle. This strategy involves the study of the linear stability (using the residue method) of a specific periodic orbit of a mean-field model. As a control parameter - the amplitude of an external wave - is varied, a bifurcation occur in the system which have drastic effect on the modification of the self-consistent dynamics, and in particular, of the macro-particle. We show how to obtain an appropriate tuning of the control parameter which is able to strongly decrease the oscillations of the intensity without reducing its mean-value.

- **Oleg Bakunin** (Russian Research Center Kurchatov Institute, Nuclear Fusion Institute.) Drift effects and percolation models of turbulent diffusion

The essential deviation of transport processes in turbulent fluids and plasma from the classical behavior leads to the necessity of search for new approaches and scaling laws [1]. One of the important directions is obtaining scaling laws that characterize the turbulent diffusion of a passive scalar. A variety of turbulence forms requires not only special description methods, but also an analysis of general mechanisms for different turbulence types. One such mechanism is the percolation transport [1,2]. Its description is based on the idea of long-range correlations, borrowed from theory of phase transitions and critical phenomena. These long-range correlations are responsible for the anomalous transport. The percolation approach looks very attractive because it gives a simple and, at same time, universal model of behavior related to the strong correlation effects [2,3]. In fact, the percolation approach gives the possibility to effectively realize the scaling representation of correlation scale and to obtain dependences of transport coefficients on the parameters characterizing common properties of a flow (characteristic velocity, spatial scale, seed diffusion etc.). Here we discuss the renormalization methods to describe turbulent transport in terms of percolation in details. The mono-scale and the multi-scale approaches are treated [3,4]. The present paper considers the influence of zonal flow and time-dependence effects on the passive scalar behavior in the framework of the percolation approach. It is suggested to modify the renormalization condition of the small parameter of the percolation model in accordance with the additional external influences superimposed on the system [3-5]. This approach makes it possible to consider simultaneously both parameters: the characteristic drift velocity Ud and the characteristic perturbation frequency w. This new effective diffusion coefficient Deff satisfactory describes the low-frequency region w in which the long-range correlation effects play a significant role. This scaling agrees well with analogous expressions that describe low frequency regimes of transport.

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- **Oded Barash** (Minerva Center and Department of Physics, Bar-Ilan University, Ramat-Gan 52900, ISRAEL) ROTATING ACCELERATOR-MODE ISLANDS
  The existence of rotating accelerator-mode islands (RAIs), performing quasiregular motion in rotational resonances of order $m>1$ of the standard map, is firmly established by an accurate numerical analysis of all the known data. It is found that many accelerator-mode islands for relatively small nonintegrability parameter K are RAIs visiting resonances of different orders $m\leq 3$. For sufficiently large K, one finds also “pure" RAIs visiting only resonances of the {\\em same} order, $m=2$ or $m=3$. RAIs, even quite small ones, are shown to exhibit sufficient stickiness to produce an anomalous chaotic transport. The RAIs are basically different in nature from accelerator-mode islands in resonances of the “forced" standard map which was extensively studied recently in the context of quantum accelerator modes.
  References:O. Barash and I. Dana, Phys. Rev. E {\\bf 75}, in press (2007); Phys. Rev. E {\\bf 71}, 036222 (2005).

- **T. Benzekri** (CPT, Marseille) Targeted mixing in an array of alternating vortices
  Transport and mixing properties of passive particles advected by an array of vortices are investigated. Starting from the ideal integrable case, it is shown that a special class of perturbations allows to preserve separatrices which act as effective transport barriers, while triggering chaotic advection phenomena. In this setting, mixing within the two dynamical barriers is enhanced while long range transport is avoided, targeted mixing is achieved. A numerical analysis of mixing properties depending on parameters value is performed. Subsequently regions for which optimal mixing is achieved are proposed. Robustness of the targeted mixing properties regarding errors in the perturbation are considered, as well as slip/no-slip boundary conditions for the flow.

- **Maxim Byshkin** (NSC KIPT, Kharkov, Ukraine) Molecular-dynamical simulation of phase transition in amorphous carbon

The molecular-dynamical investigation of amorphous carbon formed by quenching the melt is performed. The peculiarities are found on the pressure dependences of physical properties of amorphous carbon. It is shown, that these peculiarities are observed at the pressure value at which 4-fold coordinated atoms form percolation cluster. The found values of concentration of 4-fold coordinated atoms 30-40 % and pressure 13 GPa, at which the peculiarities are observed, are in good agreement with results of other authors.

- **Rodolphe Chabreyrie** (Department of Mechanical Engineering, Carnegie Mellon University, Pittsburgh, PA 15217, USA) Tailoring chaotic mixing within a translating droplet by oscillatory rotation
  In this work, we seek to create tailored chaotic mixing within an incompressible spherical droplet subjected to steady translation (buoyancy) by using time dependent swirl-like motion. The Lagrangian flow implemented corresponds to the superposition of a Hill's vortex and a small time dependent rigid body rotation. This study displays qualitative and quantitative results showing that it is possible to create chaotic mixing zones with desired sizes and locations by adjusting the amplitude and frequency of the rotation. This is a promising technique for the further development of controlled reactions (lab-on-a-chip) within single droplets.

- **Levan Chotorlishvili** (Tbilisi State University), Non-Reversible Evolution of Quantum Chaotic system. Kinetic Description
  It is well known that the appearance of non-reversibility in classical chaotic systems is connected with a local instability of phase trajectories relatively to a small change of initial conditions and parameters of the system. Classical chaotic systems reveal an exponential sensitivity to these changes. This leads to an exponential growth of the initial error with time, and as the result after the statistical averaging over this error, the dynamics of the system becomes non-reversible.In spite of this, the question about the origin of non-reversibility in quantum case remains actual. The point is that the classical notion of instability of phase trajectories loses its sense during quantum consideration. The current work is dedicated to the clarification of the origin of non-reversibility in quantum chaotic systems. For this purpose we study a non-stationary dynamics of the chaotic quantum system. By analogy with classical chaos, we consider an influence of a small unavoidable error of the parameter of the system on the non-reversibility of the dynamics. It is shown in the paper that due to the peculiarity of chaotic quantum systems, the statistical averaging over the small unavoidable error leads to the non-reversible transition from the pure state into the mixed one. The second part of the paper is dedicated to the kinematic description of the chaotic quantum-mechanical system. Using the formalism of superoperators, a muster kinematic equation for chaotic quantum system was obtained from Liouville equation under a strict mathematical consideration.

- **Guido Ciraolo** (Ecole Centrale Marseille & MSNM-GP) Control of chaotic transport and application to plasma confinement
  In plasma physics, turbulence represents a severe obstacle to the attainment of confinement and high performance in devices. Conventional methods of control aim at targeting individual trajectories. In many-body systems, such methods are hopeless and one has to design a very different strategy. I will present a strategy to channel chaos by building barriers to diffusion. The core of this approach is a small apt modification of the system which drastically enhances confinement, providing practical prescriptions for the experimental apparatus to operate in a regular regime at a low additional cost of energy. This control of chaotic transport is experimentally and/or numerically tested to plasma conditions relevant to both small plasma experiments and that of fusion plasma experiments. Robustness of the control scheme is investigated.

- **Maurice Courbage** (Université Paris 7-Denis Diderot - UMR CNRS "Matière et Systèmes Complexes") Map-based model of the chaotic spiking-bursting neural behavior
  A two-dimensional model exhibiting the chaotic spiking-bursting activity of real neurons is proposed. The model is given by the discontinuous map of the form where the x-variable describes the evolution of the membrane potential of the neuron, y - variable describe the dynamics of the outward ionic currents, the functions F(x) and H(x-d) are of the form. The parameter  (>0) defines the time scale of recovery variable, the parameter J is a constant stimulus, the parameter , (>0) control threshold property of the model. We have studied the dynamics of the system for small

values of the parameter . The distinctive characteristic of systems in this case is two time and velocity scales, so-called "fast" and "slow" motions. We have found the conditions on the parameters of the system under which chaotic attractor exists and have studied its properties. Chaotic attractor has the structure determining by the properties of the one dimension Lorenz-type map and dynamics of the slow variable. We have also studied dynamics of the system for finite . In this case we have found the conditions on the parameters under which ring-shaped absorbing domain exists. It was shown that the chaotic attractor exists inside this domain and its fractal dimension is a rational value. Chaotic attractor provides simulating of spike-bursting oscillations which are commonly observed in a wide variety of neurons. We have also showed that map is applicable for simulation of other regimes of neural oscillatory activity such as subthreshold oscillation and periodic spiking or could be used for modeling of threshold excitability property of the neurons.

- **Dan-Gheorghe Dimitriu** (Alexandru Ioan Cuza University of Iasi, Romania) Spatio-Temporal Feigenbaum Scenario of Transition to Chaos in Plasma
  We report on experimental results that emphasize a complex route to chaos in plasma, in which a Feigenbaum scenario (cascade of temporal period-doubling bifurcations) develops simultaneously with a cacade of spatial period-doubling bifurcations, in connection with the development of a multiple double layers structure in dynamic state. The multiple double layers structure consists of two or more concentric double layers attached to the anode of a glow discharge, or to a positively biased electrode immersed into an equilibrium plasma. In dynamic state, the constituent double layers periodically disrupt and re-aggregate, oscillations of the current collected by the electrode being observed. In our experiments we observed that, by gradually increasing the voltage applied to an electrode immersed into an equilibrium plasma, new double layers appear in front of the electrode (spatial period-doubling bifurcations) simultaneously with the appearance of sub-harmonics in the power spectrum of the oscillations of the current collected by the electrode (temporal perio-doubling bifurcations). So, we can speak about a scenario of transition to chaos by a cascade of spatio-temporal period-doubling bifurcations in plasma.

- **Dan-Gheorghe Dimitriu** (Alexandru Ioan Cuza University of Iasi, Romania) Complex nonlinear double layer dynamics at the origin of certain plasma instabilities The investigation of the instabilities is one of the hot topics in plasma physics, especially because of their relevance for fusion plasmas. Here, experimental results are presented that prove the role of the nonlinear dynamics of some complex space charge structures in form of simple or multiple double layers correlated to the onset and dynamics of certain electrostatic plasma instabilities. In the dynamic state, such complex space charge structures periodically release bunches of charged particles (electrons and positive ions) into the background plasma. Moving through the plasma, these particle bunches can excite instabilities like the ion-acoustic instability, the potential relaxation instability or the electrostatic ion-cyclotron instability. If the plasma parameters allow, these instabilities can be amplified and a certain resonance coupling can be identified between the complex space charge structure (as oscillation energy source) and the background plasma (as reso-nator system). Under specific experimental conditions, the nonlinear dynamics of the instabilities or the interaction among them can lead to anomalous transport of particles (the presence of flicker noise) or to the appearance of turbulent states.

- **Rossana De Marco** (Dipartimento di Fisica, Università della Calabria) A Dynamical model for wave-particle interactions in plasmas
  We investigate the dynamical approach towards equilibrium during the wave-particle interactions process in plasmas. We study a Fermi-like model where an ensemble of particles interacts with two barriers whose amplitude is proportional to the energy of wave. The amplitude can decrease or increse, according to the stochastic sequence of collisions. The system approaches statistical equilibrium through a phase mixing which can be described as a laminar mixing in a conservative system.

- **Vladimir Dobrynskiy** Noise-excited self-organization of Brownian walk dynamics of periodically forced oscillator in media with spatially nonhomogeneous friction
  On the plane with nonlinear friction we study dynamics of oscillator which are a result both a one-dimensional periodic force which acts along the y-axis and two-dimensional impulse noise. We find that the system under study demonstrates

a nontrivial behaviour of the Brownian random walk which the oscillator makes along the x-axis due to the impulse noise action. To be more precise, there is a direction which is preferable for the oscillator drift along this axis. In doing so, if the free oscillation frequency coincides with that of the periodic force, then the oscillator drift direction and that of where the energy dissipation grows up are the same. But if the aforesaid frequencies do not coincide, then the oscillator drift durection and that of where the energy dissipation grows up are opposite. At that the farther the free oscillation frequency of the oscillator diverges of that of the periodic force the lower the energy dissipation rate descends. Besides, we state that the largest energy absorption occurs when there is no the noise; in turn the noise stimulates the oscillator "to escape of resonanse" in a sense that one tries to leave the phase space areas, where the parameter values of the "oscillator-medium" system are very close to those in resonance ones. Thus, the impulse noise plays role of a "organizer" of the oscillator dynamics in the given system.

- **Yves Elskens** (PIIM, Université de Provence) Quasilinear limit for particle motion in a prescribed spectrum of random waves
  The one-dimensional motion of N particles in the field of many incoherent waves \cite{ElsEsc03,EscandeElskens02} is revisited with techniques of stochastic differential equations. When the wavefield has a single wavenumber $\\kappa$ and white noise time dependence, it is represented as $(q/m) \\rmd E (\\xi,t) =\\alpha [\\cos (\\kappa \\xi) \\, \\rmd W'_t + \\sin (\\kappa \\xi) \\, \\rmd W"_t]$. For each particle the velocity is shown to be a Wiener process with the quasilinear diffusion coefficient $\\sim \\alpha^2$. The joint N velocity processes define a martingale, the components of which become independent in the strong noise limit $\\alpha \\to \\infty$, ensuring propagation of chaos in this system. The connection with the concept of resonance box \\cite{BE98,ElsEsc03} is discussed. The key quantity in the analysis is the relative velocity between two particles. Full nonlinear dynamics results are compared with the linearization around particle ballistic motions.These analytic results are confronted with numerical simulations, both for the white noise wavefield and for other incoherent wavefields \cite{CEV90}.
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- **Yves Elskens** (PIIM, Université de Provence) Direct observation of chaotic transport in wave-particle interaction
  We report experimental and numerical observation of particle transport in a time dependent system considered as a paradigm for the transition to large scale chaos in the universality class of hamiltonian systems \\cite{ElsEsc}. A test electron beam is used to observe its non-self-consistent interaction with externally excited wave(s) in a travelling wave tube (TWT). A trochoidal energy analyzer records the beam energy distribution at the output of the interaction line. An arbitrary waveform generator is used to launch a prescribed spectrum of waves along the slow wave structure (a 4 m long helix) of the TWT. The resonant velocity domain associated to a single wave is observed, as well as the transition to large scale chaos when the resonant domains of two waves and their secondary resonances overlap \\cite{DovAu}. This transition exhibits a "devil's staircase" behavior for increasing excitation amplitude, due to the nonlinear forcing by the second wave on the pendulum-like motion of a charged particle in one electrostatic wave \\cite{Dov,MacorPhD,Mac}. The scaling of the velocity transport for decreasing wave amplitude hints to a transition from a single-wave trapping to multi-wave behaviour with moderate overlap \\cite{MacorPhD}.
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- **Farhad Farokhi** Synchronization of Two Different Chaotic Systems via Active Control
  This paper presents synchronization of chaos between two different chaotic systems through active control. The proposed technique is applied to achieve chaos synchronization for the Chua and Lorenz dynamical systems. According to numerical simulations, by a good choice of parameters the synchronization error states converge to zero and hence the synchronization between Lorenz and Chua systems is achieved. This method is so useful in chaotic safe communication.

- **Farhad Farokhi** Time Series Analysis in Chaotic Chuas Circuit
  The chaotic behavior of the Chuas circuit is investigated using the time series analysis and the correlation dimension method. The relation between embedding dimension and correlation exponent is discussed and saturation correlation dimension, minimum embedding dimension and Kolmogrov entropy are calculated. Obtaining a non-integer, finite and a positive value for Kolmogrov entropy demonstrate fractal scaling and suggest chaos.

- **Federico Frascoli** (Centre for molecular simulation, Melbourne) Rheological and chaotic properties of liquids under planar elongational flow
  The simulation of planar elongational flow (PEF) in a nonequilibrium steady state for arbitrarily long times has been made possible, combining the SLLOD algorithm from non-equilibrium molecular dynamics (NEMD) methods with periodic boundary conditions (pbcs) for the simulation box [1]. In this talk, we will present some results about the rheological and chaotic properties for this type of flow. We note here that most simulations for PEF have mainly been performed in the NVT, or isothermal-isochoric, ensemble. However, in many material processing techniques and common experimental settings, at least one surface of the fluid is kept in contact with the atmosphere, thus maintaining the sample in the NpT, or isothermal-isobaric, ensemble. For this reason, we present some results [2] for the viscosity of an atomic liquid undergoing PEF at constant pressure. We implement our algorithm using the Nosé-Hoover integral-feedback mechanism compatible with PEF periodic boundary conditions. These results for elongational viscosities are consistent with experimental data [3] and with previous findings [4] for numerical simulations of shear flow systems. We also discuss some of the most significant chaotic properties of atomic liquid systems under PEF [5], comparing them with those of the well-established SLLOD algorithm for shear flow [6]. The spectra of Lyapunov exponents for a number of state points and different types of thermodynamic ensembles are also illustrated: NVT ensemble, Gaussian isoenergetic (at constant energy) or NVE ensemble, and NpT ensemble with a Nosé-Hoover barostat. The conjugate pairing rule is tested and its validity is confirmed for PEF. This allows the evaluation of transport coefficients with the use of just two Lyapunov exponents and represents a viable alternative to standard NEMD calculations.
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- **Philippe Ghendrih** (Association Euratom-CEA) Bifurcations and Front propagation if Fusion Plasmas Control of the transport properties of fusion plasmas is a key issue regarding both the confinement and the power flux to first wall components. In both cases, transitions between two plasma states via bifurcations are understood to be essential in achieving the required performance in fusion grade plasmas. In the case of turbulent transport, a local transition is observed to occur at the plasma edge. In this region the turbulent transport is observed to be quenched and to drop to values comparable to collisional transport. This region thus separates the hot temperature core plasma from the colder edge plasma, the sharp transition region, the so-called pedestal being characterised by a sharp temperature gradient. A similar temperature profile can be found in the case of thermal bifurcations, but governed by a very different physics, namely the impurity line radiation that peaks is a narrow temperature window. In both situations the incoming energy flux is a prescribed control parameter, and the boundary conditions at the outer edge, due to the plasma-wall sheath conditions, impose both a non-vanishing temperature and non-vanishing power flux at the wall to prevent plasma collapse. These specific boundary conditions provide the condition to achieve bifurcated solutions such that the up-hill plasma is hot and the plasma in a stable temperature branch, while the down-hill plasma is cold and also in stable state, between these two regions the plasma temperature crosses the unstable region where stabilisation is governed by the thermal flux. In the present work, the overall stability of the thermal bifurcation solutions is revisited for more realistic boundary conditions of the perturbations to the equilibrium. One then recovers the typical S-curve of bifurcations and the stability associated to such solutions. In a second step one investigates the propagation of perturbations to such solutions. Depending on the magnitude of the perturbation and on the boundary conditions, both diffusive like and ballistic like propagation are observed. These perturbations also lead to transitions between the stable states. As expected for such systems with noise, the propagation of perturbations modifies the standard S-curve, in particular the back transition.

- **JEAN-MARC GINOUX** (Université du Sud-Toulon Var) INVARIANT MANIFOLD OF HOMOGENEOUS POLYNOMIAL DIFFERENTIAL SYSTEMS
  The aim of this work is to present a new method of determination of invariant manifold of dynamical systems composed of homogeneous polynomial differential equations. Based on the use of Differential Geometry such as curvature and torsion this method directly provides the analytical invariant manifold equation of such systems. Then, it is established that such manifold is first integral of these systems and enables to built the general integral while using the so-called Darboux theory of invariant curves (resp. surfaces). Examples of applications in dimension two and three emphasize this method.

- **Marcel Guardia** (Universitat Politecnica de Catalunya) Splitting of separatrices for the periodically rapidly forced pendulum
  One of the main problems of Hamiltonian Dynamical Systems is to determine the stability zones of the system. For many physical models, like particle accelerators or molecular models, these regions surround the elliptic points of the systems and their boundary is given by the invariant stable and unstable manifolds associated with close hyperbolics points. Thus, it is a fundamental question to know whether this manifolds coincide in a homoclinic connection or intersect transversally. In fact, Poincare considered the study of the splitting of homoclinic and heteroclinic connections for close to integrable systems as one of the fundamental problems of dynamics. For regular perturbation problems, the classic Melnikov theory gives the asymptotic expression of the splitting. However, when the perturbation is time dependent and fast, the splitting is exponentially small, so that in some cases the classic Melnikov theory is not valid. One of the more used models for understanding this kind of splitting is the pendulum with a fast periodic perturbation. $$\ddot{x}=\sin x+\mu\varepsilon^p\sin(\frac{t}{\varepsilon})$$ where $\mu\in\mathbb{R}$ can be big and $\varepsilon>0$ is very small. The non-perturbed system has a hyperbolic critical point at the origin whose invariant stable and unstable manifolds coincide making a homoclinic connection. In the perturbed system, for $p\geq -2$ a periodic orbit created by the perturbation appears. It has two dimensional stable and unstable invariant manifolds. Since this manifolds are lagrangian, their existence and splitting is studied with the Hamilton-Jacobi equation. It is proved that for $p>-2$ the splitting of separatrices exists and a formula for the distance between manifolds is given. For $p>-3/2$ Melnikov theory is valid and for $p\in (-2, -3/2)$ is also valid doing previously certain change of variables which modifies the non-perturbed system. For the limit case $p=-2$, it is proved that the distance between manifolds is not given in the first order by the Melnikov function. In this case, the distance, as it is claimed in [1] is obtained from the called inner equation, whose study, using Ecalle's resurgence theory, is analogous to [2]. Complex matching techniques will complete the result.
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- **Alexandros K. Karlis** (Department of Physics, University of Athens, GR-15771 Athens, Greece) Fermi acceleration in the randomized driven Lorentz gas and the Fermi-Ulam model
  Fermi acceleration of an ensemble of non-interacting particles evolving in a stochastic two-moving wall variant of the Fermi-Ulam model (FUM) and the phase randomized harmonically driven periodic Lorentz gas is investigated. As shown in [A. K. Karlis, P. K. Papachristou, F. K. Diakonos, V. Constantoudis and P. Schmelcher, Phys. Rev. Lett. 97, 194102 (2006)], the static wall approximation, which ignores scatterer displacement upon collision, leads to a substantial underestimation of the mean energy gain per collision. Herein we clarify the mechanism leading to the increased acceleration. Furthermore, the recently introduced hopping wall approximation is generalized for application in the randomized driven Lorentz gas. Due to the externally imposed stochasticity to the systems under study, the evolution of particle velocity can be described as a random walk in momentum space and the acceleration problem as a diffusion process. Utilizing the hopping approximation the transport coefficients of the Fokker-Planck equation are calculated and the asymptotic time-evolving probability distribution function o the particle velocity is derived for each system. Moreover, it is shown that, for harmonic driving, scatterer displacement upon collision increases the acceleration in both the driven Lorentz gas and the FUM by the same amount. On the other hand, the investigation of a randomized FUM, comprising one fixed and one moving wall driven by a sawtooth force function, reveals that the presence of a particular asymmetry of the driving function leads to an increase of acceleration that is different from that gained when symmetrical force functions are considered, for all finite number of collisions. This fact, helps open up the prospect of designing accelerator devices by combining driving laws with specific symmetries to acquire a desired acceleration behavior for the ensemble of particles.

- **Thomas Kreuz** (Istituto dei Sistemi Complessi - CNR, Firenze, Italy) A comparison of different approaches to measure synchronization in coupled model systems
  The investigation of synchronization phenomena on measured experimental data such as biological time series has recently become an increasing focus of interest. Different approaches for measuring synchronization have been proposed that rely on certain characteristic features of the dynamical system under investigation. For experimental data the underlying dynamics are usually not completely known, therefore it is difficult to decide a priori which synchronization measure is most suitable for an analysis. In this study we use three different coupled model systems to create a controlled setting for a comparison of six different measures of synchronization. All measures are compared to each other with respect to their ability to distinguish between different levels of coupling and their robustness against noise. Results show that the measure to be applied to a certain task can not be chosen according to a fixed criterion but rather pragmatically as the measure which most reliably yields plausible information in test applications, although certain dynamical features of a system under investigation (e.g., power spectra, dimension) may render certain measures more suitable than others.

- **Enrico Lunedei** Averaged number of visits
  We introduce a new indicator for dynamical systems, the averaged number of visits, to estimate the frequency of visits in small regions, when a map is iterated up to the inverse of the measure of this region. We compute this quantity analytically and numerically for various systems and we show that it depends on the ergodic properties of the systems and on their topological properties like the presence of periodic points.

- **Seyed Majid** Quantum Hamiltonian dynamics of the kaons phenomenology
  The Hamiltonian Friedrichs model describing the evolution of a two-level system coupled to a continuum is used in order to modelize the decay of the kaon states. Using different cut-off functions of the continuous degrees of freedom, we show that this model leads to a CP violation that qualitatively fits with experimental data improving previous numerical estimates.

- **Denis Makarov** POI FEBRAS, Vladivostok, Effect of giant particle acceleration in slow-fast Hamiltonian systems
  We study motion of non-interacting particles in a space-periodic potential well. We show that a weak wave-like external perturbation induces occurence of directed current, the so-called ratchet effect. It is found that slow modulation of

perturbation wavenumber gives rise to the specific resonant channel in phase space. Presence of this channel causes forming of particle jets with increasing velocity. Since that current is amplifying with time.

- **Riccardo Mannella** (ICTP, Trieste, Italy) Double-separatrix chaos
We show that, if an integrable Hamiltonian system possesses two or more separatrices, then chaos caused by a weak time-periodic perturbation may drastically differ from that in the conventional single-separatrix case. Namely, (1) the energy width of a chaotic layer associated with any of the separatrices may strongly depend on angle, so that the minimal width is much smaller than the width of the conventional layer for the same perturbation while the maximal width is much larger than the conventional one; (2) the layer can be strongly inhomogeneous due to large stability islands The origin of these features relates to the characteristic form of frequency of eigenoscillation as a function of its energy, w(E), in between any two adjacent separatrices. Namely, w(E) is almost constant in the major part of the interval of E between energies of given adjacent separatrices while sharply decreasing to zero as E approaches the energy of any of the separatrices. Therefore, even a rather weak perturbation with the frequency close to the local maximum of w(E) or its multiple may provide for a nearly resonant transport between vicinities of the separatrices whilst the latter vicinities are strongly chaotic. Then chaos extends to a large part of the phase space between the separatrices. Combining the separatrix map analysis and the resonant approximation, we develop the self-contained theory for the boundaries of the chaotic layers in the asymptotic limit when the energy separation between the separatrices is small. On the base of this theory, we describe the frequency dependence of the minimal perturbation amplitude that provides for chaotic transport between the separatrices. The most important and exciting feature of this dependence is the presence of deep spike-like minima in the vicinity of the maximal eigenfrequency and its multiples. Our theory nicely describes the spikes found in our earlier numerical simulations [1]. We also discuss promising applications which include: (i) the increase of the dc conductivity of an electron gas in a magnetic superlattice, (ii) the reduction of activation barriers for noise-induced escapes and the related acceleration of the noise-induced spatial diffusion, e.g., of cold atoms in an optical lattice, (iii) the facilitation of the stochastic web formation in a wave-driven or kicked oscillator and the related increase of the dc conductivity in a semiconductor superlattice subjected to magnetic and electric fields.
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- **Thanos Manos** (Université de Provence & University of Patras) Application of the Generalized Alignment Index Method to the Dynamics of Multi-dimensional Symplectic Maps
We study the detailed phase space dynamics of multi-dimensional symplectic maps, using the method of the Generalized Alignment Index (GALI). In particular, we show that the GALI provides an efficient criterion for rapidly distinguishing chaos from order, identifying the dimensions of tori and predicting slow diffusion in an array of N coupled standard maps. We study the transition from regions of weak to strong chaos, investigate the transfer of energy between the linear modes of the uncoupled system and compare our findings, with similar results obtained in the literature by different methods.

- **Maxime Mikikian** (GREMI) Self-excited instabilities in plasmas containing dust particles (dusty plasmas)
Dusty plasmas are relatively complex systems where new phenomena arise from the presence of solid dust particles trapped inside the plasma. These media are observed in astrophysics (comet tails, planetary atmospheres) and also in industry where dust particles are usually fatal for the processes in microelectronics but useful to build small objects in nanotechnologies (single electron devices, solar cells). These industrial implications stimulated studies on dusty plasmas in the late 1980's. Thermonuclear fusion is also a topical field concerned by dust production due to wall erosion. The formation of dust particles in laboratory experiments is usually achieved in two different ways: Using reactive gases such as silane or using a target sputtered by the ion bombardment coming from the plasma. These two methods usually lead to the formation of a dense cloud of submicron dust particles filling the whole plasma volume. The dust particles are trapped in the plasma due to the negative charge they acquire by attaching free electrons. This charge loss can be drastic for the plasma equilibrium and instabilities can appear due to the strong interdependence between the dust particle cloud and the plasma.In this presentation, various types of instabilities are presented. They are obtained in low pressure (0.1-1 mbar) radio-frequency

(13.56 MHz) discharges where dust particles are grown by using a reactive gas (silane, SiH_4) [1, 2] or by sputtering a surface exposed to an argon plasma [3, 4]. These instabilities consist in regular or chaotic oscillations of plasma and dust cloud properties, with frequencies (from few Hz to few kHz) and shape depending on dust particle size and density. They appear either during the dust particle growth process [1-3] or once the dust cloud is entirely formed [4]. They concern dust particles with sizes ranging from few nanometers to few hundreds nanometers. To characterize these instabilities, different diagnostics are used: electrical measurement of the plasma current, analysis of the plasma glow thanks to optical fibers, high speed imaging (around 2000 frames per second) of dust cloud and plasma glow. Variations of plasma properties and motion of the dust particle cloud are recorded and correlated. These various diagnostics show the complex evolution scheme of these instabilities.
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- **Montse Navarro** (Universitat de Barcelona) A numerical study of quasiperiodic motions and Strange Nonchaotic Attractors for a forced nonlinear oscillator.
  We study the existence of invariant tori and Strange Nonchaotic Attractors (SNAs) for a nonlinear oscillator with friction and a time dependent quasi-periodic forcing. This equation has been considered by several authors to model the radio-frequency-driven superconducting quantum interference device (SQUID) with inertia and finite damping. Using numerical methods, we show the existence of quasiperiodic motions and we discuss the existence of SNAs for certain ranges of the parameters.

- **Silvia Perri** (Universita' della Calabria, Arcavacata di Rende, Italy) Evidence for Levy walks and non Gaussian propagators of energetic particles accelerated at interplanetary shock waves
  We consider the propagation of energetic particles, accelerated by interplanetary shock waves, upstream of the shock. In connection with superdiffusive transport and Levy random walks, we have considered the relevant non Gaussian propagator which has power law tails with slope 2<\\mu<3. We show that, in the case of superdiffusive transport, the time profile of particles accelerated at a traveling planar shock can be a power law with slope \\gamma=\\mu-2 rather than an exponential decay as expected in the case of normal diffusion. We consider two datasets of interplanetary shocks in the solar wind, the forward and reverse shocks associated with the interaction between the fast and slow solar wind streams, detected by the Ulysses spacecraft between July 1992 and November 1993, and a set of coronal mass ejection driven shocks observed by the ACE spacecraft. We have found that the time profiles of energetic electrons, with energies between 65 and 290 keV for Ulysses, and between 38 and 53 keV for ACE, correspond to power laws with slopes \\gamma \\simeq 0.41–0.89, implying superdiffusive transport with a mean square deviation which grows as t^{1.11}–t^{1.59}. The propagation of ions reveals a non Gaussian propagator, too, although a roll-over to a steeper spectrum is also observed.These results show that the propagation of energetic particles in the turbulent environment of the solar wind is intermediate between ballistic and diffusive, in agreement with the results of recent numerical simulations, and promise to have applications to models of cosmic ray acceleration due to diffusive shock acceleration, as well as to the spreading of energetic particles throughout the heliosphere.

- **Silvia Perri** (Universita' della Calabria, Arcavacata di Rende, Italy) Position and velocity space diffusion of test particles in stochastic electromagnetic fields
  The two dimensional diffusive dynamics of test particles in a random electromagnetic field is studied. The synthetic electromagnetic fluctuations are generated through randomly placed magnetised clouds oscillating with a frequency \\omega. We investigate the mean squared displacements of particles in both position and velocity spaces. As \\omega increases the particles undergo standard (Brownianlike) motion, anomalous diffusion and ballistic motion in position space. Although in general the diffusion properties in velocity space are not trivially related to those in position space, we find that energization

is present only when particles display anomalous diffusion in position space. The anomalous character of the diffusion is only in the nonstandard values of the scaling exponents while the process is Gaussian.

- **T. Pierre** (PIIM, CNRS) Turbulence study and control of transport in a toroidal magnetized plasma
Turbulence measurements are carried out in the new device "MISTOR, a simple magnetized toroidal plasma. At low magnetic field with poorly magnetized ions, low frequency instabilities are recorded exhibiting quasi-periodic or turbulent regimes. The unstable frequencies vary from below the ion cyclotron frequency to higher harmonics. It is found that the ion acoustic velocity is a crucial parameter through the variation of the gas pressure. In fact, coherent modes are obtained when toroidal resonances are established. The measurement of the radial transport is performed and the result is that coherent regimes produce a lower transport. Finally, dynamical control of the quasi-periodic regimes is obtained using the time-delay autosynchronization method with polarisation of a poloidal limiter as control parameter. On the other hand, a control strategy based on spatial autosynchronization is also applied successfully and it produces a significant reduction of radial anomalous transport. Further developments are envisaged which are based on ultra-fast imaging of the spontaneous emission of the unstable modes. The dynamics is optically detected and an electric retroaction can stabilize the system.

- **Dolors Puigjaner** (Universitat Rovira i Virgili) Bifurcations and flow transitions of steady natural convective flow patterns in a cubical cavity with perfectly conducting lateral walls
Rayleigh-Bénard convection represents a dissipative dynamical system occurring in many natural and industrial systems, whose main parameters are the Rayleigh and the Prandtl numbers. While the Rayleigh number, Ra, typifies the ratio of the destabilising buoyancy to the stabilising diffusive forces, the Prandtl number, Pr, is an intrinsic property of the fluid, not of the flow that measures the rate molecular diffusion of momentum relative to that of heat. Rayleigh-Bénard convection has fundamental interest to study flow instabilities and the dynamics of nonlinear pattern-forming processes. Therefore, it constitutes an appropriate flow system to study the role of pattern formation and to examine the subsequent flow bifurcations in the development of turbulence. The first bifurcation corresponding to the instability of the motionless conductive state and the onset of thermal convection occurs when the Rayleigh number reaches a critical value (Ra_c). It is well known (refs 1 and 2) that bifurcations from the conductive state inside a parallelepipedical cavity are independent of Pr. However, the bifurcation diagrams of steady convective flow patterns inside a cubical cavity with adiabatic lateral walls reported elsewhere (refs 3 and 4) show that bifurcation diagrams depend strongly on Pr. The aim of the current work is to analyse stability, bifurcations and flow transitions of steady convective flow patterns in a cubical cavity with perfectly conducting lateral walls. In addition, the spatial configuration and heat transport characteristics of the flow patterns formed and their evolution as Ra is increased have also been investigated. Hence, this work extends previous for adiabatic lateral walls. Bifurcation diagrams of steady convective flow patterns over the region Ra< 150,000 were determined by means of an arclength continuation procedure at both Pr=0.71 and 130. The continuation procedure, which includes tools to analyse the stability character and to determine the bifurcations of tracked solutions, was based on a Galerkin spectral method with a complete, divergence-free set of basis functions satisfying all boundary conditions. A formulation of the velocity field in terms of three scalar potential functions was used to obtain an appropriate set of divergence-free basis functions to expand the velocity vector field. Four and nine different convective solutions (without taking into account the solutions obtained by symmetry) that are stable over certain ranges of Ra have been respectively identified at Pr=0.71 and 130. Current predictions are consistent with previous experimental flow transitions and topologies reported in the literature. The bifurcation diagrams at both Pr are more complex than those previously reported for adiabatic sidewalls. The dependence of the bifurcation diagrams and the topology of the flow patterns on Pr is also stronger in the case of conducting sidewalls. The spatial configurations of flow patterns that set in at bifurcations from the conductive state are very similar to those that develop for adiabatic lateral walls at values of Ra close to the bifurcation point where they set in, becoming increasingly different as Ra is increased. The higher complexity of the present problem, compared to the case with adiabatic lateral walls, is a direct consequence of the thermal activity of the lateral walls. To investigate the effect of the Pr in the stability character and topology of the flow patterns that are formed inside the cavity, a complete bifurcation study in the two dimensional (Ra, Pr) plane has been carried out for the flow pattern formed by four interconnected

half-rolls, which presents quite different regions of stability at Pr=0.71 and 130. The variation of the heat transfer rate at the bottom plate as a function of Ra and Pr for this flow pattern yielded a rather complex three dimensional manifold that presented several folds and cusp points. The presence of folds in the solution manifold reveals that up to five realisations of the flow pattern are possible over some ranges of Ra and Pr; even two stable realisations coexist over a narrow region of these parameters. The complexity of the flow explains the important differences in its spatial configuration and stability character at different Prandtl numbers.
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- **Samir RAHAL** (Department of Mechanical Engineering, University of Batna, ALGERIA) Characterization of oscillatory regimes in the Bénard - Marangoni convective instability.
  A study of dynamic regimes, in Bénard - Marangoni convection, has been carried out, for various Prandt and Marangoni numbers, in small aspect ratio geometries ( = 2.2 and 2.8). Experiments in a small hexagonal vessel, for a large extent of the Marangoni number (from 148 to 3,636), have been carried out. Fourrier spectra and an auto-correlation function have been used to recognize the various dynamic regimes. For given values of the Prantl number (Pr = 440) and aspect ratio ( = 2.2), mono-periodic, bi-periodic and chaotic states, are successively observed, as the Marangoni number is increased. The correlation dimensions of strange attractors, corresponding to the chaotic regimes, are calculated. The dimensions are found to be larger then those obtained by other authors for the Rayleigh-Bénard convection, in aspect ratio geometries of the same order. The transition from temporal chaos to spatio - temporal chaos has also been observed. Indeed, for  = 2.2, when larger values of the Marangoni number are imposed (Ma = 1,581 for Pr = 160 and Ma = 740 for Pr = 440), the spatial modes are involved through the convective pattern dynamics.

- **Marisa Roberto** (Physics Departament, ITA, S.J.Campos, SP, Brazil) Escape patterns and magnetic footprints due to ergodic magnetic limiters in reverse-shear tokamaks
  Escape patterns and magnetic footprints of chaotic magnetic field lines in a tokamak wall were studied for a configuration with resonant modes, due to an ergodic magnetic limiter. In order to investigate the escape patterns, the exit basins and the connection lengths were obtained. They are, respectively, a set of points in a chaotic region that originates field lines hitting the wall in some specific region and the number of toroidal turns given by a field line until they reach the wall. A non-monotonic safety factor profile was used, with a region of negative shear. The nontwist mappings were obtained for several values of the ergodic limiter current which describe perturbed magnetic field lines with two chains of magnetic islands and chaotic lines in their vicinity. If internal modes are perturbed, the connection lengths and the exit basins show an extremely concentrated escape in the tokamak wall. Magnetic field lines with high connection lengths also strike the wall in specific poloidal angles. These localized escape channels may deteriorate the plasma confinement quality. On the other hand, resonant modes closer to the plasma edge yield escape channels much more distributed, which results in a broader deposition pattern. The magnetic footprints show these tendencies.

- **Ronny Sczech** (Technische Universität Dresden) Periodic Instability in a Liquid-liquid system with Crown ether Complexation
  Reaction Periodic convective instability has been observed in a biphasic system during the complexation reaction of Caesium picrate and Dicyclohexano-18-crown-6 (DCK-6) from an aqueous to a hexane organic phase. Visualization of the convective fluxes was possible thanks to the precipitated crystals that are formed in both phases by the complexation reaction. The fluid motion was observed by means of an optical microscope and further analysed with the Particle Image

Velocimetry (PIV) technique. Surface tension measurements, representative of the adsorption state, showed fast adsorption during the convective stage, followed by a slower desorption process in the quiet stage. The partition is not the major driving force for the observed instabilities because only very little amount (below 1%) of Caesium is extracted to the organic phase. With means of interferometry one can visualize buoyancy-driven cellular structures penetrating into the aqueous phase which are resulting from the fluid motion near the liquid-liquid interface. Near the interface the fluid motion itself follows a back and forth movement governed by the spatial confinement of the experimental cell. This movement may result from oscillating changes of the local surface tension travelling along the interface.

- **Eric Serre** (MSNMGP, CNRS) Unsteady von Kármán swirling flow in exactly counter-rotating configuration
  We present a numerical study of the velocity field of the von Kármán swirling flow produced in an enclosed cylinder of height-to-radius ratio of two by the exact counter-rotation of the top and bottom disks. When the Reynolds number based on cylinder radius and disk rotation is increased different complex flows appear successively and the pattern flow looses its symmetry with respect to the equatorial plane. The relative amplitude of the azimuthal Fourier modes is related with the successive transitions of the steady flow. Nonetheless the flow is very complex and the Fourier modes are not sufficient for the characterisation of the pattern. The time behaviour shows the competition between the different modes and it is characteristic of a unsteady state. The resulting pattern has some features in common with the patterns observed in experimental investigations, which have shown that the axisymmetry is broken by the presence of equatorial vortices with a precession movement, being the velocity of the vortices proportional to the Reynolds number.

- **Ivan I. Shevchenko** (Pulkovo Observatory) Adiabatic chaos in planetary satellite systems
  A method of analytical estimation of the maximum Lyapunov exponent of the chaotic motion near separatrix of nonlinear resonance is developed in the framework of the periodically perturbed pendulum model of nonlinear resonance. The method is based on the separatrix map theory. In the case of slow perturbation (i.e., the case of adiabatic chaos) the method allows one to calculate the maximum Lyapunov exponent of the original Hamiltonian system almost exactly. Simple analytical formulas are given for approximate estimates. The method is applied to studies of the chaotic dynamics in near-resonant satellite systems of planets. The main objects of the study are the adiabatic chaotic regimes in the orbital dynamics of the 16th and 17th satellites of Saturn (Prometheus and Pandora) and the first and third satellites of Saturn (Mimas and Tethys). The chaotic regimes could play an essential role in the long-term orbital evolution of these satellite systems. The Lyapunov times giving the time horizon of predictability of the motion are calculated analytically for both systems. It is shown that, though rare in the course of long-term tidal orbital evolution, parametric proximity of a slowly chaotic satellite system to low-order secondary resonance drastically modifies global properties of the chaotic layer, i.e., its global structure, relative measure of inner regular component, and the value of the maximum Lyapunov exponent.

- **Yasuhide Sota** New approach to measure the transition rate of collective motions inself-gravitating system.
  We propose the method to evaluate the statistics and instability of the collective motions in local region of self-gravitating system. It is known that self-gravitating system shows a character of local virial (LV) relation in the bound region after a cold collapse. Here we investigate the correlation between the LV relation and other local characters such as velocity distribution and the transition rate of collective motions. Voronoi tessellation and Wesserstein distance are applied to evaluate such characters in local region.

- **Emanuele Tassi** (CNISM and Dipartimento di Energetica, Politecnico di Torino) Nonlinear dynamics of a Hamiltonian four-field model for magnetic reconnection in collisionless plasmas
  Magnetic reconnection (MR) is a process that allows to convert magnetic energy into kinetic and thermal energy of a plasma through a rearrangement of the topology of the magnetic field. This phenomenon is of great relevance for both laboratory and astrophysical plasmas [1,2]. In this contribution we present recent results concerning the nonlinear dynamics of a set of partial differential equations [3] describing two-dimensional MR in a collisionless plasma. The model equations, which admit a noncanonical Hamiltonian formulation [4], are solved numerically on a rectangular domain adopting a finite volume scheme and assuming double periodic boundary conditions. The numerical solutions show different nonlinear field

evolutions depending on the values of the normalized ion skin depth d_i and of the beta parameter, the latter measuring the ratio between the internal and the magnetic pressure. For beta $>>1$, or beta $<<1$, and d_i of order unity, in the nonlinear phase a vorticity layer aligned along the resonant surface tends to form. For sufficiently large or small, respectively, values of beta this layer undergoes a Kelvin-Helmholtz instability which can lead to an onset of turbulence. If d_i $>>1$ and beta $<<1$ the vorticity localization along the resonant surface is inhibited and both vorticity and current density fields tend to undergo a filamentation due to a phase mixing process, similarly to what observed in a previously investigated two-field model [5]. The behavior in this regime can be explained in terms of the Casimir invariants [4,5] possessed by this system.
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- **Mitsuyoshi Tomiya**, (Seikei University, Kichijyouji-Kitamachi 3-3-1, Musashino-shi city, Tokyo) Nodal Pattern Analysis for Conductivity of Quantum Ring in Magnetic Field
  The conductivity of the nano-sized two-dimensinal(2D) device is numerically studied. The wave functions inside the devices of the various shapes and the transmission functions are calculated. The nodal patterns of the wave functions are found to be crucial for the physical properties of the 2D devices. Especially their patterns that are close to the Fermi energy mostly determine the conductivity. The localized nodal pattern which often appears in the chaotic shape of the device leads higher resistance. The integrable shape usually causes lower resistance. The effect of the static electro-magnetic field and/or the microwave on the device is also discussed. Under the static magnetic field, the radius of the cyclotron motion is also found to be critical for the properties of the device with the quantum ring, especially under the microwave.

- **Marios Tsatsos** (Imperial College) THEORETICAL AND NUMERICAL STUDY OF VAN DER POL OSCILLATOR
  We present the basic theoretical efforts (theory of averaging, succesive approximations) that are known in order to deal with non-trivial solutions at the Van der Pol oscillations. We also construct a set of diagrams (phase portaits, bifurcation diagrams, Fourier power spectra, period of the system versus parameter) and maps, based on numerical investigations, corresponding to the expected theoretical results. Furthermore we examine closely the existence of chaotic attractors, both theoretically (with Lyapunov exponents) and numerically (period doubling cascades). We demonstrate chaotic, periodic and almost periodic solutions of this equation, with the use of Fourier analysis, whose spectra we further "audio-lize". All diagrams and numerics have been made with Mathematica (version 5.2) and C++ programming languages

- **Vladimir Uchaikin** (Department of theoretical physics, Uljanovsk state university, Russia) Fractional model of anomalous transport of resonance radiation in plasma
  The Biberman-Holstein transport equation for concentration of atoms excited by resonance radiation in plasma is represented in the form of a differential equation with partial derivatives of a fractional order. Analytical solution for large times and an infinite homogeneous medium is obtained involving Levy-stable densities. Numerical results for bounded low-temperature plasma are calculated by Monte Carlo technique applied to the fractional differential equation. Some special details of the simulation procedure are described including the algorithm of generation of anomalous paths of resonance photons. Mathematical and physical peculiarities of the process under simulation are discussed and the relation to the Levy flights and Levy motion processes are stated.

- **A. Vieiro** (Universitat de Barcelona) Some comments on local and global study of APM
  Hamiltonian systems are useful to describe several physical phenomena. They are strongly related to symplectic maps making relevant a complete (qualitative and quantitative) dynamical description of these maps. The simplest symplectic maps to study are area preserving maps (APM) which are the goal of this work. Birkhoff Resonant Normal Form approach

and interpolation by means of an integrable Hamiltonian flow are common tools used to get some well-known{\\em local} properties of the phase space around an elliptic point. Nonetheless, we look also for {\\em semiglobal} properties of the map such as thesplitting of manifolds involved in resonance chain. It turns out that what we name “inner” and “outer” splittings are generically different for a and this fact can be characterized by the twist properties of the map. Frequency map analysis allows us to obtain numerical information on some {\\em global} properties of APM. From it, twist properties, breakdown of invariant tori, twistless bifurcations, resonance location, etc, can be obtained. Local analysis around a separatrix of an island can be carried out in terms of the separatrix map and the standard map. Furthermore we introduce a model, denoted as {\\em biseparatrix map}, which allows for a qualitative explanation of the presence of islands and chaotic domains in the Birkhoff zones of APM. When dealing with APM it is relevant to determine the size and the shape of the {\\em stability domain}. In this way it becomes necessary to identify the barrier invariant objects which bound the stability domain of APM. Some numerical results in this direction will be presented. Again the biseparatrix map allows for clear understanding of the phenomena. All the machinery developed allows us to confront the problem of study APM in a {\\em quite effective} way. As an example a numerical study of the H\\'enon map will be sketched. It includes normal form approach and twist coefficients, strong resonances, inner and outer splittings, invariant tori, domain of stability, computation of maximal Lyapunov exponent, rotation number computation, etc, always in agreement with the theory described. For a detailed explanation of these topics we refer to
C. Sim
'o and A. Vieiro. {\\em Some relevant aspects of area preserving maps andthe planar conservative H\\'enon map.} 2007, in preparation, and references therein.

- **Michel Vittot** (CPT, CNRS) A Lie-Algebra version of Classical or Quantum Hamiltonian Perturbation Theory & Control, with examples in Plasma Physics How to describe the Perturbation Theory of a non-integrable Hamiltonian? Which property do we want to preserve after perturbation? We propose to use a sub-Lie Algebra of the space of “Observables”. So we consider an Hamiltonian in a sub-Lie Algebra B (which we name “admissible”) of the Lie-Algebra of “Observables”. For a “quite general but small” perturbation of this Hamiltonian, we give an expression for the sub-Lie-algebra isomorphic to B which contains the perturbed system. More precisely we give an expression for the automorphism (“change of variables”) which conjugates the 2 sub-Lie-algebras. A simpler problem is to “slightly” modify the perturbed system (by an additive “control” term, for instance quadratic in the perturbation) such that the above automorphism is simple to compute. This theory generalizes a recent control of Hamiltonian systems that has been already applied in some physical examples. Here we give some other examples, mainly in Plasma Physics.

- **Miloudi WADIH** (MSNM-GP - UMR6181 CNRS - Universités d'Aix-Marseille) On the complexity of the neutral curve for oscillatory flows
  The linear stability property of various types of oscillatory flows usually exhibits regular and smooth enough neutral curves, suggesting a light influence of unsteadiness of the basic flow; the unsteady effect compared to the classic steady flows is often limited itself to advance or delay transition. Many studies, whether theoretical or numerical in nature even failed to predict transition thresholds onto less orderly regimes observed in experimental work. Two recent works (Blennerhassett and Brassom, JFM 2002, 2006) on the linear stability of Stokes layers or oscillatory flow in a channel provide a new insight into the investigation of such flows for a better prediction of various transition modes. The most intriguing feature of their results is the fine structure of the neutral curve, which has thin finger-like protrusions from an essentially smooth curve in some range of wavenumber. In the present work, the linear stability property of periodic flow in a circular pipe is examined in order to show the existence of a much more remarkable finger-like protuberances structure. In this case, we may speak about two neutral curves: one inside which corresponds to a rather late critical threshold and the other one which makes this threshold weaker but closer to experiment observations. The mechanism of the generation of fingers on the neutral curve is explained:
  - from a mathematical point of view by an alternation of zones for real or complex Floquet exponent
  - from a physical point of view by the coalescence of two propagating waves in opposite directions.

In addition, this mechanism is generic and when the transition occurs in a zone with real value, a finger appears on the neutral curve which decreases the critical threshold and introduces a second curve closer to smaller Reynolds numbers.

- **Tatjana Zivkovic** (University of Tromsø, Norway) Low dimensional chaos in experimental data from Helimak device
  It was shown matematically [1] that low dimensional chaos could be found in magnetized plasmas imbedded in curved magnetic field. In order to prove this, we analyze the electron potential fluctuations from the Helimak device. This device is the simplest toroidal plasma configuration that exhibits an equilibrium and is suitable for studies of low-frequency gradient, driven instabilities and their routes to chaos. In a real plasma system it is not likely that one will observe 'clean' low-dimensional chaos: the typical situation is that high-dimensional turbulent dynamics dominate the smaller scales, while the lower dimensional dynamics governs the global scale of the system. Therefore, we use mean-field dimension analysis [2], where for the given level of averaging in the system (the number of points in the phase space involved in averaging), the mean-field dimension determines the minimum dimension of the embedding space in which the averaged dynamical system approaches the actual dynamics, while the small scale dynamics, affected by noise, are smoothed away. We reconstruct the phase space by a delay embedding method [3] and then use Singular Value Decomposition (SVD) to make the space orthonormal. We find that the dynamics in the system for the finest scales is irregular and cannot be embedded in a finite-dimensional space. However, for the larger scales, we find low dimensional chaos, with dimension D~3, which was obtained theoretically. Also, recurrence plots analysis of higher SVD components gives evidence of chaotic behaviour.
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